PAKISTAN'S NUCLEAR PROGRAMME: SECURITY, POLITICS AND TECHNOLOGY

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By

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Declaration

I hereby certify that this dissertation is the result of my individual research and that it has not been submitted concurrently to any other University for any other degree.

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Dedicated to the People of Pakistan and to the Memory of my late father, Dr. Muhammad Nazeer Chaudhri

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Abstract

The genesis of Pakistan's nuclear programme can be traced to the establishment of the Physics Department in Government College, Lahore soon after independence in 1947. Pakistan initiated a modest nuclear programme to harness the peaceful uses of atomic energy, in the wake of the Atoms for Peace Programme in 1956. This led to the formation of the Pakistan Atomic Energy Commission (PAEC) and the initial focus was to develop a civilian base for a peaceful and research oriented nuclear programme. During this phase, the country's nuclear programme was led by two Chairmen of PAEC, Dr. Nazir Ahmad (1956-1960) and Dr. I.H. Usmani (1960-1972). This era also saw fragmented nuclear decision-making amongst President Ayub Khan, his advisors in the civil bureaucracy and PAEC. These sixteen years were marked by the training of hundreds of scientists and engineers in various technical fields in Western nuclear establishments and Universities. During the 1960s, the United States and Canada helped Pakistan launch a modest nuclear power and research programme with the setting up of the Pakistan Atomic Research Reactor-1 (PARR-1), the Karachi Nuclear Power Plant (KANUPP), and the Pakistan Institute of Nuclear Science and Technology (PINSTECH).

However, Pakistan was unable to capitalize on the available options for acquiring nuclear fuel cycle facilities on easy terms that could have provided the country with a nuclear option, primarily due to opposition from within the civil bureaucracy. Thus, decision-making regarding the nuclear programme was adversely affected by bureaucratic politics during this time. Nonetheless, a growing threat perception following the 1965 Indo-Pakistan war and India's increasing nuclear capabilities led to the formation of two parallel pro-bomb coalitions. One comprised Zulfikar Ali Bhutto and Munir Ahmad Khan, while the other one consisted of young scientists and engineers in PAEC who wished to see Pakistan develop nuclear capability. While the 1971 Indo-Pakistan war led to the separation of East Pakistan, it led to Bhutto to power and to the convergence of the two separate pro-bomb coalitions. Dr. Usmani did not enjoy the support of the political leadership, and was opposed to making nuclear weapons. Therefore, he was replaced by Mr. Munir Ahmad Khan at the Multan Conference in January, 1972. His tenure would last for another nineteen years which would prove to be the most critical phase in Pakistan's nuclear quest.

Hence, PAEC was re-organized in 1972 and was placed directly under the Chief Executive's Secretariat and was mandated to develop the nuclear option. A long-term

comprehensive nuclear plan was approved and international cooperation solicited to develop the essential infrastructure. Even as the country's nuclear programme was struggling to stand on its own feet owing to the loss of half of its trained manpower with the separation of East Pakistan, India carried out its first test of a nuclear device in May 1974. This had the twin effect of termination of all international cooperation as the Western supplier states began to cancel agreements for the supply of nuclear fuel cycle facilities unless Pakistan brought is entire nuclear programme under safeguards. It also adversely affected the country's long-term nuclear power programme, which depended on importing nuclear power plants. When Pakistan failed to secure any international security guarantees from the big powers in the face India's nuclear threat, it resolved to develop all aspects of the nuclear fuel cycle and weapons capability on its own. In the face of sanctions, Pakistan was able to complete work on numerous projects, ranging from uranium exploration, processing, conversion, enrichment, fuel fabrication production reactors and a heavy water plant, and fuel reprocessing.

Acutely aware of India's progress in developing nuclear explosives, PAEC also began work on the establishing the infrastructure on the design, fabrication, manufacture and testing of nuclear weapons as early as March 1974. This work was carried out by the Directorate of Technical Development, which comprised different projects related to the theoretical design, trigger mechanism, machining and precision engineering of electronic and mechanical and other non-nuclear components of the nuclear device. In addition, diagnostic facilities for carrying out cold and hot tests, including the Chaghi and Kharan test sites were also developed. These fruits proved their worth when PAEC carried out the first cold test of a working nuclear device on March 11, 1983, which would be followed by two dozen more cold tests of improved weapon designs. At the same time, the nuclear fuel cycle projects also enabled Pakistan to produce indigenous nuclear fuel for KANUPP when Canada cut off supplies of fuel and spare parts. The country also succeeded in producing highly enriched uranium by the mid-1980s under the auspices of KRL. This project, originally launched by PAEC in 1974-75, was taken over by Dr. A.Q. Khan and separated from its parent organization within two years.

Moreover, work on developing the infrastructure for the plutonium route had begun in earnest in 1973, which was completed by the early 1980s. However, as KANUPP was under safeguards, PAEC began work on a heavy water production plant and a 50 MWt plutonium production reactor and a tritium plant along with other nuclear infrastructure projects. These were completed within a decade, which has now enabled Pakistan to utilize the hitherto untapped capability to produce weapons-grade plutonium and tritium. The latter can also be used to develop thermonuclear weapons. While

Pakistan had acquired nuclear capability by the early 1980s, it refrained from demonstrating it due an un-favourable international climate. However, an opportunity was provided by India's nuclear testing in May 1998 and this time Pakistan was able and ready to respond and carried out six nuclear tests on May 28 and 30 respectively. A threat perception emanating from an enduring rivalry India is widely seen as the only factor that drove Pakistan's nuclear programme throughout the country's nuclear history. While security concerns provided a justification for evolving a consensus for the development of the nuclear programme, other factors played equally important roles in determining how the programme evolved through different stages. Thus, decisions by Pakistan's nuclear establishment and political decision-makers were largely driven by technological determinism, considerations of domestic and bureaucratic politics, and nuclear myth making. All these factors led to the emergence of Pakistan's nuclear programme as it is today.

Abbreviations, Acronyms and Glossary

Abbreviations

AC	Alternate Current
ACD	Applied Chemistry Division
ADU	Ammonium Diurinate
ADW	Airport Development Workshop
AEC	Atomic Energy Commission/ Atomic Energy Centre
AEMC	Atomic Energy Mineral Centre
AHQ	Air Head Quarters
AJK	Azad Jammu and Kashmir
AMF	American Machine Foundry
ANL	Argonne National Laboratory
ATCOP	Al-Technique Corporation of Pakistan
ATS	Air Transport Squadron
BBC	British Broadcasting Corporation
BC-1	Baghalchur-1
BNFL	British Nuclear Fuels Limited
CAA	Civil Aviation Authority
CANDU	Canadian Deuterium Uranium Reactor
CEA	Commissariat a l’ Energie Atomique

CENTO	Central Treaty Organization
CERN	European Organization of Nuclear Research
CGE	Canadian General Electric
CHASNUPP	Chashma Nuclear Power Project
CIA	Central Intelligence Agency
CIR	Canadian Indian Reactor
CIRUS	Canadian Indian Reactor United States
CNNC	China National Nuclear Corporation
CPC	Chemical Plants Complex
DC	Direct Current
DCC	Defence Committee of Cabinet
DESTO	Defence Science and Technology Organization
DIL	Directorate of Industrial Liaison
DNM	Directorate of Nuclear Minerals
DSO	Defence Science Organization
DTD	Directorate of Technical Development
EAD	Economic Affairs Division
	Executive Committee of National Economic Council
FDO	Physical Dynamics Laboratory
FWO	Frontier Works Organization
GC	Government College

GHQ	General Head Quarters
GSP	Geological Survey of Pakistan
HEU	Highly Enriched Uranium
HFF	Heavy Foundry and Forge
HMC	Heavy Mechanical Complex
HMX	His Majesty's Explosive
HRD	Hard Rock Division
HTL	High Tension Laboratory
IAEA	International Atomic Energy Agency
ICBM	Inter-Continental Ballistic Missile
ICTP	International Centre for Theoretical Physics
IINSE	International Institute of Nuclear Science and Engineering
IISS	International Institute of Strategic Studies
ISL&MP	In-Situ Leaching and Mining Project
ISNSE	International School of Nuclear Science and Engineering
KANUPP	Karachi Nuclear Power Plant
KCP	Khushab/Kundian Chemical Plant
KfK	Karlsruhe Nuclear Research Centre
KNFC	Kundian Nuclear Fuel Complex
Kr-85	Krypton-85
KRL	Kahuta/Khan Research Laboratories
LEU	Low Enriched Uranium
LRF	Laser Range Finder

LWR	Light Water Reactor
MAD	Mutually Assured Destruction
MNSR	Miniature Neutron Source Reactor
MoF6	Molybdenum
MT	Metric Tonnes
NCNDT	National Centre for Non-Destructive Testing
NDC	National Development Complex
NEW	Nuclear Equipment Workshop
NLC	National Logistic Cell
NPT	Nuclear Non-Proliferation Treaty
NSG	Nuclear Suppliers Group
NTG	Nukleartechnik GmbH
NWFP	North West Frontier Province
OP	Observation Post
ORSORT	Oak Ridge School of Reactor Technology
P S T	Pakistan Standard Time
PAEC	Pakistan Atomic Energy Commission
PAF	Pakistan Air Force
PAKNUR	Pakistan Nuclear Reactor
PARR-1	Pakistan Atomic Research Reactor-1
PBC	Pakistan Broadcasting Corporation
PC-1	Planning Commission-1
PCSIR	Pakistan Council of Scientific and Industrial Research

PEL	Pakistan Electron Limited
PINSTECH	Pakistan Institute of Nuclear Science and Technology
PNE	Peaceful Nuclear Explosion
POF	Pakistan Ordnance Factory
PPP	Pakistan Peoples Party
PTBT	Partial Test Ban Treaty
PTV	Pakistan Television
Pu	Plutonium
PWI	Pakistan Welding Institute
PWR	Pressurized Water Reactor
QAU	Quaid-i-Azam University
R&D	Research and Development
RIAD	Radio Isotope and Applications Division
SCOT	Social Construction of Technology Theory
SDW	Special Development Works
SEATO	South East Asia Treaty Organization
SES	Scientific and Engineering Services
SGN	Saint Gobain Nuclear
SKD	Semi Knocked Down
SSG	Special Services Group
STP	Seamless Tube Plant
SUPARCO	Space and Upper Atmosphere and Research Commission
SWO	Special Works Organization

SWU	Separate Work Unit
TFG	Theoretical Physics Group
TROC	Tritium Removal by Organic Compounds
UC	Ultra Centrifuge
UCN	Ultra Centrifuge Netherland
UF4	Uranium Tetra-fluoride
UF6	Uranium Hexafluoride
UKAEA	United Kingdom Atomic Energy Agency
UML	Uranium Metal Laboratory
UO2	Uranium Dioxide
URENCO	Uranium Enrichment Corporation
USA	United States of America
USAID	United States Agency for International Development
VDT	Van Doorne Transmissie
VMF	Verenigde Machine-Fabrieken
ZDF	Zweites Deutsches Fernsehen

INTRODUCTION

Statement of the Problem

This study attempts to trace the evolution of Pakistan's nuclear programme from its inception to the 1998 nuclear tests. It evaluates the various phases of the country's nuclear development that were shaped by the security, politics and technology dynamics. It also attempts to explore how these factors affected the nature, scope and direction of the nuclear programme in varying degrees and at different levels of decision-making. These aspects eventually determined the ways in which competing nuclear pathways and projects were prioritized during the different periods of Pakistan's nuclear journey. Even though the country's nuclear endeavour has essentially been a technological enterprise, its direction has been directly affected by national, regional and international security and political factors in successive decades.

This introductory section, first, discusses the background and dynamics that motivated Pakistan towards the pursuit of nuclear capability, followed by the study's main hypothesis and research questions. The next section reviews in detail the literature published on the subject so far. The literature-review points to gaps and weaknesses in the existing body of knowledge on Pakistan's nuclear quest and identifies areas that need further research on the subject. How the present work adds to this research through its original contribution to the field is mentioned, including research methodology and source material. Finally, the plan of study for this research work is laid out.

Pakistan justifies its nuclear programme as a self-defence response emanating from the country's threat perception of India's conventional military superiority and nuclear threat. This security dilemma is rooted in the partition of British India in 1947, which led to the creation of Pakistan and India as independent states, followed by the 1948 Indo-Pakistan war over the disputed region of Jammu and Kashmir. In 1965, the two countries again fought a war over Kashmir. It was this war that profoundly impacted Pakistani decision-makers' political thinking and security concerns regarding India's growing nuclear capabilities. The potential nuclear threat from India was perceived by them to be an additional and more worrisome source of Pakistan's security dilemma.

While Pakistan's nascent nuclear programme was struggling to stand on its feet, the 1971 Indo-Pakistan resulted in the separation of East Pakistan. The loss of its one part had a deep and long-lasting impact on the national psyche of Pakistan. Moreover, the dismemberment of Pakistan, accompanied by the surrender of thousands of Pakistani troops at the hands of Indian forces, demonstrated two things: One was the emergence of a mortal threat to Pakistan's survival in the face of a strong and belligerent India, and the other was the failure of Pakistan's international allies, primarily its strategic Cold War partner, the United States, to come to its aid during the 1971 war.

Therefore, it was obvious that Pakistan had to have a defence capability that would enable it to develop such a deterrent that another East Pakistan-like episode would not repeat itself. Since Pakistan lacked the resources to match India in conventional military forces, the only alternative was to consider the nuclear option. Then, in May 1974, India exploded its first nuclear device close to the Pakistani border, a development that took place only three years after the loss of East Pakistan. This compelled Pakistan to embark on a crash programme to develop a nuclear deterrent of its own. From that point on, both India and Pakistan continued to develop their respective nuclear weapons programmes. While they kept their deterrents in a recessed state during the next three decades, the cycle of South Asian nuclear action-reaction culminated in the nuclear testing by India in May 1998 followed by Pakistan.

Furthermore, international, regional and domestic politics also had a profound bearing on the evolution of Pakistan's nuclear programme. The country's nuclear pursuit began in 1956 as a result of the United States' Atoms for Peace Programme that focused on the peaceful uses of atomic energy. Pakistan's participation in the US-led Cold War international security alliances like South-East Asian Treaty Organization (SEATO) and Central Treaty Organization (CENTO) had failed to secure American support during its two wars with India in 1965 and 1971. Nor was Pakistan successful in obtaining any security guarantees from the United States or the Western world in the immediate wake of India's 1974 nuclear test. In fact, in the wake of India's first nuclear test, the United

States and other Western nuclear supplier states began to unilaterally abrogate bilateral agreements for the supply of nuclear facilities to Pakistan, even under international safeguards. While India had a relatively mature nuclear programme in the 1970s and beyond, nuclear sanctions badly affected Pakistan's nascent nuclear plans. This forced the country to embark on a nuclear weapons programme on its own, and develop a nuclear fuel cycle capability indigenously—and, of course, through whatever other international sources that were available.

Apart from the international factor, domestic politics within Pakistan also played a key role in determining the way its nuclear programme evolved from the time of its inception in 1956 and in subsequent decades. Throughout this period, nuclear decision-making in Pakistan was characterised by bureaucratic tussling among the scientists, civil and military bureaucrats and politicians. Some key decision-makers within and outside the country developed different and often varying perceptions about the nature, scope and aim of the nuclear programme. While nuclear decision-making remained largely personalized throughout the four decades of the country's nuclear development, different interest groups and the so-called "lobbies" and "coalitions" emerged that determined how the nuclear programme would move forward. This, in turn, essentially determined the shape of the development of nuclear science and technology in the country.

Pakistan's actual nuclear journey, however, remains a technological endeavour. In subsequent decades, the country was able to acquire nuclear technology for peaceful and military purposes in the face of nuclear sanctions from outside and scarcity of resources at home. Thousands of scientists and engineers, working in several nuclear projects and facilities, with consistent support from successive civil-military bureaucrats and political leaders, contributed to the country's success in the nuclear domain. The overall nuclear programme—including civil, military and research reactors, nuclear fuel cycle[1] facilities, nuclear weapons design, manufacturing and testing facilities, and all other Research and Development (R&D) facilities—was developed and run by the Pakistan Atomic Energy Commission (PAEC).[2] In addition, all peaceful applications of

[1] See Annex-I
[2] See Annex-II

atomic energy, such as nuclear medicine and agriculture, were also the responsibility of PAEC. However, from 1976 onwards, one of PAEC's projects, the gas- centrifuge based uranium enrichment project, known as Project-706/DIL or Engineering/Kahuta/Khan Research Laboratories, became autonomous and was later made independent from PAEC. Thereafter, Pakistan's nuclear endeavour became a tale of fierce rivalry between two competing institutions; i.e., PAEC and Khan Research Laboratories (KRL).

Seen in this backdrop, the main hypothesis of this study is that development of Pakistan's nuclear programme was shaped by the interplay of domestic politics and bureaucratic rivalry among key decision-makers in its nuclear, civil-military and political establishments. The security threat from India, however, may also have been a major motivational factor in this regard. In addition, the consistent international pressure may have also determined the course of Pakistan's nuclear programme. However, the influence that afore-mentioned internal factors have had in determining its nature and dynamics is over-bearing—and it is also an area that existing scholarly works have failed to explore sufficiently, or even correctly. Hence, to prove the above hypothesis, the study attempts to explore and answer the following questions:

- What were the factors that determined or hindered the development of the formative phase of Pakistan's nuclear programme? Why was Pakistan not able to develop a nuclear option and what were the notable achievements during the initial decade of its nuclear journey?

- What led to the re-orientation of Pakistan's nuclear programme from a peaceful to weapons-oriented one in the immediate wake of the 1971 Indo-Pakistan war? How did this change affect the nuclear decision-making in Pakistan, both within and outside PAEC? Was this change in the nature and direction of Pakistan's nuclear programme an abrupt phenomenon or the result of concerted efforts by interest groups and individuals within and outside PAEC?

- How did Pakistan get on the path to acquire nuclear capability and master the nuclear fuel cycle after the focus of the nuclear programme had shifted from a civilian to a weapons programme in 1972? How did India's nuclear test of 1974 upset Pakistan's nuclear plans, and why did international nuclear suppliers refuse to honour agreements for the supply of nuclear fuel cycle facilities to Pakistan? How did Pakistan master the front end of the nuclear fuel cycle in the wake of India's nuclear test and international sanctions?

- How and why did Pakistan embark on developing a plutonium production and fuel reprocessing capability that comprises the back end of the nuclear fuel cycle? How was the country able to build an indigenous nuclear reactor, a reprocessing plant and associated infrastructure for nuclear self-reliance in the face of a virtual international embargo on the sale of reactor technology, even for civilian purposes and under safeguards? What was the controversy and reality surrounding the Franco-Pakistan reprocessing plant agreement, and why did France back out of the deal, in spite of it being under international safeguards? Why did the country's nuclear power programme not develop as planned by PAEC? How did Pakistan develop nuclear fuel reprocessing capability in the wake of the French cancellation of the reprocessing plant contract with it?

- Why and how did Pakistan initiate a uranium enrichment programme based on gas-centrifuge technology? What was the status of the gas-centrifuge project prior to the arrival of and the project's take-over by Dr. A. Q. Khan? How and why did he become part of Pakistan's nuclear programme, and how significant was the information gathered by him in the Netherlands for Pakistan's enrichment project? What were the circumstances leading up to his arrival in Pakistan and his appointment as head of the gas-centrifuge project? How and why was the gas-centrifuge project first made autonomous and subsequently separated from PAEC and how did it develop subsequently?

- How did Pakistan initiate, develop and establish a nuclear weapons programme? Was it essentially the result of indigenous efforts? Which organization was responsible for Pakistan's nuclear weapons design, development and testing?

Review of Literature

Given the lack of in-depth scholarly research of various aspects of Pakistan's nuclear development, this study attempts to bridge gaps in the existing literature on the subject. The study largely depends on primary sources, unlike much of the existing literature on the subject—which essentially relies on either secondary sources or on information that may require additional validation through primary sources. The study makes ample use of the hitherto unavailable new body of primary source information in the form of interviews, documents and speeches of key figures of the country's nuclear programme to explain a number of controversies and questions on the subject.

For the sake of analysis, the existing literature on Pakistan's nuclear programme can be divided into three categories. The first category includes literature that primarily identifies Pakistan's nuclear programme with A. Q. Khan. The writers in this category equate Pakistan's nuclear capability with A. Q. Khan's alleged theft of gas-centrifuge technology from the Netherlands along with nuclear proliferation activities attributed to him. Since the unearthing of the so-called A. Q. Khan proliferation network in 2004, several publications have been authored by Western scholars and journalists. These include Gordon Corera's *Shopping for Bombs,*[3] and the 2006 Dossier on the A. Q. Khan network published by the International Institute of Strategic Studies (IISS), entitled *Nuclear Black Markets: Pakistan, A. Q. Khan and the Rise of Proliferation Networks*.[4]

These were followed by *Deception: Pakistan, the United States and the Global Nuclear Weapons Conspiracy*[5] by Adrian Levy & Catherine Scott Clark, and *The Nuclear Jihadist*[6] by Douglas Frantz and Catherine Collins. All these books appear to narrowly focus on the A. Q. Khan network and largely fail to take into consideration the broader issues relating to the evolution of Pakistan's nuclear programme. It is not that

[3] Gordon Corera, *Shopping for Bombs* (London: Hurst & Company, 2006).
[4] Mark Fitzpatrick, *Nuclear Black Markets: Pakistan, A Q Khan and the Rise of Proliferation Networks* (London: International Institute of Strategic Studies, May 2007).
[5] Adrian Levy & Catherine Scott Clark, *Deception: Pakistan, the United States and the Global Nuclear Weapons Conspiracy* (New Delhi: Penguin Books, 2007).
[6] Douglas Frantz and Catherine Collins, *The Nuclear Jihadist* (New York: Hachette Book Group USA, 2007).

these publications do not provide useful information on Pakistan's nuclear programme. They certainly do, but the information included in them and the analysis offered is quite often marred by factual, historical and technical inaccuracies. Such errors not only relate to how this programme evolved over time but also about the various twists and turns that the country's nuclear policy took during the period.

The two works authored by an American journalist, William Langewiesche, namely *The Wrath of Khan*[7] and *The Atomic Bazaar: The Rise of the Nuclear Poor*[8] underscore the broader approach to, and interpretation of Pakistan's nuclear history as is generally manifested in publications on the subject by Western writers. On the technical side, Langewiesche particularly seems to have limited understanding of how a nuclear device works and what contributes to the making of such a device. Like Corera, Fitzpatrick, Levy and Clark, he is fascinated with gas-centrifuges only and seems to be unable to appreciate the challenges and significance of the mastery of the front end of the nuclear fuel cycle and production of uranium feedstock in the form of uranium hexafluoride gas (UF6) for uranium enrichment. For instance, he does make a passing reference to UF6, when he states, "Natural uranium is converted to gas and fed through a cascade of spinning centrifuges….."[9]

However, he fails to mention who produced the feedstock in Pakistan and how UF6 was produced. This is important because when discussing any uranium enrichment programme, a gas-centrifuge plant is one of its two constituent elements, the other being a plant that produces the UF6 gas feedstock. Therefore, without this gas, the centrifuges cannot enrich uranium.[10] Moreover, most academic and journalistic works published in the United States, Europe and India, as well as some in Pakistan, in the aftermath of the revelation of the proliferation network in 2004 suffer from similar flaws. These

[7] William Langewiesche, "The Wrath of Khan," *The Atlantic Monthly,* (November, 2005).
[8] William Langewiesche, *The Atomic Bazaar: The Rise of the Nuclear Poor* (New York: Farrar, Straus and Giroux, 2007).
[9] Ibid, p. 83.
[10] For details, please see Chapter Four.

publications[11] have not been able to identify or explain the significance and the role of mastering the complete nuclear fuel cycle in pursuit of nuclear capability by any country that wishes to develop an atomic bomb. Since A. Q. Khan headed the Kahuta gas-centrifuge project, such publications' primary focus has been only this project and the politics, events and successes related to it. While Pakistan's gas-centrifuge project has captured their imagination, several other equally important projects that were outside A. Q. Khan's control have been marginalized or ignored in their discussion. This has been so in spite of the fact that Pakistan has developed a broad-based and diverse nuclear programme comprising the complete nuclear fuel cycle, beginning with uranium exploration, mining and refining, production of feedstock for enrichment, nuclear fuel fabrication, nuclear reactors, plutonium production and reprocessing in addition to the design, development and testing of nuclear weapons.

Therefore, these writers designate the title of "the father of Pakistan's nuclear programme and the country's atomic bomb" to A. Q. Khan, while giving the impression that PAEC was probably a sideshow in the country's nuclear programme. In doing so, they primarily refer to sources invariably reflecting views on Pakistan's nuclear programme that perceive the programme to be revolving around only one individual. For example, just two such recent books, including *The Nuclear Jihadist,* confer the title of the father of the so-called Islamic bomb to A. Q. Khan.[12] Frantz and Collins also go on to

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[11] See, for instance, Christopher O. Clary, *The A. Q. Khan Network: Causes and Implications* (Monterey, CA: U.S. Naval Postgraduate School, December 2005); David Albright and Corey Hinderstein, *Uncovering the Nuclear Black Market: Working Toward Closing Gaps in the International Nonproliferation Regime* (Washington, DC: Institute for Science and International Security, July 2, 2004); Peter Lavoy and Feroz Hassan Khan, "Rogue or Responsible Nuclear Power? Making Sense of Pakistan's Nuclear Practices," *Strategic Insights*, Vol. 3, No. 2 (February 2004); Wilson John, "Notes from the Nuclear Underground," *The Pioneer*, June 9, 2006; Henry D. Sokolski, ed. *Pakistan's Nuclear Future: Worries Beyond War* (Carlisle, PA: Strategic Studies Institute, US Army War College, 2007); and Garima Singh, *Pakistan's Nuclear Disorder* (New Delhi: Lancer Publishers, 2008).

[12] "This book explores the rise of A. Q. Khan and his role as one of the principal architects of the second nuclear age, examining how a scientist of mediocre skills and great ambition first helped Pakistan build the bomb and then had no qualms about spreading nuclear weapons to some of the most unstable regions of the world." Frantz & Collins, op. cit., p.15.

make some claims that appear to be factually inaccurate[13] and may require further investigation, since their veracity is important for an analysis that is closer to the truth.

On another page, *The Nuclear Jihadist* appears to attribute the entire uranium enrichment route to A. Q. Khan, without clarifying the source and significance of producing the essential gaseous uranium feedstock for the gas-centrifuges. The book also does not explain what elements comprise the enriched uranium or plutonium routes to the Pakistani atomic bomb programme. In addition, the book has not identified which part of the nuclear fuel cycle was developed by KRL or PAEC and what was the status of their corresponding development during the evolution of Pakistan's nuclear programme.[14] Furthermore, the book *Deception* by Levy and Clark raises similar questions and doubts about the sources and information contained therein pertaining to the development of Pakistan's nuclear programme. The authours also rely on sources whose veracity is questionable.[15]

With the benefit of hindsight and the availability of considerable primary source material today, the above-mentioned claims appear to be inaccurate. The information used by Levy and Clark is either not corroborated by any primary source material, or is based on sources whose conclusions and information does not correspond with the facts on ground. This is so because following the 1998 nuclear tests by Pakistan, some of the key players in the country's nuclear programme have on several occasions made information public that was otherwise considered classified earlier. Contrary to what the two authours mention, the production of fluorine compounds and uranium hexafluoride gas was undertaken by PAEC and not KRL. Nor was the latter responsible for setting up

[13] Already his [Munir Khan's] reluctance to engage in the necessary lies was so strong that the control over Siddique A. Butt and his procurement ring had been transferred by Bhutto from the atomic energy agency to the military. When A. Q. Khan confronted Munir Khan about the lack of progress on the pilot plant that Bhutto had ordered started in late 1974, Munir Khan explained that the PAEC had many priorities, and uranium enrichment would wait its turn. As far as Munir Khan was concerned, it could wait forever. Ibid, p. 67; Moreover, S.A. Butt reported directly to the Chairman of PAEC and not the Pakistani military. For details, please see Chapters Four to Nine.
[14] Ibid., p. 76.
[15] Please see Levy & Clark, pp. 31, 33, 34, 41-45. In fact Mr. Bhutto placed PAEC under his control and made the Chairman of PAEC directly answerable to him in 1972. For details, please see Chapter Three

any such facility in Pakistan.[16] Therefore, these issues require more research and analysis, preferably through primary sources so as to present a relatively factual account of Pakistan's nuclear development.

The second category of authours and publications that are cited frequently as a source of information on the evolution of Pakistan's nuclear programme appear to have been outrightly supportive of A. Q. Khan and his version of events. They are also sharply critical of PAEC and its scientists, while only eulogizing A. Q. Khan. A prime example is Zahid Malik's *Dr. A. Q. Khan and the Islamic Bomb*, which is generally considered to have been the official biography of A. Q. Khan.[17] Some other publications echo similar views.[18] Nevertheless, there is literature on Pakistan's nuclear programme, which is very informative and provides insights into several important issues, personalities, institutions and events relevant to the subject. This may be classified as a third category of literature on Pakistan's nuclear programme. It includes *The Islamic Bomb,*[19] *Long Road to*

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[16] Shahid-ur-Rehman, *Long Road to Chaghi* (Islamabad: Print Wise Publications, 1999), pp. 67-74.

[17] For example, the book states at one point: "To quickly fulfill its needs of electricity and industrial progress, Pakistan must pay attention to Light Water Power Reactors. The hollow promises of producing nuclear power made by the incompetent and inefficient Chairman of the Pakistan Atomic Energy Commission over the past 19 years had been like a lemon to the nation. Apart from the turnkey project of KANUPP in 1972, not a single kilowatt-hour of nuclear energy has been added to the national grid. Billions of dollars have been wasted, literally thrown down the drain. The main reason is that the Chairman of the Pakistan Atomic Energy Commission is neither qualified nor competent to meet the national needs. He even took credit for a 27 kilowatt, zero power reactor, supplied and commissioned by the Chinese. Due to his mismanagement and inefficiency, 35 tons of heavy water leaked out from KANUPP in 1989 causing a heavy loss of at least US $ 25 million to this poor nation. In another country, Munir Ahmad Khan would have been sent to wash the floors in a factory. According to Dr. Khan, Kahuta's scientists and engineers also have the ability to make these reactors, if the Government directs them to do so. The truth is that in this matter, the PAEC has shown carelessness, lack of planning, inefficiency and lack of leadership due to which Pakistan has been left far behind in this field. We should not waste any more time now but clear the inefficient and fossilized scientists and engineers of the Pakistan Atomic Energy Commission. We must learn and benefit from the achievements of the scientists and engineers of the Kahuta plant. If Kahuta can make an impossible task possible, then it can also free the nation from load shedding. Only a few right decisions are required. It is highly advisable that the responsibility of reorganizing the Pakistan Atomic Energy Commission be given to the man (Dr. Khan) who is renowned for his patriotism, devotion, efficiency and foresight. Zahid Malik, *Dr. A. Q. Khan and the Islamic Bomb* (Islamabad: Hurmat Publications, 1992), pp. 262-263.

[18] See, for instance, Maulana Kausar Niazi, *Aur Line Kat Gaye* (Lahore: Jang Publications, 1991); F. Hassan, "An Analysis of Propaganda Against Pakistan's Nuclear Programme," *The Muslim,* (Islamabad), March 16, 1984; and R. Ali, "Laser Range Finder-The Truth," *Pakistan Observer* (Islamabad), June 24, 1989.

[19] Steve Weismann and Herbert Krosney, *The Islamic Bomb: The Nuclear Threat to Israel and the Middle East* (New York, Times Books, 1981).

Chaghi,[20] *Pakistan's Nuclear Development,*[21] and *The Genesis of South Asian Nuclear Deterrence: Pakistan's Perspective*[22] that provide a comprehensive picture on how Pakistan developed nuclear capability. In addition, several other publications[23] on Pakistan's nuclear programme are useful for research on the subject. However, some conclusions and assertions contained in the above-mentioned publications may also need further explanation, analysis and a comprehensive interpretation drawn from primary source information.

Nevertheless, currently the benefit of doing research on the evolution and development of Pakistan's nuclear programme is the availability of sufficient primary source material on the subject. This includes some de-classified intelligence documents,[24] speeches, interviews and writings of the former officials and heads of PAEC[25] and KRL[26] and other affiliated organizations in addition to other scientists and engineers involved in Pakistan's nuclear programme. Moreover, some news reports and

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[20] Shahid-ur-Rehman, *Long Road to Chaghi* (Islamabad: Print Wise Publications, 1999).

[21] Ashok Kapur, *Pakistan's Nuclear Development* (London: Croom Helm, 1987).

[22] Naeem Salik, *The Genesis of South Asian Nuclear Deterrence: Pakistan's Perspective* (Karachi: Oxford University Press, 2009).

[23] See, for example, Bhumitra Chakma, "Road to Chagai: Pakistan's Nuclear Programme, Its Sources and Motivations," *Modern Asian Studies*, Vol. 36, No. 4, October 2002; and Zalmay Khalilzad**,** "Pakistan, the Making of a Nuclear Weapon Power," *Asian Survey*, Vol.16, No.6, June 1976.

[24] While scores of such documentary evidence will be utilized and analyzed in subsequent chapters, a few of them are listed here, including Central Intelligence Agency, "Bhutto Seeks Nuclear Policy Assurances," *National Intelligence Daily*, May 24, 1974; Central Intelligence Agency, *Pakistan: A Safeguards Exemption As A Backdoor To Reprocessing*, May 20, 1983; Declassified Air-gram, US Mission, IAEA, Vienna to Department of State, Subject: Discussion with I.H. Usmani, former Chairman, Pakistan Atomic Energy Commission, June 8, 1972; and Dutch Ministry of Foreign Affairs, "Report on the Inter-ministerial Working Party Responsible for Investigating the 'Khan Affair," October, 1979.

[25] See, for instance, I. H. Qureshi, "Recollections from the Early Days of the PAEC," *The Nucleus,* Vol. 42, Nos. 1-2 (2005), pp. 7-11; I.H. Qureshi, "Development of Physical Sciences at PINSTECH," *The Nucleus,* Vol. 42, Nos. 1-2 (2005), pp. 41-47; M. Amjad Pervez, "Heavy Manufacturing Facilities of Pakistan Atomic Energy Commission," *The Nucleus*, Vol. 42**,** Nos**.** 1-2 (2005). In addition, there are a number of newspaper and academic articles and public speeches by Mr. Munir Ahmad Khan; Dr. N. M Butt (former Director-General of PINSTECH); Mr. Parvez Butt (former Chairman of PAEC); Dr. Samar Mubarakmand (former Chairman, National Engineering and Scientific Commission and former Member-Technical, PAEC; Sultan Bashiruddin Mahmood (former Director-General, Nuclear Power, PAEC). All these publications and public statements and speeches by the country's chief nuclear scientists and engineers are utilized in this study.

[26] See, for instance, Dr. G. D. Alam. Interview with Urdu Daily *Asaas-o-Lashkar*. June 12, 1998; and selected articles by Dr. A. Q. Khan, including "Bhutto, GIK and Kahuta," *The News* (Islamabad), July 29, 2009; "Capabilities and Potentials of the Kahuta Project," *The Frontier Post,* September 10, 1990; and "Pakistan's Nuclear Programme: Capabilities and Potentials of The Kahuta Project-Speech," *Pakistan Institute of National Affairs,* September 10, 1990.

analyses have appeared in journals, magazines[27] and newspapers[28] on Pakistan's nuclear programme, which are also very helpful. These sources provide useful information regarding the status of development of various nuclear projects in Pakistan, and the procurement efforts made by Pakistan during the formative years of their development. Such sources include two premier international publications, *Nuclear Fuel*[29] and *Nucleonics Week,*[30] which deal with issues related to international nuclear commerce and industry and have carried several investigative reports on Pakistan's nuclear programme during the last four decades.

Significance of Study

Pakistan's nuclear programme has been the subject of continuous debate and controversy, both within and outside Pakistan. This became more pronounced following the re-orientation of Pakistan's nuclear programme from one only focusing on peaceful uses to another geared towards building nuclear weapons weapons in 1972. In addition, with the surfacing of the so-called A. Q. Khan proliferation network, Pakistan's nuclear programme has become a favourite topic for sometimes-sensational media stories, especially in the Western media. Moreover, much of the available literature on the subject remains confined to publications that are based on either secondary or primary sources whose veracity is questionable. Consequently, the discourse on Pakistan's nuclear programme, especially with regard to its evolution on the technical side, continues to be marred by confusion and disinformation.

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[27] Mark Hibbs, "Nuclear Exports to Pakistan Reported," *Der Speigel,* February 20, 1989; and Mark Hibbs, "Nuclear Contacts with Pakistan," *Der Speigel*, February 27, 1989.

[28] R. Jeffery Smith and Thomas W. Lippman, "Pakistan Building Reactor That May Yield Large Quantities of Plutonium," *The Washington Post,* April 8, 1995.

[29] See, for instance, the two articles by Mark Hibbs, "German Firms Exported Tritium Purification Plant to Pakistan", *Nuclear Fuel,* February, 6, 1989; Mark Hibbs, "U.S. Repeatedly Warned Germany on Nuclear Exports to Pakistan," *Nuclear Fuel,* March 6, 1989.

[30] See Mark Hibbs, "Zia Orders Pakistan AEC To Design Indigenous Nuclear Reactor," *Nucleonics Week,* 13 November 1986; Mark Hibbs, "Pakistan Told The Netherlands It Had Italian Centrifuge Design," *Nucleonics Week,* September 22, 2005.

This study attempts to challenge some of the existing myths and clarify some major misperceptions about Pakistan's nuclear programme, particularly with regard to its historical evolution. Since this study relies significantly on primary source information, it may help to distinguish between the misinformed discourse and a perspective based on actual facts pertaining to the subject. Moreover, the study traces the evolution of Pakistan's nuclear programme, from its inception, through the various phases of its development spanning four decades, culminating in the nuclear tests of 1998. For this reason, it constitutes a comprehensive research work on the subject, which is largely non-existent in contemporary and past literature. The present work also presents a detailed analysis of the roles played by key decision-makers and leaders of various projects during Pakistan's nuclear history, including that of the country's political and military figures in its nuclear programme—something that is seriously lacking in the available literature.

Finally, the present work should not be misconstrued as an attempt to demolish or eulogize the role played by any important decision-maker or scientist/engineer in the country's nuclear programme or re-write Pakistan's nuclear history. It is just that the overwhelming scholarly and journalistic discourse on the subject published so far has narrowly focused on two points—first that the development of the centrifuge project in Pakistan was allegedly based on theft of centrifuge technology from the Netherlands—and second that the same technology was illegally proliferated to other countries. Therefore, the real significance of this study lies in its attempt to encompass all aspects of the country's nuclear programme, especially the largely ignored technical side, from its inception till the nuclear tests of 1998.

Research Methodology/Source Material

The study adopts a descriptive and analytical approach to understand Pakistan's nuclear programme in its security, politics and technology aspects. In doing so, it follows the historical interpretative (qualitative) method for a retrospective analysis of Pakistan's nuclear quest as a case study. The research tools used for the purpose include document analysis and elite interviewing. In order to arrive at a comprehensive understanding of the evolution of Pakistan's nuclear programme from its inception till the nuclear tests, it is imperative to carry out an in-depth study of the subject. This requires that all the important events, phases, milestones, controversies and debates vis-à-vis the development of the country's nuclear programme be discussed at length. Such an approach helps to address the weaknesses in the existing body of knowledge on the subject and also reach conclusive understandings about Pakistan's nuclear quest that are closer to the truth. Moreover, the descriptive and analytical approach helps in comprehending the various political and technical challenges faced by Pakistan during its nuclear history and how these were overcome.

Therefore, for any research effort based on the qualitative approach to be useful, it is necessary that it should draw its strength from primary sources. As stated before, such sources of information on Pakistan's nuclear programme used in this study comprise interviews, speeches and statements of some of the important scientific and political Pakistani nuclear decision-makers. In addition, de-classified official documents such as those of the Central Intelligence Agency (CIA), or such documents from private collections of some of the key players in Pakistan's nuclear programme, are utilized. Such primary source material includes private letters and correspondence of some of the key Pakistani nuclear decision-makers.

Furthermore, elite interviewing and document analysis helps in sifting through the existing literature on Pakistan's nuclear programme and categorizing information on the basis of their factual, scientific or technical accuracy. Given that Pakistan's nuclear quest has largely been a scientific and technological enterprise, an understanding of the basic technologies involved in the emergence of a nuclear Pakistan is, therefore, necessary. This makes data collection and information gathering for research on the subject more focused and valuable. In addition, the use of the above-mentioned techniques in carrying out research on Pakistan's nuclear development assists in making this study more reliable than other previous research works on the subject. This is so because much of the existing body of knowledge and literature on Pakistan's nuclear programme, barring that on the A. Q. Khan network, originated prior to or shortly after the May 1998 nuclear tests. Since then, primary sources on Pakistan's nuclear programme have become accessible like never before, making it possible to carry out more meaningful research on the subject.

It is also pertinent to mention that Pakistan's nuclear programme was developed through decades of compartmentalization within the nuclear establishment with no single individual having a complete picture of all aspects of the programme. The only exception to this was perhaps the Chairman of PAEC. Therefore this study relies on the statements, interviews, private collections and speeches made by successive Chairmen of PAEC and Project-Directors who headed various projects comprising Pakistan's nuclear programme. In addition, this study also draws on similar sources from decision-makers outside the country's nuclear establishment who were associated with the nuclear programme in one way or another. It needs to be emphasized that the prior consent of the players and decision-makers in the country's nuclear journey who have been interviewed and the repositories of other relevant primary source information used in this study, was taken during data collection for subsequent use in this study.

Lastly, the study relies on the Chicago Manual of Style, fifteenth edition, for references and citations in terms of primary sources. These citations pertain to speeches, statements, interviews and private correspondence or conversations of all individuals associated with Pakistan's nuclear decision-making. In addition other relevant published primary and secondary source material used in the study is also cited in a similar manner. It is important to mention here that while the Chicago Manual does not subscribe to the use of "op. cit" in footnotes and endnotes, this study, however, has not discarded this practice.

Plan of Study

Besides this introductory section, the study consists of nine chapters followed by a concluding part. The first chapter focuses on the theoretical framework of nuclear proliferation and the academic debate surrounding it. It sheds light on why states go nuclear. In addition, it focuses on the contemporary theoretical models and approaches that explain the proliferation of nuclear weapons in the past century along with their respective strengths and weaknesses. The second chapter deals with the formative phase of Pakistan's nuclear programme. This includes such important events as the U. S. Atoms for Peace Programme and establishment of PAEC. It also discusses the opportunities for acquiring nuclear capability that were either missed or availed during these years and how this affected the evolution of Pakistan's nuclear programme. The focus of the third chapter is on the genesis of the alliance between Munir Ahmad Khan and Zulfikar Ali Bhutto and the emergence of "bomb lobbies" within and outside PAEC.

It traces the events leading up to the Multan Conference of January 20, 1972, which marked the beginning of the nuclear weapons programme. It also explains why Mr. Munir Ahmad Khan replaced Dr. I. H. Usmani as Chairman of PAEC. Chapter Four discusses the development of the front end of the nuclear fuel cycle including the development of various fuel cycle facilities and infrastructure. This chapter analyzes Pakistan's efforts to achieve self-reliance in nuclear technology that led to the successful mastery over uranium enrichment and nuclear fuel fabrication technology for Pakistan. Chapter Five explores the development of the back end of the nuclear fuel cycle, which includes the civil and military reactor projects. It focuses on Pakistan's efforts to develop an indigenous plutonium production capability thus giving Pakistan complete mastery over the nuclear fuel cycle, and enabling Pakistan to develop the technological base for a thermonuclear capability. In addition, Pakistan's efforts to achieve self-reliance in nuclear power are also discussed.

Then, in the sixth chapter, the development of the nuclear fuel-reprocessing programme in Pakistan is discussed. Most importantly, it traces the controversy surrounding the Franco-Pakistan reprocessing contract and how Pakistan mastered reprocessing technology. Chapter Seven focuses on the genesis of the uranium enrichment programme prior to the arrival of A. Q. Khan in Pakistan. It discusses the initiatives taken and the plans conceived in launching this project and attempt to resolve some of the controversies surrounding this project. Chapter Eight traces the involvement of A. Q. Khan in Pakistan's nuclear programme, specifically the centrifuge enrichment project. It explains how and why the project was separated from PAEC and the controversies surrounding this event. In Chapter Nine, the present work focuses on the development of the nuclear weapons design, fabrication and testing programme in Pakistan. It also attempts to explain the duplication of effort in this field vis-à-vis PAEC and KRL and the events leading up to the 1998 Chaghi tests. Finally, the concluding section provides a brief overview of the main findings of the study.

CHAPTER 1

NUCLEAR PROLIFERATION THEORY AND PAKISTAN'S NUCLEAR PROGRAMME

The atomic bombing of Hiroshima and Nagasaki in August 1945 brought the Second World War to an end but ushered in the nuclear age. During the Cold War that followed, nuclear weapons helped preserve world peace for half a century through nuclear deterrence grounded in the concept of Mutually Assured Destruction (MAD). In this context, individual states' acquisition of, or abstinence from developing nuclear weapons has been the subject of extensive debate among political scientists across the globe. Moreover, in addition to "why" states acquire nuclear weapons, it is equally important to explain the proliferation process itself, i.e. "how" states acquire nuclear weapons. In this respect, an overview of the relevant theoretical debate regarding nuclear proliferation in general and with specific reference to Pakistan is essential for understanding the dynamics, processes and motivations of the country's nuclear programme.

While much of the mainstream proliferation debate focuses on why states acquire nuclear weapons or what motivates them to do so, relatively less emphasis is placed on how states actually do it—and this has equally important policy implications. The second approach of explaining the proliferation process is also useful in predicting future proliferation paths and reaching an appropriate and accurate understanding of a state's behaviour while it is undergoing nuclear proliferation. Though it is widely believed that threat perception from India was the basic motivation for Pakistan to acquire nuclear capability, how this goal was actually achieved needs to be discussed and analyzed at length.

In this context, the present chapter briefly attempts to establish linkages between some of the important theoretical approaches, paradigms, models and assumptions in explaining the proliferation process in Pakistan. These include Scott D. Sagan's

"Domestic Politics" and Graham Allison's "Bureaucratic Politics" Models and Peter Lavoy's "Nuclear Myth-Making" Model. In addition, the technological determinist and psychological approaches such as the "Social Construction of Technology" or SCOT theory are also useful in explaining Pakistan's nuclear development. Even as the relationship of these approaches with Pakistan's nuclear programme is established in greater detail in subsequent chapters, the nuclear proliferation debate in terms of the above-mentioned models, approaches and paradigms is discussed below.

1.1. Realists, Organizational Theory and Nuclear Proliferation

Since the 1950s, the nuclear proliferation debate has been dominated by the realist paradigm. This is primarily because realist theory, whether classical or neo, provides a simple, easy, and convincing justification and explanation of why states acquire nuclear weapons or other weapons of mass destruction. Therefore, the realism-dominated proliferation discourse remained prevalent during the Cold War, as it provided a persuasive explanation of the proliferation puzzle without having to deal with the domestic politics, issues, and characteristics of individual states.[1] Realism's explanations of international politics are "based on the assumption that states are unitary actors that seek to maximize their power in order to survive in a competitive international system."[2]

Kenneth Waltz is the leading proponent of the neo-realist theory for explaining the dynamics of nuclear proliferation. In his 1981 paper, *The Spread of Nuclear Weapons: More May Be Better*[3] and his 1990 article, "Nuclear Myths and Political Realities,"[4] he has employed the rational deterrence theory to understand why nuclear weapons remained restricted to a few countries. He has also discussed the impact of this slow spread on the international system. Waltz argues that once a state acquires nuclear

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[1] Tanya Ogilvie-White, "Is There a Theory of Nuclear Proliferation? An Analysis of the Contemporary Debate," *The Nonproliferation Review*, Vol. 4, No. 1 (Fall 1996), p. 44.
[2] Ibid.
[3] Kenneth N. Waltz, *The Spread of Nuclear Weapons: More May Be Better,* Adelphi Paper No. 171 (London: International Institute of Strategic Studies, 1981).
[4] Kenneth N. *Waltz*, "Nuclear Myths and Political Realities," *The American Political Science Review*, Vol. 84, No. 3 (Sep, 1990), pp. 731–745.

weapons and a second strike capability, the possibility of war between two such states is eliminated due to the prospect of mutually assured destruction.[5] Therefore, this capability becomes an incentive for states that wish to prevent war and sustain their survival.

Moreover, Waltz asserts that once such an incentive induces more states to acquire nuclear weapons capability, this process eventually will become an inevitable feature in the international system. He further argues that the more nuclear weapons spread, the better it will be for international stability as they bring about a certain element of restraint and caution among nations.[6] However, neo-realism does not provide a holistic and comprehensive understanding of the nuclear proliferation puzzle, which results in an over-simplified explanation of nuclear decision-making and behavior.[7] In addition, the rational deterrence theory based on the neo-realist paradigm is not free from problems. These weaknesses of rational deterrence theory are inherent in two basic assumptions of the classical realism[8], i.e., the state is a unitary actor and a rational actor; and it has a narrow military focus and ignores the political and economic aspects of power.

Zachary S. Davis and Richard K. Betts have also developed approaches based on the realist model, but have expanded the scope of their discussion while keeping in view the inherent problems of rational deterrence theory. For instance, Davis in "The Realist Nuclear Regime"[9] states: "Classical realism provides a complete explanation for the causes of nuclear proliferation and international responses to it, i.e. non-proliferation."[10] In this context, Davis argues that states only decide to acquire nuclear weapons when they believe that doing so will add to their national security. Similarly, when states come to believe that nuclear weapons will be a liability rather than an asset, which may threaten or weaken their national security, they tend to join the non-proliferation camp. Although this approach was helpful in explaining why nuclear proliferation did not take

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5 Ogilvie-White op cit, p.45.
6 Ibid.
7 Ibid.
8 Ibid.
9 Zachary S. Davis, "The Realist Nuclear Regime," *Security Studies,* Vol. 2, Nos. 3-4 (Spring/ Summer, 1993).
10 Ibid, p. 24.

place at a pace predicted in the 1950s and 1960s, it has not been able to explain other anomalies in the proliferation puzzle.

These include reasons why some states opted to acquire nuclear weapons in spite of the fact that doing so did not necessarily add to their security. Nor does it explain why some states abstained from joining nuclear non-proliferation efforts even when strong incentives for becoming part of such efforts existed. On the other hand, Betts argues that states seek nuclear weapons due to international anarchy, wherein a state's response to nuclear proliferation or non-proliferation is determined by its relative position in the international system. This may be so if a state feels isolated, desires prestige or is insecure due to a strong adversary or neighbouring state. These approaches, however, do not provide a holistic and comprehensive explanation of why states develop nuclear weapons, but certainly move ahead from the primarily military focus of rational deterrence theory. In doing so, Davis has also added the political and economic elements of national power into the debate.[11]

Betts, on the other hand, has indirectly attempted to acknowledge the importance of domestic politics and the peculiar internal characteristic of different states that may affect a state's choice to forego or develop nuclear weapons.[12] Nevertheless, the answers to these puzzles lie in domestic politics and organizations that determine the prospects of vertical proliferation within different states. Therefore, the realists' main focus is on the external factors and threats that motivate states to acquire nuclear weapons. Whereas neo-realist theory is essentially based on the same assumptions as those of classical realism, it has made an addition to the latter by recognizing that the structure of the international system determines global politics and events. This international system may either be unipolar, bipolar or multipolar.[13]

In his 1979 book *Theory of International Politics,*[14] Kenneth Waltz applied the neo-realist theory for the first time in order to explain the long period of peace during the

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[11] Ogilvie-White, op cit, p. 46.

[12] Richard K. Betts, "Paranoids, Pygmies, Pariahs and Non-Proliferation Revisited," *Security Studies* Vol. 2, (Spring/Summer 1993), pp. 107-109.

[13] Ogilive-White, op cit, p. 46.

[14] Kenneth N. Waltz, *Theory of International Politics* (Reading, MA: Addison Wesley, 1979).

Cold War and attributed it to the bipolar system. However, this theory was unable to determine why individual states sought to acquire nuclear weapons, because its primary emphasis and focus was on systemic rather than unit level factors and outcomes.[15] Pakistan is a case in point, which faced a conventional and nuclear military threat from India.[16] This threat perception became the primary and long-standing raison d'être for the beginning and sustainability of Pakistan's nuclear weapons programme. In this regard, a former Chairman of PAEC claimed:

> Pakistan has been compelled to retain the nuclear option as a response to a real threat from a larger neighbour, which decided to add nuclear weapons to its overwhelmingly superior conventional forces. For Pakistan's policy makers, the nuclear option is seen as a realistic deterrent against any possible threat or aggression against its security and survival.[17]

Thus the realist paradigm can be seen relevant to the understanding of the birth of the pro-bomb lobby in Pakistan during the formative years of the country's nuclear programme. This phase comprised the era of the 1960s and came to be characterized by the bureaucratic debates and turf battles among the various stakeholders in Pakistan's civil bureaucracy and its nuclear establishment. Although the relative perceptions of these decision-makers regarding the future course of Pakistan's nuclear development did not converge, India's growing nuclear capability and the 1965 Indo-Pakistan war gave rise to a security dilemma. This in turn led to the genesis of the "bomb lobby," both within and outside the country.

Pakistan's decision to shift the focus of its nuclear programme from acquiring the "nuclear option" in 1974 to a nuclear weapons capability was essentially driven by nuclear developments across the border. Various Indian public proclamations of planning to test a "Peaceful Nuclear Explosive" or PNE and eventually carrying out such a test in 1974, only a few years after the dismemberment of East Pakistan, further accentuated Pakistan's security dilemma. It also provided vindication of the positions held by those individuals in Pakistan's nuclear establishment and political leadership

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[15] Ibid, p. 40 and p. 73.
[16] Ibid, p. 45.
[17] Munir Ahmad Khan, "Why Nations Go Nuclear," *The Muslim* (Islamabad), March 13, 1993.

who had been advocating the inevitability of acquiring nuclear capability for several years. These issues are discussed in depth in Chapters Two and Three, explaining how nuclear decision-making in Pakistan was profoundly affected by nuclear and geo-strategic developments in South Asia during the 1960s and 1970s. Similarly, Pakistan's decision to test nuclear devices in May 1998 is widely seen as a response to India's nuclear tests carried out the same month, something that re-confirms the relevance of the realist theoretical framework to Pakistan's nuclear quest. The rational actor decision-making model in addition to the realist theory are useful in explaining the decision by Pakistan to carry out nuclear tests in 1998 in response to India's tests the same month. The motivations, compulsions and developments leading up to the Chaghi tests of May 1998 are discussed at length in Chapter Nine.

With regard to understanding the dynamics of Pakistan's nuclear development, the utility of the Organizational Theory is limited, which is why it is not employed in this study. It is primarily due to this theory's main focus on organizational culture and structural forces, wherein the role of individuals in nuclear decision-making is ignored. This aspect also denies the influence individuals may have had on organizational culture itself. In addition, organizational theory cannot categorize which organizations affect policy the most and why they tend to do so.[18] Therefore, as will be seen in subsequent chapters, the evolution of Pakistan's nuclear programme and its nuclear decision-making process remained highly personalized. Nor did any institutional or organizational set-up govern it as the heads of the organizations involved in the country's nuclear programme largely took decisions on their own along with the political leadership. This arrangement only changed soon after the nuclear tests of 1998.

1.2. Domestic and Bureaucratic-Politics Models and Nuclear Proliferation

Scott D. Sagan is the proponent of the organizational-process model of decision-making, in addition to the rational-actor and domestic-politics decision-making approaches. As

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[18] Ogilvie-White, op cit, p. 51.

stated in the previous section, Pakistan's nuclear decision-making process was largely delegated to the scientists/technocrats or the civil, military or political leaders holding important positions in the government. As a result, decisions pertaining to the country's nuclear programme since its inception remained largely personalized in the absence of any formal or institutional body. Hence, domestic and bureaucratic politics dominated Pakistan's nuclear decision-making process throughout the critical years of the country's nuclear quest, thus making organizational process model, for the most part, irrelevant to the understanding of the subject**.**

Another important model that explains nuclear proliferation is Scott D. Sagan's domestic-politics model. It focuses on "the domestic actors who encourage or discourage governments from pursuing the bomb."[19] This model states that even if the pursuit or acquisition of the bomb serves the national interest of a state, it may concurrently also serve the parochial or bureaucratic interests of some individual actors in that state. These individual actors can be classified into three categories[20], i.e., the nuclear energy establishments of the state and officials working in state-run nuclear facilities; important segments of the military establishment; and politicians in states where political parties or masses strongly support the acquisition of nuclear weapons. When such actors within a state are able to form strong and influential coalitions, they acquire the ability to directly or indirectly affect decision-making within a government that supports the development of a nuclear weapons programme.[21]

However, no well-developed domestic political theory of nuclear proliferation exists which is able to explain the conditions under which these coalitions come into being and produce their desired results.[22] Nonetheless, the domestic-politics model has been influenced by bureaucratic politics and "social construction of technology concerning military procurements in the United States and the Soviet Union during the Cold War."[23] In these writings, bureaucratic actors are not considered as "passive

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[19] Scott D. Sagan, "Why Do States Build Nuclear Weapons? Three Models in Search of a Bomb," *International Security,* Vol. 21, No. 3 (Winter, 1996-1997), p. 63.
[20] Ibid, pp. 63-64.
[21] Ibid, p. 64.
[22] Ibid.
[23] Ibid.

recipients of top-down political decisions." Rather they are seen as active participants in the decision-making process wherein they generate the conditions that favour spending on weapons development and acquisitions by supporting like-minded politicians. They also trigger and support extremist and alarmist perceptions of external threats and thereby succeed in lobbying for increased defence spending.[24]

On the other hand, the "bottom-up" perspective focuses on coalition building within the "scientific-military-industrial-complex" that generates demand for or advocates the development and acquisition of specific weapon systems and technologies. These scientists exist in state-run laboratories and institutions that support such new initiatives and projects simply because they are technically innovative and exciting and simultaneously ensure the continued flow of resources and prestige. Such scientists are also able to acquire the support of like-minded military professionals, politicians and government officials whose bureaucratic interests or particular areas of specialization and responsibilities lead them to support certain projects and weapon systems.[25]

Yet, the domestic-politics model also has its critics such as the Realists. They are of the view that the parochial interests and perceptions of domestic political actors within a state only have a marginal effect on decision-making related to national security issues.[26] The decision whether to build x or y number of bombs or missiles may be debated and influenced by domestic bureaucratic struggles. However, a state's decision to build nuclear weapons and missiles to counter an external threat becomes the decisive factor in national security decision-making.[27] In addition, one of the most important approaches for explaining the proliferation puzzle that employ the domestic politics model, and also explains Pakistan's nuclear development, is that of Stephen M. Meyer. In *The Dynamics of Nuclear Proliferation,*[28] Meyer argues that "nuclear weapons do not generate spontaneously from stock-piles of fissile material" and "the decision to go

[24] Ibid.
[25] Ibid.
[26] Ibid.
[27] Ibid.
[28] Stephen M. Meyer, *The Dynamics of Nuclear Proliferation* (Chicago: The University of Chicago Press, 1984).

nuclear is the crucial step in the nuclear proliferation process."[29] While he agrees that the motivations and intentions of leading up to the decision to acquire nuclear weapons need to be analyzed, but maintains that an understanding of the nuclear decision-making process is essential for solving the proliferation puzzle.[30]

He divides the nuclear decision-making process into three stages, namely:[31] an explicit government decision to develop a latent capacity; a decision to transform the latent capacity into an operational capability; and a decision to begin an operational nuclear weapons programme. Meyer has identified the stage when "a decision to transform the latent capacity into an operational capability"[32] as the "proliferation decision" and is therefore considered as the most important and critical stage towards the acquisition of nuclear weapons. Thus, the proliferation decision is reached when a state is sufficiently motivated to develop nuclear weapons at a time when a hedging or latent capability also exists. This occurs when the decision makers in the state believe that the acquisition of nuclear weapons will enable the state to achieve certain objectives in the field of defence, security, foreign policy or domestic politics.[33]

However, the time lag between the second and third stage differs from state to state, depending on certain internal or external stimuli that can accelerate or slow down the process. Moreover, a reversal from the second stage or proliferation decision to the first stage can also occur if sufficiently strong incentives exist which can occur at any point in time.[34] Meyer's three-stage "proliferation decision" process is clearly evident in the important milestones of Pakistan's nuclear journey, as discussed in Chapters Two, Three, Four and Nine respectively. These chapters analyze the various stages of the growth and development of Pakistan's nuclear programme, in terms of shifting its direction and scope from one that focuses on acquiring a nuclear option to a nuclear weapons capability. In 1972, this decision was formally taken at the Multan Conference, and India's 1974 test triggered the "proliferation decision" in Pakistan's nuclear policy

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[29] Ibid, p. 6.
[30] Ogilvie-White, op cit, p. 50.
[31] Meyer, op cit, p. 5.
[32] Ogilvie-White, op cit, p. 50.
[33] Ibid.
[34] Ibid.

when the Prime Minister tasked PAEC to begin work on the bomb. This change was also reflected in other fuel cycle projects and in the 1998 nuclear tests.

1.3. Graham Allison's Bureaucratic-Politics Model

Since Pakistan's nuclear decision-making has largely been the result of personalized as opposed to institutional or organizational decision-making, the above-mentioned model also creates one of the theoretical frameworks in the international scholarly discourse on nuclear proliferation for the present work. The Bureaucratic-Politics Model, as theorized by Allison, states that decision-making is the result of partially coordinated actions by a "unified group of leaders." But these individuals or group leaders who head various organizations are not a monolithic group of decision-makers; rather each organizational head comprising the various governmental organizations, "in his own right, is a player in a central competitive game."[35] This game is also known as politics and decision-making is the result of bargaining amongst these players who are positioned at various levels within a government, along regular or formally defined paths or circuits. Therefore, government behavior and decision-making can be understood as an outcome of the bargains among key players in important positions.[36]

Moreover, unlike the rational-actor model, the bureaucratic-politics model does not recognize any single unitary actor but several actors, who act as players. These players do not necessarily focus on any single strategic issue within a country or act according to any one or a "consistent set of objectives."[37] Rather, their actions can be understood as a diverse and pluralist conception of "national, organizational and personal goals."[38] Therefore, these players do not act according to any single rational choice but by the "pulling and hauling" which is known as politics.[39] Furthermore, each national

[35] Graham Allison, *Essence of Decision: Explaining the Cuban Missile Crisis* (Boston: Little Brown and Company, 1971), p 144.
[36] Ibid
[37] Ibid.
[38] Ibid.
[39] Ibid.

government comprises a complex stage where an intra-national game of politics is played. The central players of this stage also encompass men who head major and important organizations along with the political leaders who sit on top of a government apparatus, and they together form a "circle of central players."[40] The members of this circle have an independent standing and they may have their own peculiar understanding and perception of how to solve certain policy challenges or problems. Hence, they may differ over various approaches or produce different and conflicting recommendations for finding solutions to these problems. In addition, each individual who forms part of the circle of central players has his own distinct area of responsibility and this determines what he perceives as important. These men also share power and authority, while they differ on what decisions need to be taken, and this implies that government decisions are taken as a result of a political process.[41]

In this process, one group of individuals wins over another who is struggling for the implementation of other alternative solutions or decisions. Also, different groups that struggle amongst themselves for the ascendency of their views or decisions pull in different directions, for obtaining a favourable outcome. Even as the end result is actually a compromise or mixture of their conflicting approaches and perceptions, this pathway to a decision also results in an unequal share of power for various individuals. Invariably the desired outcome is different from what the individual or group were originally striving for. In doing so, the final outcome is not the consequence of "the reasons that support a course of action" or "the routines of organizations" that produce an alternative course of action."[42] Rather it is "the power and skill of proponents and opponents of the action in question" that produces the final outcome or decision.[43]

Thus, the bureaucratic politics model states that the decisions and actions of governments are not necessarily chosen as solutions to certain problems but are the consequence of compromise, conflict and confusion among various government officials. Each of them has their own diverse interests, perceptions and relative positions

[40] Ibid.
[41] Ibid, p. 145.
[42] Ibid.
[43] Ibid.

of influence and power in the government. The processes through which these decisions and actions emerge are known as "bargaining" among different member of the government. These games are structured by regular and formal parameters within which they are played. [44] Furthermore, governmental action as a political resultant may occur at three levels, i.e., governmental actions that are "agglomerations of relatively independent decisions and actions by individuals or groups of players"[45]; "formal" government decisions or actions that are the result of "a combination of preferences and relative influence of central players in the game"[46]; and similar decisions and actions relevant to a "subset of players in the game."[47]

In addition, the Organizing Concepts that describe the Bureaucratic Politics Model can be categorized along three lines, i.e., [48] who plays?; what determines each player's stand?; and how does the game combine players' stands, influence, and moves to yield governmental decisions and actions? The "players" refer to those individuals whose interests and actions directly affect government's actions and decisions and men holding different government jobs. These individuals also act as players in the "national security policy game" when they become attached to formalized channels associated with national security policy and decision-making and execution. When these individuals are grouped together as players, they constitute the agents for governmental actions and decisions.[49] The relative positions of these players determine how they may act and what they may or may not do. This also defines the strengths and weaknesses of a player in terms of how effectively he may be able to operate within a government in respect to his position.

Also, each players' abilities in performing various complementary and sometimes conflicting roles vis-à-vis his position is also determined by his personal abilities in addition to his position. This is primarily because the players are human beings who differ in their abilities to take decisions and carry out actions. "The hard core of the

[44] Ibid, p. 162.
[45] Ibid, p. 164.
[46] Ibid.
[47] Ibid.
[48] Ibid, pp. 164-169.
[49] Ibid, p. 164.

bureaucratic-politics mix is personality."[50] Moreover, each player's stand or position on a certain issue is determined by the following factors:

a. Parochial Priorities and Perceptions:

The understanding and interpretation of an issue under consideration is often influenced and coloured by the position from which the issue or question is being considered. In taking decisions about certain questions or issues, organizational parochialism also influences the players who are either sitting at the top of or within these organizations. Therefore, a player's position and priorities with regard to questions and issues essentially determines his behavior and preferred choice of action.[51]

b. Goals and Interests:

Goals and Interests also play a key role in determining a player's actions and the decisions taken with regard to certain questions or issues. These include interests related to national security, his or her organization, domestic and personal interests. Whereas a general consensus on some core national security interests is widely achieved, individuals and players may differ on how a certain issue may affect the national security of a state. Also, a player's own perception and stand with regard to an issue, which may reflect his own stake or interest, can also affect the outcome of his role in decision-making.[52]

c. Stakes and Stands:

The governmental decisions and actions either enhance, encourage or impede, or discourage each individual's or players' perceptions of what constitutes the national or organizational interest. It also affects the player's conception of the programmes and projects to which he is committed, the welfare of his associates

[50] Ibid, pp. 165-166.
[51] Ibid, pp. 166-167.
[52] Ibid, p. 167.

and friends along with his personal interests. These stakes, in turn, determine the respective stands or positions of the players regarding the issue. [53]

d. Deadlines on Issues:

Deadlines on issues force the busy players to take stands and arrive at decisions. Deadlines also influence the face or perception of a particular issue, which may undergo a change in the eyes of the decision maker. [54]

Therefore, the single most important factor in determining each player's influence and impact on outcomes and results is "Power" which may be defined as: "The effective influence on government decisions and actions." [55] It consists of at least three elements, i.e.,[56] bargaining advantages; skill and will in employing those bargaining advantages; and other players's perceptions of the above-mentioned two elements. Bargaining advantages essentially depend upon the authority and responsibility a player derives from the position he holds. The skill and will in employing those bargaining advantages includes a player's ability to influence the objectives, motives and goals of other players in other games, including games played in the domestic political arena.[57] In addition, personal charisma, inter-personal skills, personal relationships, associations and friendships, along with access to and influence on other important players in the game is also necessary to sustain and nurture power. The effectiveness of the strategy employed by a player in the overall game of relative power and influence basically determines his reputation vis-à-vis other players in the power game.[58] Moreover, "each player pulls and hauls with the power at his discretion for outcomes that will advance his conception of national, organizational, group, and personal interests.[59]

This study employs the domestic and bureaucratic-politics models in understanding and analyzing the factors that inhibited the development of a "nuclear

[53] Ibid, pp. 167-168.
[54] Ibid, p. 168.
[55] Ibid.
[56] Ibid, pp. 168-169.
[57] Ibid, p.169.
[58] Ibid.
[59] Ibid, p.171.

option" during the formative years of Pakistan's nuclear development. It explores various aspects of the country's nuclear quest in the context of the above-mentioned models in Chapters Two and Three, respectively. These models help in understanding the formation of bomb lobbies/alliances and coalitions, which led to the transformation of Pakistan's nuclear programme from a peaceful to a military-oriented one in 1972. The assumptions of these models are also validated when one looks at the change of guard at PAEC at the Multan Conference in 1972 that led to the replacement of Dr. I. H. Usmani as Chairman of PAEC.

Moreover, the attributes of the domestic and bureaucratic-politics models are clearly exemplified in the rivalry between two technocrats, i.e., Munir Ahmad Khan and Dr. A. Q. Khan from 1976 onwards. This is vividly manifested in Chapter Eight, which discusses the arrival of A. Q. Khan, the status of the uranium enrichment project and the genesis of rivalry between the two heads of PAEC and KRL. Thus, the struggle for relative ascendency for power, prestige and resources between the PAEC and KRL not only affected nuclear decision-making in Pakistan, but also public perceptions and polices regarding the country's nuclear programme in subsequent decades. During the 1970s, Pakistan's plutonium programme also suffered as a result of bureaucratic tussling amongst different stakeholders in the country's nuclear establishment. This happened as a coalition of stakeholders successfully held back the activation of the plutonium route even though the capability existed.

Chapter Six of the present study demonstrates this aspect of the country's nuclear development, which pertains nuclear fuel reprocessing and plutonium production. Nevertheless, other fuel cycle projects in Pakistan's nuclear programme were also blemished by controversies, especially the uranium enrichment project, which is discussed in detail in Chapters Seven and Eight respectively. In addition, the assumptions of the bureaucratic-politics model are also visible in the "uranium gas" controversy, which is discussed in detail in Chapter Four, within the larger framework of the development of the nuclear fuel cycle. Also, the history of the inception and formative years of the uranium enrichment project seem to be replete with most of the above-mentioned attributes of both the domestic and bureaucratic-politics models.

Chapter Nine of this work pertaining to nuclear weapons design, development and testing also shows how these models are validated and manifested with the establishment of two competing projects in PAEC and KRL. The result has been a spate of controversies and distorted and confused public perceptions on the issue that persist to this day. As PAEC and KRL were two separate strategic organizations, their leaders also had different perceptions about the concept and nature of Pakistan's national security interests and nuclear policy.

1.4. Nuclear Mythology, Psychological Approaches, and Nuclear Proliferation

The above-mentioned theoretical models and approaches have not been able to explain all the pieces of the proliferation puzzle in their entirety, especially with regard to Pakistan's nuclear development. This leaves room for more explanatory approaches and models that can help bridge the gap left by the other approaches. Allison's bureaucratic-politics model, for instance, is unable to explain the decisions taken by certain individuals who hold top governmental positions or national elites, and who appear to be irrational. This can be explained by applying the concept of "belief systems" which states that the beliefs and actions of individuals are interdependent and actions are based on beliefs.[60] Thus, decision-making in the nuclear and foreign policy arena cannot be explained unless the beliefs of the decision-making individuals are not taken into account and understood. It may happen that such individuals take seemingly irrational decisions, especially in crisis situations. This can occur because their own comprehension of others' actions and behaviour is based on their beliefs and interpretations, which may or may not correspond to reality. As a result, they tend to make inaccurate assumptions about the actions and behaviour of other decision-makers and states.[61]

However, the belief systems approach is unable to explain why certain groups of individuals share common beliefs and adopt identical behaviours even when they lack objective or accurate information about a certain issue or problem. To further understand

[60] Ogilvie-White, op cit, p. 52.
[61] Ibid.

this, Peter Lavoy has developed the "nuclear myth-maker" model that attempts to explain the causes of nuclear proliferation. He states:

> A state is likely to go nuclear when national elites, who want the state to develop nuclear weapons, emphasize the strategic beliefs and political behavior of nuclear mythmakers. A state is likely to go nuclear when national elites, who want the state to develop nuclear weapons, emphasize the country's insecurity or its poor international standing to popularize the myth that nuclear weapons provide military security and political power.[62]

Similarly, this model also provides an insight into the dynamics of nuclear non-proliferation. In this regard, Lavoy states: "When enterprising and well-connected individuals succeed in cultivating national consensus on the myth of insecurity through nuclear weapons, their government is less likely to initiate or continue efforts to obtain military nuclear capabilities."[63] Therefore, nuclear myth making as a source of nuclear proliferation or non-proliferation is based on three assumptions, i.e.,[64] the beliefs of individuals matter for foreign policy making; policymakers' beliefs about nuclear weapons are particularly important; and talented and well-placed experts can help create, diffuse, and perpetuate nuclear myths. He also emphasizes the significance of the above-mentioned variables in decision making about nuclear proliferation.[65]

Lavoy takes the argument further, arguing: "the nuclear myths of a state's political and military leaders determine whether that state will launch a nuclear weapons programme."[66] Any change in these myths is therefore likely to bring about a change in the thinking and behaviour about nuclear weapons. This process of nuclear myth making occurs when policy and decision-makers realize their limitations in understanding of and

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[62] Peter R. Lavoy, "Nuclear Myths and the Causes of Nuclear Proliferation," *Security Studies,* Vol. 2, No. 3-4 (Spring/Summer, 1993), p. 199.

[63] Ibid, p. 199.

[64] Ibid.

[65] "The observation about decision-making is well-known, i.e. strategic policies and choices are mediated by the policymaker's goals, judgments, and perceptions. Analysis of decision-making is useful to show why people in similar situations behave differently and why people react similarly to different circumstances. Analysis of decision-making is not necessary for all problems of security studies, but it is impossible to explain important nuclear weapons decisions and strategies without reference to decision makers' beliefs about the political and military characteristics of these weapons. This is so because of the multiple and only partially predictable consequences of developing, deploying, and using nuclear arms." Ibid, p. 200.

[66] Ibid.

dealing with complex policy-making decisions and problems. This in turn propels them to turn to specialists to find solutions to such problems.[67] On the other hand, if national leaders are confident about their strategic beliefs and perceptions of national security or other national issues, experts and specialist advisors can influence the policy and decision-making processes. This is particularly true with regard to nuclear decision-making in India following China's nuclear test of 1964, which took place only two years after India's defeat at the hands of the Chinese in the Sino-Indian war of 1962.[68] In addition, Lavoy, while quoting Synder's *Myths of Empire,* says that strategic myth making is a manipulative activity. He goes on to elaborate thus:

> Groups with clear-cut interests, monopolies of information, and other propaganda advantages concoct false arguments to mislead others about their interests and about the costs and benefits of competing policies. Strategic myths that arise from domestic politics can then take a life of their own. Mythmakers can become entrapped in their own rhetoric, in the political arrangements of the myths created, and in the internationalization of myths by second-generation elites.[69]

However, psychological approaches that attempt to explain the nuclear proliferation puzzle also suffer from drawbacks. These flaws demonstrate that such models can only offer a limited understanding of the proliferation puzzle since psychological factors are difficult to quantify.[70] While these approaches are useful in understating belief systems and their impact on nuclear decision-making, yet they are limited in their scope in terms of explaining the relationship of other factors with belief systems with regard to the proliferation puzzle.[71] Another useful approach towards explaining the proliferation dynamics is one that explains that nuclear technology is the outcome and part of the "mundane social processes" of the ordinary world. Donald

[67] Ibid.
[68] Ibid.
[69] Ibid, p. 202.
[70] Ogilvie-White, op cit, p. 53.
[71] Ibid.

McKenzie has used this approach to explain the development of Intercontinental Ballistic Missiles (ICBM) in the United States and Soviet Union.[72]

In his 1993 article, entitled: "Exploding the Black Box: The Historical Sociology of Nuclear Proliferation,"[73] Steven Flank has used the "Social Construction of Technology" or SCOT theory to explain the dynamics of nuclear proliferation. This theory attempts to provide a "historical sociology of nuclear proliferation" and shows that an analysis of technology and its development can help explain the development of nuclear programmes in India and South Africa.[74] For instance, in India, the development of the nuclear programme was essentially driven by alliances forged between various individuals and organizations. Likewise, Pakistan's nuclear development has been directly affected by the growth and relative ascendancy of alliances among like-mined scientists, politicians and bureaucrats, which is reflected in all subsequent chapters of this study. These alliances in turn directly affected the nature and direction of the nuclear programmes in India and Pakistan.

Hence, they can help in understanding and explaining the nature and shape of the nuclear programmes of both countries.[75] SCOT theory focuses on more variables and factors in explaining the proliferation dynamics than most other traditional approaches.[76] This gives it an advantage over the others. In this regard Flank argues that nuclear weapons are the product of society and the process of proliferation is closely linked to wider political and international issues.[77] However, social approaches have their demerits as well. One is that these take into account several dependent variables, which limit their

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[72] In his 1990 book, Donald Mackenzie argues that the emergence of ICBM forces that can strike targets with great precision was achieved thus: "It was not the inevitable consequence of technological change or the desires of political leaders but instead the product of a complex process of conflict and cooperation between a range of social actors including ambitious, energetic technologists, laboratories and corporations and political and military leaders and the organizations they head." Donald Mackenzie, *Inventory Accuracy: A Historical Sociology of Nuclear Missile Guidance* (Cambridge: MIT Press, Massachusetts, 1990), p. 3.

[73] Steven Flank**,** "Exploding the Black Box: The Historical Sociology of Nuclear Proliferation," *Security Studies*, Vol. 3, No. 2 (Winter 1993-94).

[74] Ogilvie-White, op cit, p. 54.

[75] Ibid.

[76] Ibid.

[77] Steven Flank, "Nonproliferation Policy: A Quintet for Two Violas?" *The Non-Proliferation Review* (Spring/ Summer 1994), p 71.

predictive ability with regard to future proliferation. Secondly, these approaches, especially, the SCOT theory, make an analysis of the proliferation puzzle very descriptive as it takes numerous variables into account. [78]

1.5. Technological and Prestige Determinism and Nuclear Proliferation

One of the main hypotheses dominating the debate on the causes of nuclear proliferation is known as "technological determinists." This approach argues that once a country acquires the a level of nuclear technology which makes nuclear weapons development feasible, then such a state is tempted to build the bomb. Therefore, the presence of nuclear technology itself becomes the propelling force behind the development of nuclear weapons.[79] Such countries are also known as "threshold states" that have the capability of the "nuclear option" and the necessary know-how, resources and infrastructure to build the bomb. Whereas some of them may go ahead with developing a weapons capability, others may restrain themselves and not go for the bomb.

Robert J. Oppenheimer voiced similar thoughts about the "technological pull" dynamic of nuclear proliferation. During hearings of the Personnel Security Review Board in 1954, he denied that concerns about the development of the hydrogen bomb had increased, as the project seemed more technically feasible.[80] In addition, individuals and organizations essentially determine the technological momentum or freeze of any nuclear programme in a state, as argued by Peter Lavoy.[81] Therefore, the "technology

[78] Ibid, pp-54-55.
[79] Ibid, p. 44.
[80] "I think it is the opposite of true. Let us not say about use. But my feeling about development became quite different when the practicabilities became clear. When I saw how to do it, it was clear to me that one had to at least make the thing. Then the only problem was what one would do about them when one had them. The programme in 1949 was a tortured thing that you would well argue did not make a great deal of technical sense. It was therefore possible to argue that you did not want it even if you could have it. The programme in 1951 was technically so sweet that you could not argue about that." Ibid, p. 195.
[81] "Uranium enrichment plants, intermediate-range ballistic missiles, and atom bombs do not build themselves. The production of any large, military, technological system involves a long series of heated debates and difficult decisions about technical, economic, military, political, and moral issues. Of course, proponents of the technological imperative acknowledge that humans choose to invest, engineer and manufacture nuclear weapons; their claim is that technological momentum is so strong and the desire for

imperative" provides a useful explanation regarding the dynamics of nuclear proliferation and this study utilizes some of the above-mentioned assumptions. However, this approach also falls short of meeting empirical testimony and provides a limited interpretation of why states choose to acquire nuclear weapons and arsenals. It ignores the roles played by individuals and organizations that shape the perceptions that make technology appealing enough to decision-makers to initiate and sustain nuclear weapons programmes. Furthermore, the assumptions of Lavoy's nuclear myth-making, the various psychological approaches and the technological determinist approaches are validated through the understanding of the creation of a bomb lobby in Pakistan in the shape of Zulfikar Ali Bhutto, Munir Ahmad Khan and A. Q. Khan. Their assumptions also help in understanding the dynamics that led to a radical change in the nature and scope of Pakistan's nuclear programme, especially in the context of the Multan Conference of 1972.

In addition, the dynamics behind the arrival and take-over of the uranium enrichment project by A. Q. Khan that led to the project's separation from PAEC soon thereafter can also be understood through the nuclear myth-making model and the above-mentioned psychological approaches in addition to the technological determinist approach. Throughout the critical years of Pakistan's nuclear development, the heads of both PAEC and KRL continued to generate, sustain and accentuate myths regarding the growth and relative ascendency of the plutonium route and the centrifuge project respectively. This was done for a variety of technical, personal and political reasons, as will be seen in subsequent chapters.

Moreover, PAEC's pursuit of reprocessing and plutonium technology in spite of opposition at home and sanctions from abroad can also be explained in the context of these models and approaches. This was so because Munir Ahmad Khan and the PAEC remained an ardent advocate of the plutonium option since the 1960s, which is why it was consistently perceived and advocated as a strategic necessity for Pakistan.

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nuclear arms so pervasive that decision-makers are pulled along." He adds: "Technological artifacts are invented and innovated by individuals. Similarly, a technological system "grows" and "drifts" when scientists, bureaucrats, and politicians have vested interests in the growth and durability of the system. Technological change cannot be well understood by assuming the submission of individuals and the insignificance of their political interests." Ibid.

Therefore, this study employs the above-mentioned models and approaches in understanding the factors affecting Pakistan's nuclear development in Chapters Three, Five, Six, and Eight, respectively.

The various theories, models and approaches discussed above attempt to provide a unique explanation of the dynamics of nuclear proliferation and also help in the analysis of the proliferation process. However, each one of these approaches has its own strengths and weaknesses and no single theory, model or approach is holistic or comprehensive enough to fully explain why states acquire nuclear weapons and how this process actually occurs. Nonetheless, they can be applied selectively, where appropriate and relevant, depending on the particular case study in question. As mentioned in the introductory section, while much of the mainstream proliferation debate focuses on why states acquire nuclear weapons or what motivates them to do so, less emphasis is placed on how states actually do it, which has equally important policy implications. The second approach is also useful in predicting future proliferation paths and reaching an appropriate and accurate understanding of a state's behaviour while it is undergoing the process of nuclear proliferation, such as Iran and North Korea.

In retrospect, the chapters that follow will discuss the entire spectrum of Pakistan's nuclear development, especially from the perspective of the leading personalities and the organizations that were part of the proliferation process. The discussion will be based on some of the important theoretical approaches, paradigms, models and assumptions in explaining the proliferation process in Pakistan, especially Sagan's Domestic-Politics and Allison's Bureaucratic-Politics Models in addition to Lavoy's Nuclear Myth-Making Model. Pakistan's nuclear development has been directly affected by the interplay of several of the above-mentioned theoretical approaches and paradigms. These primarily include domestic and bureaucratic politics, technological determinants, and nuclear myth making and psychological approaches like SCOT theory. In the following chapters, the utility and validity of these approaches in explaining and analyzing the various dynamics of the evolution of Pakistan's nuclear programme shall be tested against empirical evidence. Hence, following this theoretical section, this study will analyze how and why Pakistan joined the nuclear age that would eventually lead it to the path of becoming a nuclear power, which is the theme of the next chapter.

CHAPTER 2

PAKISTAN'S NUCLEAR PROGRAMME: THE FORMATIVE PHASE

Pakistan became an overt nuclear power in 1998 when it carried out six nuclear tests at Chaghi and Kharan. But the journey towards this goal began with the establishment of the Pakistan Atomic Energy Commission (PAEC) in 1956, which marks the beginning of its nuclear quest. The initial focus of the nascent nuclear programme was geared towards the establishment of a small, but vibrant civilian nuclear infrastructure. The initiatives taken, the plans conceived, and the choices and opportunities availed and missed during these formative years, would eventually decide the nature and scope of Pakistan's nuclear programme. In later years, this phase also proved to be fundamental for acquiring the basic nuclear knowledge and setting up linkages with various Western nuclear establishments and facilities. Under the auspices of the United States led "Atoms for Peace" Programme, North American and European nuclear facilities also offered openings for training Pakistani scientists and engineers in the peaceful uses of atomic energy. These opportunities enabled the development of the technical base, which made it possible to re-orient the civilian programme in 1972 for making nuclear weapons. However, this phase came to be symbolized by reluctant decision-making, bureaucratic struggles among different institutions and individuals, both within the PAEC, and between the PAEC and the civil bureaucracy. These turf battles directly affected the evolution of Pakistan's nuclear programme during these formative years.

Therefore, this chapter explores the various achievements and failures, which Pakistan experienced during the first fifteen years of its nuclear programme. It also analyzes the role played by PAEC in establishing the civilian nuclear infrastructure during this period in-spite of the bureaucratic odds. The chapter is divided into three main sections, namely: Government College, Lahore: Nucleus of Nuclear Pakistan;

Creation of PAEC; the Usmani Era and the Nuclear Option, Fuel Cycle Debates and Bureaucratic Apathy, followed by a conclusion. Thus, the following pages explore these three periods, which constitute the formative phase of Pakistan's nuclear programme. The concluding paragraphs discuss the relevant theoretical approaches, paradigms and models in the light of the empirical evidence presented in the chapter.

2.1. Government College, Lahore: Nucleus of Nuclear Pakistan

Nuclear Pakistan found its roots in the Physics Department of Government College, Lahore, when Dr. Rafi Muhammad Chaudhri migrated to Pakistan from India in 1948. He was a Professor of Physics at the Muslim University of Aligarh (former British India), now in India, who taught at Aligarh University from 1923 to 1929 and proceeded to Cambridge in 1929 on a scholarship for his Ph.D. He worked under Professor Ernest Rutherford, a Nobel Laureate who had discovered the atomic nucleus.[1]

Subsequently, Dr. Chaudhri returned from Cambridge in 1933 and joined the Aligarh University in 1938 where he worked until 1948 when the Government of Pakistan invited him to join the Government College, Lahore. He was subsequently appointed as a Professor and head of the Department of Physics at Government College, following his migration to Pakistan. Dr. Chaudhri's arrival in Lahore was made possible when Sir Mark Oliphant wrote to the founder of Pakistan and the first Governor-General, Quaid-i-Azam, Muhammad Ali Jinnah, who recommended him to join Government College. In 1952, Dr. Chaudhri is believed to have single-handedly planned and installed a 1.2 million volt high-tension generator at the College. The machine was set up in the High Tension and Nuclear Research Laboratory (HTL) for atomic research in the College and was the first one of its kind in South Asia.[2]

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[1] "Nucleus of a Nuclear Power," *Daily Times* (Lahore), January 12, 2004. http://www.dailytimes.com.pk/default.asp?page=story_12-1-2004_pg7_27 (accessed December 15, 2008).

[2] Ibid; In his regard, Dr. N.M. Butt, a former Director-General of the Pakistan Institute of Nuclear Science and Technology (PINSTECH) and one of Dr. Chaudhri's students stated "Mr. Jinnah arranged the service of Prof. Chaudhri at the Pakistan's best educational institution, the Government College, Lahore offering him the best academic job in physics and at the salary of the maximum of the prevailing government pay-scales, a due honour paid to an educationist. Prof. Chaudhri with his dedication, devotion and hard work

Dr. R. M. Chaudhri remained Director of the High Tension and Nuclear Research Laboratory at Government College, Lahore, from 1948-1965.[3] Throughout the 1950s and 1960s, a large number of students were trained in nuclear science and technology under his supervision. They conducted several experiments and got first-hand experience of essential nuclear techniques of radiation detection and also fabricating nuclear equipment. This equipment included nuclear radiation detectors, and students conducted research on the latest and current nuclear topics of the time.[4] In addition, Dr. Chaudhri's students were given practical training in vacuum technology, glass blowing and in the mechanical and electronic workshops. Following the completion of advanced nuclear studies abroad, mostly Ph.Ds and working for some years at home, Dr. Chaudhri's students "played a leading role in making Pakistan a nuclear country." [5]

They included Mr. Munir Ahmad Khan,[6] Dr. Ishfaq Ahmad, Dr. Samar Mubarakmand, Dr. G. D. Alam, Dr. Javed Arshad Mirza, Mr. Parvez Butt, Chaudhry Abdul Majid, and Dr. Muhammad Yunus, among others.[7] In this regard, Dr. Samar Mubarakmand would recall Dr. Chaudhri as the true father of Pakistan's nuclear programme.[8]

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started establishing the nuclear laboratories at this institution in Lahore and soon, within the next few years was able to get a nuclear accelerator, the 1.2 MeV Cockcroft Walton-Accelerator, a modern nuclear accelerator of the time and probably the best in Asia." N.M. Butt, "Nuclear Radiation Education and Nuclear Science and Technology in Pakistan," Paper presented at the 2nd International Congress on Radiation Education, Debrecen, Hungary, August 20-25, 2002.

[3] "Nucleus of a Nuclear Power," op cit.

[4] N.M. Butt, op cit.

[5] Ibid.

[6] "Nucleus of a Nuclear Power," op cit.

[7] N.M.Butt, op cit, and Ibid.

[8] "One of the pioneers of science, physics and I would say the true father of the Pakistani nuclear programme was Dr. Rafi Muhammad Chaudhri. He migrated to Pakistan from Aligarh University and established the Physics Department at the Government College Lahore and was also the pioneer setting up the High Tension laboratories. There an atomic accelerator was set up and real high-level research was made possible. One of his early students was Dr. Tahir Hussain who was my teacher and of course, the present Chairman of PAEC was one of his early students. Similarly the tradition of physics was set up in the Physics Department of the Punjab University. The two departments in the Government College and the Punjab University had a very healthy competition. This produced a team of physicists that is now leading Pakistan's nuclear programme." Dr. Samar Mubarakmand, "A Science Odyssey: Pakistan's Nuclear

Therefore, the establishment of a Physics Department in Government College, Lahore, provided the intellectual and academic foundations for producing the first generation of nuclear scientists and engineers in Pakistan. It also became the focal point of research and education in physics and related disciplines that ultimately introduced the age of atomic energy in Pakistan. Thus, it proved to be the breeding ground of a core group of young Pakistanis who would later be trained abroad and would return to Pakistan to launch and develop a nuclear programme.

2.2. Creation of PAEC

The formation of an Atomic Energy Research Organization was announced on October 19, 1954, by the then Minister of Industries, Khan Abdul Qayyum Khan.[9] He disclosed this during his Presidential address to the Pakistan Council of Scientific and Industrial Research (PCSIR), which coincided with a meeting between the then Prime Minister of Pakistan and President Eisenhower of the United States.[10] However, this announcement had its background in the establishment of a Directorate of Scientific and Industrial Research, soon after independence in 1947. This organization, in turn, led to the formation of a Pakistan Council of Scientific and Industrial Research or PCSIR, in 1953, headed by Dr. Salimuzzaman Siddiqui. Subsequently, a Planning Committee was set up under the aegis of PCSIR, headed by a physicist, Dr. Nazir Ahmad, to carry out feasibility for the establishment of needed laboratories.

In the meantime, President Eisenhower had made his famous "Atoms for Peace" speech. He declared: "The United States knows that peaceful power from atomic energy is no dream of the future. That capability, already proved, is here, now, today."[11] Pakistani scientists, however, were quick to capitalize on this speech. In January 1954,

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Emergence," Speech delivered at the Khwarzimic Science Society, Centre of Excellence in Solid State Physics, Punjab University, Lahore, November 30, 1998.

[9] Zia Mian, *Nuclear Passions and Interests: The Founding of Atomic Pakistan* (Washington D.C. and Amsterdam: Social Science Research Council and International Institute of Social History, 2005). p,1. Available at: http://programme s.ssrc.org/gsc/publications/gsc_activities/SA_Nuclear_Project/culture.papers/MianPaper.doc (accessed on March 23, 2009).

[10] Ibid.

[11] Dwight Eisenhower, "Atoms for Peace Speech," United Nations General Assembly, New York, December 8, 1953.

Dr. Raziuddin Siddiqui, the then Vice Chancellor of Peshawar University, addressed the 6th Pakistan Science Conference in Karachi. In his speech, he remarked that while "science and education were a defence against ignorance and consequent poverty and disease,"[12] they offered the promise of modern defence for a country like Pakistan.[13] Moreover, Pakistan had also started taking serious interest in the "Atoms for Peace" plan. The first sign of this came in September 1954, when the U.S. National Planning Association (NPA) announced that it was to carry out a series of studies on various economic and policy related issues emerging from atomic energy in developing countries. The list also included Pakistan.[14] A few weeks later, the then Minister for Industries of Pakistan, Khan Abdul Qayyum Khan formally expressed its interest for harnessing atomic energy at the second meeting of the PCSIR, which was held on October 14, 1954.[15]

Furthermore, Dr. Salimuzzaman Siddiqui, the head of PCSIR, explained that a committee was being set up to prepare a "detailed, phased Atomic Energy Programme." He elaborated that the first task in this direction "was to survey and assess the country's resources in radioactive minerals."[16] However, he emphasized that the success of any such plan depended on "a large nuclear science community," which would require sending young scientists and engineers abroad for specialized training. When the Raw Materials Sub-Committee of the U.S. Congress Joint Committee on Atomic Energy visited Pakistan in the fall of 1954, it noted that Pakistanis were enthusiastically looking forward to assistance in the field of atomic energy.[17]

A U. S. Atoms for Peace exhibition was held in Bahawalpur in January 1955, where the Pakistani public got its first exposure to the world of atomic energy. This "traveling exhibition" was organized by the United States Information Agency and

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[12] Mian, op. cit, p.12.
[13] Ibid, pp. 14-15.
[14] Ibid, p.15.
[15] Ibid.
[16] Ibid, p.16.
[17] Ibid, pp. 16-17.

spanned an area of 3000 square feet.[18] Pictures, films and models were used to show the evolution and potential of nuclear energy to the Pakistani people visiting the exhibition. It was reported to be a "smash hit" as more than 2500 people visited it during the first two hours of its opening and another 6000 visiting it the next two days.[19] When the exhibition ended, an estimated 50,000 people had visited it. The exhibition then came to be jointly organized by the Pakistan Atomic Energy Committee and the U. S. Embassy and moved to Karachi, Lahore and Peshawar. It was viewed by as many as 300,000 people in Karachi alone.[20] Therefore, in order to capitalize on the potential benefits of the Atoms for Peace Programme, the Government of Pakistan in January 1955 decided to establish an Institute of Atomic Energy. It was aimed at harnessing atomic energy for various applications and led to the formation of a committee of twelve scientists, in the Ministry of Industries, headed by Dr. Nazir Ahmad who was heading the Tariff Commission at the time. [21] The committee itself was established on January 6, 1955, through the Ministry's Resolution No. 20 (19) S&D-11/54.[22] It was mandated to prepare a Research and Development or R&D programme for an Institute of Atomic Energy, in addition to begin recruitment and training of manpower in various fields of nuclear science and technology.[23] It was further assigned the following tasks:

(1) To regulate the procurement, supply, manufacture and disposal of radioactive substances and carry out survey for radioactive materials.

(2) To assess the country's requirements in respect of the uses and applications of atomic energy and to take all necessary steps for their fulfillment.

(3) To plan and establish Atomic Energy and Nuclear Research Institutes at suitable places.

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[18] Ibid, p.7.
[19] Ibid, pp. 16-17.
[20] Ibid.
[21] I.H Qureshi, "Recollections from the Early Days of the PAEC," *The Nucleus,* Vol. 42, Nos. 1-2 (2005), p.7.
[22] Ibid.
[23] Ibid.

(4) To prepare estimates of receipts and expenditure for approval of the Government and incur expenditure on any item within the approved budget.

(5) To create posts and make appointments of all technical and non-technical staff.

(6) To carry out negotiations with Atomic Energy Bodies of other countries on all matters relating to atomic energy.

(7) To perform such other functions in connection with atomic energy development in Pakistan as may be desired by the Government.

The Committee comprised the following members:[24]

1	Dr. Nazir Ahmad	Chairman, Tariff Commission
2	Dr. Saleem-uz-Zaman Siddiqui	Director, Scientific & Industrial Research, Government of Pakistan, Karachi
3	Dr. Raziuddin Siddiqui	Vice Chancellor, University of Peshawar
4	Dr. Bashir Ahmad	Director, PCSIR Regional Laboratories, Lahore
5	Dr. M.Q.Khuda	Director, Scientific and Industrial Research Laboratories, Dacca
6	Lt. Col. M. Jafar	Director General of Health Services, Government of Pakistan, Karachi
7	Dr. Mujtaba Karim	Head, Department of Physics, University of Karachi
8	Dr. S. Chaudhri	Ministry of Agriculture, Government of East Pakistan, Dacca
9	Dr. Rafi Muhammad Chaudhri	Professor of Physics, Government College, Lahore
10	Dr. M. Hafeez Tusi	Nishter Medical College, Multan
11	Mr. Zafar Alam	Principal, Agriculture College, Lyallpur (Faisalabad)
12	Dr. Maqsood Butt	Assistant Professor of Physiology, Veterinary College, Lahore

[24] Ibid, p.8.

Therefore, on October 31, 1955, this committee recommended to the Government of Pakistan to establish an autonomous Atomic Energy Commission.[25] As a result of this recommendation, on February 29, 1956, the Government of Pakistan, vide Resolution No. P.22 (44) AE/55, established a Council of Atomic Energy. This Council comprised a Governing Body and the Atomic Energy Commission.[26] The Governing Body in turn comprised the Ministers of Industries and Foreign Affairs, Secretaries of Ministry of Industries and Finance, and the Chairman of PAEC.[27] The PAEC itself comprised four full-time members, each for research, power, finance and administration, and three part-time members who were headed by the Chairman. In addition there were two scientists, one each from East and West Pakistan, to be appointed by the Government, as part-time Members.[28] The Advisory Committee headed by the Minister for Industries and thirty members was also constituted to advise the Atomic Energy Council on various matters.

Moreover, the Atomic Energy Council was registered under the Societies Act XXI of 1860 and this became a semi-government department with effect from September 13, 1958.[29] The Pakistan Atomic Energy Council, its Governing Body and the Atomic Energy Commission were reconstituted, i.e., it consisted of Atomic Energy Council, a Governing Body and the Atomic Energy Commission.[30] In 1965 the PAEC acquired the status of a statutory body through an Act of legislature and attained some measure of autonomy to fulfill its statutory obligations in respect of internal administration and international cooperation.[31] The objectives and functions as stated under the 1965 Ordinance were as under:[32]

(1) The function of the Pakistan Atomic Energy Commission shall be to do all acts, things, including research work, necessary for the promotion of the peaceful uses of atomic energy in the fields of agriculture, medicine and industry and for the execution of

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[25] Ibid., p.7
[26] Ibid.
[27] Ibid.
[28] Ibid.
[29] Ibid.
[30] Ibid.
[31] Ibid.
[32] Ibid.

development projects involving nuclear power stations and the generation of electric power.

(2) The Commission, may, on behalf of or with the approval of the Central Government, or on behalf of any Provincial Government, perform such other functions relating to the peaceful uses of atomic energy and on such terms and conditions as may be agreed upon between the Commission and such Government.

In addition, the PAEC Act 1965 was amended in 1968 and again in 1974 thereby exempting the Commission from the application of Industrial Relations Ordinance 1969.[33] The provision regarding East Pakistan was also changed in view of the changed political condition of the country. Dr. Nazir Ahmad was appointed as the first Chairman of PAEC, who assumed charge on April 11, 1956. PAEC remained an attached department of the Ministry of Industries and Mineral Resources uptil 1964 after which it became autonomous. In 1955, the first United Nations International Atoms for Peace Conference was held in Geneva, which was attended by a Pakistani delegation led by Dr. Nazir Ahmad. Here, the United States offered a grant of US $ 350,000 to help counties participating in the Conference to initiate research projects and programmes in the peaceful uses of atomic energy.[34]

Therefore, in March 1956, in the wake of a request by the Government of Pakistan, U.S. atomic energy consultants visited the country to carry out the feasibility of setting up a research reactor facility.[35] Consequently, on May 21, 1956, Dr. Nazir Ahmad, Chairman of PAEC, informed the Governing Body of PAEC about the United States' offer of providing financial assistance to meet the cost of the reactor and briefed the meeting about the visit of the U.S. Atomic Energy Consultants.[36] In 1957 plans were formulated to set up experimental facilities to train manpower. A small laboratory with limited facilities was set up at the West Wharf, Karachi in 1957.[37]

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[33] Ibid.
[34] Ibid, p. 8.
[35] Ibid.
[36] Ibid.
[37] Ibid, p.9.

Following extensive deliberations, the Governing Body proposed to acquire a medium sized research reactor such as the CP-5, DIDO or Swimming-Pool type research reactor and to seek funds for its purchase from the U.S. International Cooperation Agency or other aid or donor agencies.[38] Moreover, in numerous communications, Dr. Nazir Ahmad pleaded with the Ministries of Finance and Foreign Affairs to obtain an allocation of U.S. $ 1 million or a loan from USEXIM.[39] This was intended for a CP-5 reactor, like the one at the Argonne National Laboratory, Illinois, USA. In one such letter Dr. Nazir Ahmad wrote that the CP-5 offered greater advantages for research compared to the swimming pool reactor, owing to the latter's running the risk of becoming obsolete in due course of time.[40]

In spite of PAEC's recommendations, the matter was shelved and no action was taken. Instead negotiations with Canada were initiated for the purchase of an NRX-type reactor at a prohibitive cost of U.S. $ 7 million. However, the Planning Commission of Pakistan did not approve this initiative, as it sought to spend the money on the Warsak Dam project.[41] Moreover, the matter pertaining to the supply of a swimming-pool type reactor was kept pending for three more years uptil March 9, 1959 when "in a tense atmosphere in a PAEC Board meeting, Dr. Nazir Ahmad announced the installation of this reactor."[42] Hence, in 1959, the Government of Pakistan decided to set up a 5 MWe Swimming Pool type reactor, which came to be known as Pakistan Atomic Research Reactor-1 (PARR-1) at a cost of US $ 600,000.[43]

A committee comprising the Chairman of PAEC, Dr. Nazir Ahmad, Dr. I. H. Usmani, (Member), PAEC, and Dr. Abdus Salam (part-time Member, PAEC), selected a suitable site for the reactor. It was to be set up at Nilore village, on the Lehtrar Road, on the outskirts of Islamabad.[44] Therefore while the Government of Pakistan was quick to make the best of the Atoms for Peace Programme, it did not provide the autonomy,

[38] Ibid, p.8.
[39] Shahid-ur-Rahman, *Long Road to Chaghi* (Islamabad: Print Wise Publications, 1999), pp. 22-23.
[40] Ibid.
[41] Ibid.
[42] Ibid.
[43] I.H. Qureshi, op cit, p.8.
[44] Ibid, p.9.

discretion and importance to the opinion of the PAEC Board or the Chairman of PAEC. Such official support was necessary for PAEC to make decisions, which would have a lasting impact on the future growth of the nuclear programme.

Thus, uptil the beginning of the 1960s, PAEC lacked the administrative freedom and financial autonomy required to obtain the necessary infrastructure support and facilities from abroad. This infrastructure was supposed to become the basis of nuclear science and technology in Pakistan. Nevertheless, PARR-1 was to become the centerpiece for research and training in atomic energy for the next three decades around which the PINSTECH complex would develop into the premier nuclear research establishment in Pakistan.

2.3. The Usmani Era

Dr. Ishrat Hussain (I. H.) Usmani was the second Chairman of PAEC and remained in office from 1960-1972. His term in office witnessed the establishment of PINSTECH and the Karachi Nuclear Power Plant or KANUPP, which launched the civilian nuclear programme in Pakistan. More importantly however, his era is remembered for having trained hundreds of scientists and engineers who were later employed in developing a much larger peaceful and nuclear weapons programme. Therefore, this section, besides discussing these aspects, discusses the training programme launched by Dr. Usmani and PAEC in the 1960s.

I. H. Usmani originally joined the nascent PAEC on May 21, 1959 as (Member) Research.[45] He belonged to a respected Muslim family of Delhi and Aligarh. He obtained his B.Sc (Honours) degree from the Aligarh Muslim University in 1936 and subsequently an M.Sc (Physics) degree from Bombay University.[46] In 1937, he proceeded to the Imperial College, University of London, to carry out research in atomic physics under the

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[45] Ibid.

[46] S.A. Hasnain, "Dr. I.H. Usmani and the Early Days of the PAEC," *The Nucleus,* Vol. 42, Nos. 1-2 (2005), p. 13.

supervision of the Nobel Laureate, Prof. P.M.S. Blackett. His Ph.D. thesis entitled, "A Study of the Growth of Compound Crystals by Electron Diffraction" was completed in 1939.[47] As there was no physics job available in British India, Usmani took the Indian Civil Service exam before independence. Upon his return to British India, Usmani joined the Indian Civil Service in 1942 and at the time of independence, he opted to go to Pakistan, where he served as Chief Controller, Imports and Exports.[48]

In 1958, President Ayub Khan asked Dr. Abdus Salam, the then Chief Scientific Advisor to the President of Pakistan, to help with the creation of the PAEC. Moreover, "it was Salam who salvaged Usmani from the civil service at a time when he was about to be dismissed and asked Ayub Khan to make him Chairman of PAEC."[49] Prof. Salam recalled that when he first came across Dr. Usmani by chance in a railway carriage in 1957, the latter had recently been appointed as head of Pakistan's Geological Survey. He had earlier served as Director-General of the Customs Department and Salam claimed to have successfully persuaded Usmani to accept President Ayub Khan's invitation to assume the charge of Chairman of PAEC.[50]

One of the first steps taken by Dr. Usmani after assuming office was the establishment of R&D and training facilities. These included two Atomic Energy Centres in 1961 and 1962 respectively, one each at Lahore and Dacca. These centres had the best research facilities in Pakistan at the time and included a 14 MeV Neutron Generator and a sub-critical assembly of magnox-clad natural uranium rods. A Van-de-Graff linear accelerator and an IBM 1620 computer were set-up at the Dacca Centre.[51] Moreover, among the first steps initiated by the Atomic Energy Centre, Lahore, also known as the Atomic Energy Mineral Centre or Lahore Centre, was the exploration of uranium. This activity continued from 1960-1963 and uranium deposits were found in Dera Ghazi Khan District, in southern Punjab province. Mining of uranium began the same year and a

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[47] Ibid.
[48] Ibid.
[49] Munir Ahmad Khan, letter to Ehsan Masood, London, October 5, 1995.
[50] I.H. Qureshi, op. cit., p.15
[51] Ibid. p.10.

PAEC geologist, Khalid Aslam, was given the first-ever national civil award for discovering deposits of uranium. [52]

Therefore, the association of Prof. Salam and Dr. Usmani proved to be the starting point for the growth of nuclear science and technology in Pakistan. They also worked together to keep the political leadership apprised of the importance of developing science and technology in general and atomic energy in particular. Moreover, the advent of Dr. Usmani as Chairman of PAEC would herald in a new era in Pakistan's nuclear programme, especially with regard to the training of scientists and engineers. This initiative, which began during Dr. Nazir Ahmad's tenure as Chairman of PAEC, is discussed at length in the following paragraphs.

2.3.1. The Training Programme

The U.S. led Atoms for Peace Programme opened the gates of U.S. nuclear establishments to young scientists and engineers of the Third World for the first time. The graduates of these institutions would go on to become leaders of national nuclear programmes in their home countries in subsequent years. Some of them would also become pioneers for the newly created International Atomic Energy Agency (IAEA). Prominent among graduates of Atoms for Peace nuclear science and engineering training who played such roles were Wynand de Villiers and Munir Ahmad Khan who served as chairmen of the South African and Pakistan Atomic Energy Commissions respectively.[53]

Moreover, several Indian, Israeli, Argentinean and Brazilian scientists benefitted from such training and educational programmes. Therefore, by the end of the 1970s, several thousand foreign nuclear scientists and engineers were trained and produced by the United States including some 1,100 Indians.[54] The two most prominent U.S. nuclear establishments, which offered atomic energy training and education, were the Oak Ridge National Laboratory, Tennessee, and the Argonne National Laboratory, Illinois.[55] The

[52] Samar Mubarakmand, op cit.
[53] David Fischer, *Stopping the Spread of Nuclear Weapons: The Past and the Prospects* (London and New York: Routledge, 1992), p.46.
[54] Ibid.
[55] S.A. Hasnain, op cit, p.14.

Argonne National Laboratory was the first institution in 1954 to establish an International School of Nuclear Science and Engineering (ISNSE), which later became the International Institute of Nuclear Science and Engineering (IINSE).[56]

The University of Chicago originally established this laboratory in 1946 as the United States Department of Energy Laboratories, which was mandated to conduct atomic energy research. The Argonne National Laboratory constituted the West's most advanced nuclear research establishment, with supercomputer technology and a working accelerator where atomic particles were bombarded against each other in order to study fission.[57] Graduates at ISNSE were exposed to a one-year training course in Nuclear Reactor Engineering where fifteen PAEC engineers were sent for training.[58]

The first semester took place at the North Carolina State University and Pennsylvania State University, followed by the Argonne National Laboratory. The third ISNSE batch included Muhammad Yusuf (future Member Power, PAEC) and Munir Ahmad Khan (future Chairman of PAEC). When the ISNSE began its first session on March 14, 1955, President Eisenhower addressed forty students from twenty countries at the opening session. He told them: "You represent a positive accomplishment in the Free World's efforts to mobilize its atomic resources for peaceful uses and the benefit of mankind."[59]

In 1957, a research reactor, the Argonaut, was set up at ISNSE as a key training facility for foreign students. The Argonaut (Argonne Nuclear Assembly for University Training) was built to teach reactor theory, nuclear physics and engineering laboratory experiments. By 1959, ISNSE had produced 420 graduates in nuclear science and engineering from forty-one countries.[60] Moreover, the Oak Ridge National Laboratory also set up the Oak Ridge School of Reactor Technology (ORSORT), which offered two

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[56] Ibid.
[57] Adrian Levy & Catherine Scott Clark, *Deception: Pakistan, the United States and the Global Nuclear Weapons Conspiracy* (New Delhi: Penguin Books, 2007), p. 462.
[58] I. H. Qureshi, op. cit., p. 10.
[59] Argonne National Laboratory: History http://www.anl.gov/Science_and_Technology/History/Anniversary_Frontiers/eduhist.html (accessed March, 23, 2009).
[60] Ibid.

training courses, i.e. Reactor Operations or Reactor Hazards Evaluation.[61] Out of ten PAEC trainees sent to ORSORT, nine opted for the Reactor Operations.[62] ORNL only allowed limited training attachments to PAEC trainees in nuclear engineering and allowed them access to the X-10 site, where there was little nuclear engineering, while the laboratory's Y-12 site remained "classified."[63]

Therefore, it remained out of bounds for PAEC personnel. Hence, a nuclear engineering team for PAEC could not be set up at the ORNL.[64] The U.S. International Cooperation Administration, later known as United States Agency for International Development (USAID), provided funds for PAEC trainees at these institutions.[65] In addition, as part of the PAEC's ambitious training programme, each year fifty outstanding M.Sc students in physics, chemistry, geology etc. and B.Sc students in engineering were selected on merit from universities across Pakistan. They came to be known as Officers on Special Training or OSTs and were given a nuclear orientation course at the Atomic Energy Centre, Lahore.[66]

Subsequently, they were sent to universities and research institutes in Europe and North America, which including the United Kingdom Atomic Energy Authority (UKAEA) establishments. These facilities were the UKAEA's Harwell and Winfrith, Chalk River Nuclear Laboratory, Canada, and the Universities of Sydney, Birmingham, Manchester, Toronto, Stanford and Rochester.[67] The University of North Carolina was the first institution in the world to set up a nuclear engineering programme in 1953, along with the Universities of Michigan, Pennsylvania State and Massachusetts Institute of Technology.[68]

While foreign students were being trained in nuclear science and technology under the Atoms for Peace Programme, Pakistan was also able to secure admission to the

[61] S.A. Hasnain, op cit, p.14.
[62] Ibid.
[63] Ibid, p. 15.
[64] Ibid.
[65] Ibid, p. 14.
[66] Ibid.
[67] Ibid.
[68] Ibid.

newly created IAEA. It was established in 1957 as part of the Atoms for Peace Programme, and Pakistan was also elected to the Agency's Board of Governors, supported by the United States. Throughout the formative phase of its nuclear programme, Pakistan depended on the United States and other Western countries, both in terms of acquisition of hardware and technology and training of manpower in nuclear science and technology. Several bilateral agreements between the U.S. National Nuclear Laboratories, such as Oak Ridge, Brookhaven and Argonne, and Pakistan were signed for training of essential technical staff that would play their part in various PAEC programmes. [69]

Thus, Pakistan primarily looked to the United States, especially in the backdrop of the Atoms for Peace Programme, for assistance in the nuclear field. In this regard, Munir Ahmad Khan, one of the first Pakistanis trained at the Argonne National Laboratory under Atoms for Peace, praised the plan which ushered in an era of technological growth in less developed countries.[70]

Consequently, on August 11, 1955, the United States and Pakistan signed a five-year agreement of 'Cooperation in Civil Uses of Atomic Energy.' This enabled Pakistan to obtain funding for a small research reactor and technical literature on nuclear science and engineering. By 1961, PAEC had 144 scientists and engineers who had either completed or were undergoing foreign training in nuclear science and technology.[71] Moreover, during 1960-67, PAEC sent about 600 scientists and engineers abroad for specialization and higher studies, out of which 106 returned with Ph.Ds.[72] Consequently,

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[69] Shirin Tahir-Kheli, *The United States and Pakistan: The Evolution of an Influence Relationship* (New York: Praeger, 1982), p. 116.

[70] "Whatever the motives behind the plan, it was without doubt a unique and commendable gesture. The end result of the 'Atoms for Peace' Plan was a large-scale and worthwhile transfer of peaceful nuclear technology. The United States trained thousands of engineers and scientists in its own laboratories and provided a large number of research reactors and other facilities to several advanced as well as developing countries. Many developing countries took a keen interest in this new technology, which offered both prestige and long-term potential economic benefits. The net effect of the 'Atoms for Peace' Programme was decidedly positive and far-reaching as far as the less developed countries were concerned. Besides imparting know-how in nuclear research, it acted as a catalyst for initiating a quiet but meaningful scientific and technological change." Munir Ahmad Khan,"Working Paper for International Consultative Group of Nuclear Energy," Rockefeller /RIIA Joint Publication, 1979.

[71] Mian, op cit, p. 18.

[72] Shahid-ur-Rahman, op cit, p.19.

the nascent nuclear programme began to be strengthened with nuclear know-how being acquired from the best institutions of the United States and Europe. This was Usmani's most important contribution, which would provide the critical mass necessary to sustain and expand Pakistan's nuclear programme.

2.3.2. PINSTECH

While several PAEC trainees were obtaining specialized training in nuclear science and technology in Western establishments, a need was felt to set up an appropriate nuclear research centre to provide them with adequate research facilities. The answer was the Pakistan Institute of Nuclear Science and Technology or PINSTECH.[73] The PINSTECH site was selected by Dr. Abdus Salam, the then Chief Scientific Advisor to the President of Pakistan, and Dr. I. H. Usmani, Chairman of PAEC. In 1961, PAEC asked American Machine Foundry (AMF) Atomics, U.S.A., to prepare a master plan for building PINSTECH. However this proposal was not approved, as it did not comply with PAEC's technical and aesthetic requirements.[74]

Therefore, Dr. Usmani contracted the world famous architect, Edward Stone, to prepare a plan to build PINSTECH.[75] The foundation stone of PINSTECH was laid on April 20, 1963, by Zulfikar Ali Bhutto, the then Minister of Industries and Mineral Resources (including Atomic Energy).[76] PAEC selected the 5 MWe swimming pool-type reactor in place of CP-5 and DIDO reactors, for installation in PINSTECH. This reactor was designed to use highly enriched uranium fuel, which was supplied by the United States through the IAEA and was installed in a dome shaped building by AMF-Atomics.[77] It was commissioned and made operational by the scientists and engineers of PINSTECH. On December 21, 1965, at 1905 hrs, the first criticality was achieved, i.e. a self-sustaining fission chain reactor was initiated in the reactor. This was a landmark in

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[73] Pakistan Atomic Energy Commission-History, http://www.paec.gov.pk/pinstech/history.htm (accessed March 23, 2009).
[74] S. A. Hasnain, op cit, p. 17.
[75] Ibid, p.16.
[76] I.H. Qureshi, op cit, p.9.
[77] Ibid.

the history of Pakistan and was heralded Pakistan in the "Atomic Age." The reactor itself attained full power of 5 MWe on June 22, 1966.[78]

PARR-1 is the main experimental research facility at PINSTECH. It has been used for research in nuclear research and technology, training of manpower and production of radioisotopes. The first batch of radioisotopes was produced at PINSTECH in 1967. The R&D programme picked momentum once the PINSTECH laboratories were completed and most of the manpower was shifted from Atomic Energy Centre, Lahore to PINSTECH in 1972. PINSTECH, however, would become fully operational by 1974. In this regard, a former Chairman of PAEC wrote in 1995:

> However, much more was needed to make PINSTECH more than a 'Taj Mahal." It had to be equipped with laboratories, library, supporting infrastructure and trained manpower. This did not start in earnest until 1972 when PINSTECH building was mostly empty and largely incomplete. A great deal of work has been done in the last twenty-five years to make it a living centre of Research and Development. Today it is the most advanced R & D Centre in the Muslim world and among the top four or five centers of its kind in the Third World (ranking after BARC in India and the Taejon Science City in South Korea).[79]

PINSTECH started with only four Divisions in 1966, and by 1992, it expanded to nine Divisions in addition to four R&D support Divisions and three Special Labs and Centres, manned by over 2000 scientists, engineers and technicians.[80] In 1966, PINSTECH comprised the following Divisions;[81] namely, Nuclear Physics Division; Radio Isotope Production Division; Reactor Operation Division; Health Physics Division; Reactor Design Group; and the Reactor School. However, by 1992, the expanded PINSTECH comprised the following Divisions, R&D support Divisions and Special Labs/Centres and Research work continued in them, namely;[82] Nuclear Physics; Nuclear Materials; Nuclear Chemistry; Nuclear Engineering; Health Physics; Radioisotope Applications; Applied Physics; Applied Chemistry; Radiation Physics. The

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[78] I.H. Qureshi, "Development of Physical Sciences at PINSTECH," *The Nucleus,* Vol. 42, Nos. 1-2 (2005), p.42.
[79] Munir Ahmad Khan, letter to Ehsan Masood, op.cit.
[80] N.M Butt, et al., "Development of Physical Sciences at PINSTECH," *The Nucleus,* Vol. 29, Nos. 1-4 (1992), p. 2.
[81] Ibid.
[82] Ibid.

R&D Support Divisions included, Electronics; Computer; General Services; Scientific Information. In addition, the Special Labs/ Centres consisted of the Centre for Nuclear Studies; Micro-seismic Studies; and the Optics/Laser Laboratories.

Moreover, a 27 Kw Miniature Neutron Source Reactor (MNSR), known as PARR-2 was installed at PINSTECH[83] in 1989 and by 1991, the PARR-1 reactor was upgraded from 5 MW to 10 MW.[84] It was also converted to run on 20 % Low Enriched Uranium (LEU) fuel instead of the HEU fuel. This was achieved by indigenous efforts of PINSTECH manpower and included the complete overhaul and re-designing of the reactor.[85] The PINSTECH Complex, as it turned out to be in the years after becoming operational in 1974, became a symbol of nuclear research and technology in Pakistan. It also provided the leadership for all projects, both on the civil and classified sides of the nuclear programme. [86] While it was being built, it earned the accolades of everyone who saw it, which reflected the promise it held forth for the future of nuclear science and technology in Pakistan. These sentiments can be gauged from the comments in the visitor's book. The architect, Eduard Stone wrote in PINSTECH's visitor's book:

> It is four years now since Dr. Usmani asked me to start work on this project. I now see the reactor dome and its tower completed, and I am elated. I can now see the construction and I believe it is likely that this can be my greatest work. I am proud that it looks like it belongs in this country with such a rich architectural heritage. I am grateful for the inspired guidance of Dr. Usmani and for the work of the contractors and thousands of Pakistanis who have made it possible.[87]

After the reactor went critical, President Ayub Khan wrote:

> I am delighted to have seen the completion of this reactor and magnificent attached buildings. But above all I am deeply encouraged by the quality of the scientists that work here. They are keen and enthusiastic and seem to realize that they are engaged in a holy crusade in getting this nation to enter this age of science and technology and help to

[83] Mudassar F. Wyne, "PARR-2 and its Utilization," *The Nucleus,* Vol. 29, Nos. 1-4 (1992), p.31.
[84] Aijaz Karim and Showket Pervez, "Renovation and Up-gradation of PARR-1," *The Nucleus,* Vol. 29, Nos.1-4 (1992), p.7.
[85] Ibid, pp. 7-11.
[86] N.M. Butt, op cit.
[87] "25 Years of PINSTECH: Silver Jubilee Technical Report, 1965-1990," Scientific Information Division, PAEC, PINSTECH, Nilore, Islamabad, 1992, p. 167.

> resolve the gigantic problems that people are faced with. I wish them all success in this endeavour.[88]

Dr. Abdus Salam wrote on August 9, 1968, that PINSTECH would be "an institution the nation will be proud of."[89] Dr. Glenn T Seaborg (Nobel Laureate) and Chairman, U.S. Atomic Energy Commission visited PINSTECH on January 12, 1967. He wrote: "I am very much impressed with the fine facilities for nuclear research which you have underway here and I am sure that this will be the basis for a growing nuclear industry in Pakistan."[90]

2.3.4. KANUPP

With the advent of Dr. I. H. Usmani in 1960 as Chairman of PAEC, feasibility studies for introducing nuclear power in Pakistan were initiated. In this regard, two American firms, Gibbs and Hill and the Inter-Nuclear Company were asked to prepare a joint study.[91] They submitted their report, in May 1961, entitled: "Study of the Economic Feasibility of Nuclear Power in Pakistan."[92] This report came to be known as the Gibbs and Hill report, which became the "standard reference" on nuclear power in Pakistan.[93]

Moreover, the 1962 IAEA report, *Prospects of Nuclear Power in Pakistan*, suggested that the growing energy requirements of Karachi could easily be met by nuclear power instead of natural gas.[94] Dr. I. H. Usmani vigorously carried out the marketing of nuclear power prospects in Pakistan, thus inviting the attention of international nuclear power plant suppliers. Therefore, in 1962, PAEC began negotiations with Canada for the supply of a nuclear power plant to be set up in Karachi. Following the submission of a proposal in 1964, an agreement was signed between Pakistan and Canada whereby Canada pledged to give Pakistan a soft loan of $ 23

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[88] Ibid, p. 168.
[89] Ibid, p. 170.
[90] Ibid, p. 169.
[91] S.A. Hasnain, op cit, p.15.
[92] Ibid.
[93] Ibid.
[94] Ibid.

million and credit of an additional $ 24 million.[95] This was intended to meet the foreign exchange costs of the proposed nuclear power plant.

Moreover, Canada would also train Pakistanis for commissioning and operating the plant. On January 5, 1964, the Executive Committee of the National Economic Council (ECNEC) gave approval for the construction of a 137 MWe nuclear power plant at Karachi.[96] In May 1965, Canada General Electric Company (CGE) signed a contract with PAEC to build the 137 MWe Karachi Nuclear Power Plant on a turnkey basis.[97] Pakistan also sent forty-six trainees to Canada to be trained in commissioning and operating KANUPP,[98] which went critical on August 1, 1971 and started commercial operation in 1972.[99] It remained the "flagship of the entire nuclear programme"[100] for the next two decades. However, it was commissioned in 1972 with great difficulty when half the technical manpower had left PAEC in the wake of the separation of East Pakistan.[101]

Therefore, with the training programme launched by Dr. Usmani and the establishment of PINSTECH and KANUPP, Pakistan's civil nuclear infrastructure was erected on strong foundations. These projects along with the acquisition of technical know-how through foreign trainings of hundreds of scientists and engineers became the backbone of nuclear science and technology in Pakistan. This applied to both the civilian nuclear programme and the nuclear weapons programme in future years as well. These initiatives also put Pakistan's nuclear programme on an irreversible path, which no future government could stop, freeze or abandon. This generated its own technological momentum, which in turn propelled the political and technical decision-makers to further expand the nuclear programme as and when required.

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[95] Shahid-ur-Rahman, op cit, p. 24.
[96] Ibid.
[97] Ibid.
[98] Munir Ahmad Khan, "Significance of Chashma Plant," *Dawn* (Karchi), August 8, 1993.
[99] I. H. Qureshi, "Recollections from the Early Days of the PAEC," op cit, p. 11.
[100] Munir Ahmad Khan, Speech delivered at the Chaghi Medal Award Ceremony, Pakistan Nuclear Society, PINSTECH Auditorium, Nilore, Islamabad. March 20, 1999.
[101] Ibid.

2.4. The Nuclear Option Missed Opportunities: Fuel Cycle Capability Debate and Civil-Military Bureaucratic Apathy

This section discusses the various missed opportunities that were once available to PAEC for acquiring the know-how and the nuclear fuel cycle facilities. Had these been availed on time they would have enabled Pakistan to acquire the technological capability to develop nuclear weapons if needed. However, several such opportunities were missed, wasted or deliberately ignored due to bureaucratic apathy, indifference or deliberate intent on the part of a few individuals. This section particularly relates to the initiatives taken by PAEC during the 1960s in the field of nuclear power and nuclear fuel cycle facilities, and the reasons due to which they did not materialize. This state of affairs was described by Iqbal Akhund, a former Pakistani diplomat as the result of the perceived shortsightedness of the country's political and civil-bureuacratic leadership.[102]

Consequently, this attitude remained dominant in decision-making on the country's nuclear programme, which is evident in the following sections. Therefore, even though the PAEC started functioning by the late 1950s, no careful planning was done at the highest decision-making levels to acquire nuclear capability. On the issue of safeguards for KANUPP, Pakistan's Ambassador to Canada in 1965, Sultan Muhammad Khan claimed that decision-makers in Pakistan mishandled the whole issue. While protracted negotiations had been going on regarding the supply KANUPP by Canada, Pakistan's Foreign Office opined that Pakistan should demand similar terms for this plant as India. However, the contentious issue during negotiations was the Canadian

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[102] "The PAEC was set up in the fifties, not long after India's, and under the dynamic leadership of late Dr. Ishrat Usmani, a good deal of training and research got underway at a fairly early stage. It was apparent that in the course of things, Pakistan too could acquire nuclear capability, and in time reach a rough parity with India in nuclear technology. The crucial question was that of the time gap between the achievements of nuclear weapons capability by the two countries. This factor was crucial for Pakistan on two grounds: firstly Pakistan's military and diplomatic disadvantage could become virtually absolute vis-à-vis an India armed with nuclear weapons; and secondly, as soon as India went nuclear, Pakistan could become the main target of the non-proliferation diplomacy that was being spearheaded by the United States.Unfortunately, Pakistan's nuclear effort at that stage did not have the kind of political and financial support that Nehru had ensured for the Indian programme. Far from being gung-ho about the matter, the Pakistani leadership was skeptical and the attitude of decision-makers in the early stage was marked by diffidence and self-depreciation. What, Pakistan go nuclear! The very idea seemed extravagant and wacky to many of them. In a discussion on the subject one senior official laughed at my arguments, 'Let us first learn to manufacture a proper bicycle!". Iqbal Akhund, *Memoirs of a Bystander* (Karachi: Oxford University Press, 2006), pp. 261-262.

demand of stringent inspections for the sale of the plant to Pakistan, unlike India. The Canadians asserted that since Pakistan was obtaining the nuclear power plant through Canadian aid, while India had financed it herself, the only way Pakistan could have the plant on terms similar to India's was to pay for it. Moreover, Pakistan was told that further deplay in making a decision might lead to a lapse of funds being exntended by Canada.[103]

Therefore, the Ambassador wrote to President Ayub Khan and voiced his opinion that since the plant was meant for civilian uses and was being supplied on easy credit, periodic inspections could be considered as an option. He added that if Pakistan would ever decided to suspend inspections for reasons of national security, then the country would need to find independent souces for providing fuel for the reactor and keeping it running. He claimed that Mr. Saeed Hasan, the Deputy Chairman, Planning Commission, was sent to Ottawa by President Ayub Khan to sign the agreement, who arrived and then abruptly left for New York, while giving a vague time-frame for his return to sign the agreement. It took a personal directive from the President of Pakistan to Saeed Hassan before he returned to finally sign the agreement for the supply of the power reactor.[104] Therefore, Pakistan was unable to secure a favourable safeguards agreement with Canada for KANUPP, which otherwise, could have provided Pakistan with a means to acquire the nuclear option at an early date, like India. However, this was not to be, perhaps due to the bureaucratic apathy or some misplaced perception of the national interest held by the decision-makers of the country.

Although PAEC started functioning as early as 1956, during the early part of the regime of President Ayub Khan, no serious effort was made to acquire the nuclear option. The President was apparently not convinced about the role of atomic energy in the future of Pakistan and he followed the advice he got from his Ministers like Mr. Shoaib, the then Finance Minister, without looking into the consequences. He left all the decisions concerning atomic energy to the bureaucrats of his regime who continued to oppose it. In October 1965, during his visit to Vienna, Mr. Bhutto discussed with Munir

[103] Sultan Muhammad Khan quoted in Shahid-ur-Rahman, op cit, pp. 24-25.
[104] Ibid.

Ahmad Khan, at Hotel Imperial, the steps necessary for acquiring the nuclear option. In this regard, Bhutto also arranged his meeting with President Ayub, which took place on December 11, 1965 at the Rochester Hotel, London.[105]

Moreover, Dr. Abdus Salam and Munir Ahmad Khan also prepared a paper, which was presented by Dr. Salam to President Ayub Khan in July-August 1967.[106] This proposal was also rejected on economic grounds. This proposal called for the establishment of the following facilities, which could develop the plutonium route in Pakistan:

- A refining plant for uranium
- A fuel fabrication plant
- A reactor for producing plutonium
- A plutonium separation plant.

Moreover, it might have been that a similar proposal to set up a plutonium separation plant could not be approved in 1966. This proposal was put forward by the then Foreign Minister, Zulfikar Ali Bhutto. In this regard, in his last days in office as Foreign Minister in 1966, he asked the Foreign Office to call a meeting of relevant officials to consider the nuclear question and recommend a strategy to the government in this regard. Consequently a working group came into being, comprising some senior army and intelligence officers, some Foreign Office officials, and Dr. Usmani. The working group, after deliberating on the matter, unanimously recommended the acquisition of a plutonium separation (reprocessing) plant, and the French Atomic Energy Commission had given an offer of setting up such a plant for U.S. $ 25 million. Although this was to be under safeguards, these were not so strict at the time, nor would

[105] *Pak Atom* -Newsletter of PAEC, May 1974. For details, please see Chapter 3.
[106] Munir Ahmad Khan, "Salam Passes into History," *The News* (Islamabad), November 24, 1996.

Pakistan be prevented from developing plutonium technology indigenously outside safeguards.[107]

When these proposals were ready to be submitted to Bhutto, an order from the President's House cancelled the meeting called for the purpose. In addition, when Bhutto left the Cabinet, the matter was shelved indefinitely and the working group disbanded. Its recommendations "ran into a wall of skepticism, reticence, and obduracy on one ground or another from almost all the top policy-makers."[108] The then Finance Secretary, Ghulam Ishaq Khan, apparently believed that the plutonium project was a wasteful endeavour and "the country would find itself in a spiral of expenditure on research, then bombs, then missiles."[109] Nor could Pakistan keep up with such an arms race with India. The Foreign Secretary S. M. Yusuf and even the Defence Secretary raised similar objections. The latter said that Pakistan could not afford to develop a nuclear capability and India would not use nuclear weapons against Pakistan due to world opinion.[110]

Therefore, in the brief prepared for President Ayub Khan on the eve of his visit to France, the Defence Secretary emphatically stated that, "the Pakistani President need not raise the issue" of acquiring a plutonium separation or reprocessing plant with General de Gaulle.[111] One senior diplomat again took the matter up with President Ayub Khan, but to no avail:

> I spoke on the subject to President Ayub Khan when I paid a farewell call on him before leaving to go as Ambassador to Cairo in 1968, and tried to persuade him of the importance and urgency of taking up the French offer of a plutonium reprocessing plant. He listened intently and spoke of his excitement at a reported uranium find in the north. I submitted that meanwhile we would import 'yellow cake' (unprocessed uranium) that was available in the market. But nothing further seems to have been done in the matter until Bhutto returned to the scene in 1972.[112]

Thus, due to the apathy of the civil and military bureaucrats, and the indifference of Presidents Ayub and Yahya Khan, Pakistan consistently missed valuable opportunities

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[107] Akhund, op cit, p. 262.
[108] Ibid. p. 263.
[109] Ibid.
[110] Ibid.
[111] Ibid.
[112] Ibid, p. 264.

for acquiring facilities, such as the reprocessing plant. These decisions, however, coupled with the haste with which the KANUPP safeguards agreement was signed, shows that developing the nuclear option with a view to transform this into military capability was not adequately realized or appreciated at the highest levels of decision-making. Things were left to committees and the negative role played by the officials of the Ministry of Finance and Planning Commission made things more difficult for PAEC.

2.5. Concluding Comment

From the above discussion, it is evident that Pakistan began its nuclear quest, not as a strategic necessity per se, but as a result of the technological promise, which Atoms for Peace and atomic energy seemed to offer to developing countries. The Pakistani bureaucracy appreciated this and several positive initiatives taken during the formative years of PAEC, which paid dividends in subsequent decades. Had the training opportunities for scientists and engineers not been harnessed by Pakistan through the Atoms for Peace Programme, it would have been virtually impossible to develop the technological base and know-how needed to set up even a small civilian nuclear programme. Pakistan was also able to capitalize on the prevalent conducive international climate for cooperation in civilian and peaceful uses of atomic energy by acquiring a research and power reactor and building PINSTECH, which would later prove to be the backbone of Pakistan's nuclear know-how. However, while the formative phase of Pakistan's nuclear programme was useful in many ways, it was also a time when the country could have matched India in acquiring the necessary know-how and technology that could have provided it with a nuclear option.

This was not done because of intense bureaucratic rivalries among different government departments and PAEC and because of lack of long-term strategic planning, both in PAEC and at the political level. Moreover, in spite of having been warned and informed of India's growing nuclear march towards nuclear weapons capability, the decision makers in Pakistan, primarily outside PAEC, chose to look the other way. Therefore, when Pakistan could have acquired all the necessary infrastructure and facilities which India did during the 1960s, it missed the boat altogether. However, this would not be the case for long, as will be seen in the next chapter.

Theoretically speaking, from the above discussion, it is also evident that the "technological pull" and fascination of the newly found atomic energy and the promise of "Atoms for Peace" proved to be the first catalyst in Pakistan's nuclear programme. It led to the establishment of PAEC, which at the beginning only seemed as a technological imperative. Prior to this, as per the nuclear myth-making model, a "talented and well-placed" physicist, Dr. Rafi M. Chaudhri succeeded in laying the foundations of a nuclear Pakistan at Government College, Lahore. Moreover, during the formative years, statements made by Dr. Raziuddin Siddiqui, one of the founding members of PAEC, and Khan Abdul Qayyum Khan pointed towards the potential of harnessing science and technology. This included the prospect of acquiring nuclear technology for socio-economic development, and as Dr. Siddiqui mentioned, for the defence of the country as well.

Then the advent of Dr. Salam and Dr. Usmani in the decision-making process had the most significant impact on the future of the nuclear programme. Dr. Salam was advisor on Science and Technology to the President of Pakistan, and Dr. Usmani, Chairman of PAEC. Another outsider in the process was Munir Ahmad Khan at the IAEA. They formed a trio that shared similar views about the growth of atomic energy in Pakistan and therefore had formed an influential coalition within the overall nuclear decision-making process. Although they, along with Bhutto, tried to justify the acquisition of nuclear option by invoking an existing and growing nuclear threat from India, their alliance only had a direct impact on the growth of the nascent civilian nuclear infrastructure during the 1960s. However, their relative positions in the governmental structure, and the influence Munir Ahmad Khan had on nuclear decision-making at this stage remained weak. However, Usmani, Salam and Bhutto along with Munir Khan can be termed as the nuclear mythmakers of the formative years of atomic energy in Pakistan.

Their efforts remained partially successful due to the civil bureaucracy's continued resistance to the implementation of the nuclear plans. This bureaucratic tussling had initially begun from the days of Dr. Nazir Ahmad and continued throughout the era of Dr. Usmani. However, according to the bureaucratic-politics model, the civil bureaucrats sitting at important positions in the critical governmental decision-making channels did not share the views of the technical experts regarding the future of the country's nuclear programme. It seems that the decision-makers sitting at important positions in Pakistan's Ministries of Planning, Finance and Foreign Affairs had divergent perceptions about what was in Pakistan's national security interests that the nuclear energy establishments, nor did they perceive any nuclear threat from India at the time. Therefore, they were constrained by their own organizational and personal interpretations. They were not pulled along with the lure of atomic energy and lacked the vision needed to recognize Pakistan's long-term security interests.

They continued to misguide President Ayub Khan on nuclear matters and the views of this group of individuals largely prevailed over that of the technical experts. Since decision-making was taking place as a result of compromise between two coalitions of actors, i.e. PAEC and civil bureaucracy, the latter group largely prevailed over the former and succeeded in forging its ascendency over the former. Thus, the implementation of several initiatives and projects for the development of a latent nuclear capability was effectively scuttled. Moreover, those opposed to the acquisition of nuclear capability comprised the national elite that seemed to have its own vested interest in creating false impressions and generating misleading beliefs and interpretations about the need to develop the country's nuclear programme.

Therefore, it succeeded in discrediting the arguments of the opposing camp, led by PAEC and Bhutto and both President Ayub and Yahya remained oblivious to Pakistan's national security requirements in respect of its nuclear programme. Thus, some of the basic assumptions of the domestic and bureaucratic and domestic politics and the nuclear myth-making models, the technological determinist are evidently appear to have been validated in the above discussion. Nevertheless, the ascendency of the pro-bomb lobby or coalition in the 1970s that emerged during the preceding decade would eventually change the shape and scope of Pakistan's nuclear programme for the future. This is discussed in detail in the following chapter.

CHAPTER 3

ZULFIKAR ALI BHUTTO AND THE BOMB LOBBY

The previous chapter dealt with the formative phase of Pakistan's nuclear programme. It discussed the conditions which led to the creation of PAEC and the nuclear programme and the struggle it had to go through during the first fifteen years of its existence. However, in the next decades, a major shift in the orientation, nature, scope and direction of the country's nuclear programme took place, both at political and technical levels. This was made possible due to close association of two separate, yet ideologically convergent, "bomb lobbies" or coalitions/alliances that existed during the 1960s, and surfaced after the 1965 Indo-Pakistan war. The external bomb lobby or coalition that emerged outside the PAEC consisted of Zulfikar Ali Bhutto and Munir Ahmad Khan. It was supplemented by a similar coalition of nuclear hawks within the PAEC, comprising young and disgruntled nuclear scientists and engineers. They were essentially shaken by the events that led to the fall of East Pakistan who virtually revolted against the PAEC establishment, and directed their criticism at the Commission's Chairman, Dr. I. H. Usmani. In this context, the present chapter discusses the birth of these bomb coalitions. It also analyzes how historical events enabled these alliances to take over the reigns of Pakistan's nuclear programme and PAEC. Consequently, the merger of these alliances led Pakistan on the path to nuclear weaponization and Dr. Usmani was replaced as Chairman, PAEC in 1972 with Mr. Munir Ahmad Khan.

This chapter consists of five sections, namely: Bhutto's Nuclear Vision; Munir Ahmad Khan's Background and Nuclear Plans; The Arrival of Munir Ahmad Khan; PAEC Bomb Lobby and the Multan Meeting; and finally, Dr. I.H. Usmani's Departure and Change of Guard at PAEC. The chapter concludes with an analysis of the relevant theoretical approaches, paradigms and models in respect of the empirical evidence presented in it.

3.1. Bhutto's Nuclear Vision

In December 1971, Zulfikar Ali Bhutto took over as President of Pakistan, and later as Prime Minister. As early as 1961, as a member of the Cabinet in the Ayub Khan regime, he had been articulating his ideas about the crucial role of atomic energy in Pakistan's economic development and national security.[1]

During a cabinet meeting in 1963, Bhutto raised the question of India's growing nuclear programme and declared that Pakistan must also develop such a capability in response. Apparently, President Ayub Khan remained unconvinced and believed that the nuclear option could only be acquired from a foreign country. Therefore, in response to Bhutto's remark, President Ayub remarked: "If India went nuclear, we would buy a nuclear weapon off the shelf somewhere."[2] However, following the 1965 Indo-Pakistan war, a transformation occurred in the leaderships' perceptions regarding India's nuclear developments, which were reflected in Pakistan's decision not to sign the NPT in 1968. This kept the door open for Pakistan to retain the nuclear weapons option, as advocated by Bhutto in *The Myth of Independence*.[3]

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[1] "Pakistan was determined not to be left behind in the atomic race. As a nation of 90 million, occupying such a strategic place in Asia, we cannot afford to stop. I assure you the revolutionary regime will do everything to harness atomic energy for peaceful purposes imperative as it is to the country's progress and security." *Pakistan Times,* March 3, 1961, quoted in P.L. Bhola, *Pakistan's Nuclear Policy* (New Delhi: Sterling Publishers Private Ltd, 1993), p. 32.

[2] "Statement of the Prime Minister of Pakistan Regarding the Indian Nuclear Explosion," in *Pakistan Horizon*, Vol. 27, No. 2 (Second Quarter 1974), p. 133, quoted in Bhumitra Chakma, "Road to Chaghi: Pakistan's Nuclear Programme, its Sources and Motivations," *Modern Asian Studies,* Vol. 36**,** No. 4 (2002), Cambridge University Press, p. 879.

[3] "All wars of our age have become total wars; all European strategy is based on the concept of total war; and it will have to be assumed that a war waged against Pakistan is capable of becoming a total war. It would be dangerous to plan for less and our plans should, therefore, include the nuclear deterrent. Difficult though this is to employ, it is vital for Pakistan to give the greatest possible attention to nuclear technology, rather than allow herself to be deceived by an international treaty limiting this deterrent to the present nuclear powers. India is unlikely to concede nuclear monopoly to others and, judging from her own nuclear programme and her diplomatic activities, especially at Geneva, it appears that she is determined to proceed with her plans to detonate a nuclear bomb. If Pakistan restricts or suspends her nuclear programme, it would not only enable India to blackmail Pakistan with her nuclear advantage, but would impose a crippling limitation on the development of Pakistan's science and technology." Zulfikar Ali Bhutto, *The Myth of Independence* (Karachi: Oxford University Press, 1969), pp. 117-118.

Moreover, he openly demanded that Pakistan must also begin its own nuclear programme in order to attain the nuclear option before India could achieve a decisive advantage, especially during any future crisis.[4] Writing from his jail cell in 1977, Bhutto would later recall his commitment and determination in propelling forward the nascent nuclear programme of Pakistan and putting it on sound footing.[5] He also described his personal association and initiatives in launching some of the first important projects in PAEC.[6] From his death cell, Bhutto again re-claimed his contribution to the development of nuclear capability for Pakistan, both during the 1960s as a Minister for Foreign Affairs and Industries, and later as President and Prime Minister. He also saw this as an essential means for Pakistan to acquire prestige, power and leadership in the Muslim world, in addition to offsetting the Indian threat in South Asia.[7]

Therefore, it is evident that Bhutto propelled, protected and promoted Pakistan's nuclear programme in various capacities, and at different times during the 1960s and 1970s. He had realized the unqualified necessity of nuclear technology for Pakistan's

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[4] Ibid, p. 118.

[5] "I have been actively associated with the nuclear programme of Pakistan from October 1958 to July 1977, a span of nineteen years. I was concerned directly with the subject as Foreign Minister, as Minister for Fuel, Power and Natural Resources and as Minister in Charge of Atomic Energy. When I took charge of Pakistan's Atomic Energy Commission, it was no more than a signboard of an office. It was only a name. Assiduously and with granite determination, I put my entire vitality behind the task of acquiring nuclear capability for my country. I sent hundreds of young men to Europe and North America for training in nuclear science. I commissioned Edward Stone to build PINSTECH and laid its foundation stone in the then wilderness of Islamabad. I negotiated the agreement for the 5 MW research reactor located in PINSTECH. In the teeth of opposition from Finance Minister Shoaib and Deputy Chairman of Planning Commission, Said Hassan, I negotiated with success to obtain from Canada the 137 MWe Karachi nuclear power plant and performed its opening ceremony. Towards the middle of 1976, I gave approval for the Chashma nuclear power plant. And of course, I negotiated and concluded the Nuclear Reprocessing Plant Agreement with France in 1976." Zulfikar Ali Bhutto, *If I Am Assassinated* (New Delhi: Vikas Publishing House Pvt. Ltd, 1979), p. 139.

[6] Ibid.

[7] "Due to my singular efforts, Pakistan acquired the infrastructure and the potential of nuclear capability. It was not a simple task to catch up the lost time in a poor and underdeveloped country like ours. When I assumed charge of atomic energy, Pakistan was about twenty years behind India's programme. When I ceased to be Prime Minister, I believe, that at the most, Pakistan was five to six years behind India. If the internal opposition to the nuclear programme had not come from the beginning from certain powerful ministers and bureaucrats, I could have further narrowed the gap. For this reason, I gave the highest priority to train thousands of nuclear scientists in foreign countries. We were on the threshold of full nuclear capability when I left the Government to come to this death cell. We know that Israel and South Africa have full nuclear capability. The Christian, Jewish and Hindu civilizations have this capability. The communist powers also possess it. Only the Islamic civilization was without it, but that position was about to change." Ibid. p. 140.

security and development and was determined to make it an integral part of his vision for the country's future.

3.2. Munir Ahmad Khan's Background and Nuclear Plans

President Bhutto appointed Mr. Munir Ahmad Khan as Chairman of PAEC in January 1972. However, their association began after the 1965 Indo-Pakistan war, which evolved into an alliance and mutual friendship, lasting until the final days of the Pakistani Prime Minister. Ostensibly Munir Khan was an outsider who had not served in PAEC yet, but had gained the trust and confidence of Z. A. Bhutto. It is likely that his career profile at the IAEA was also a critical factor in forging his coalition with, and gaining the trust of Bhutto. Therefore, it is necessary to explore the factors that enabled and fostered the close association of the two men.

Munir Ahmad Khan had begun his educational career, like several other Pakistani nuclear scientists and engineers, from Government College, Lahore. He obtained a Bachelors degree in Physics and Mathematics in 1946 from Government College and a B.Sc in Electrical Engineering in 1949 from Punjab University's Engineering College, Lahore. After serving as Assistant Professor in Lahore Engineering College, he proceeded to the United States on a Fulbright and Rotary scholarship. He completed his M.S in Electrical Engineering in 1952 from North Carolina State College of Agriculture and Engineering, University of North Carolina, Raleigh, USA, and was elected to the Sigma Xi (Research Society of America) in recognition of his scientific research. He carried out post-graduate research work in Electric Power at the Illinois Institute of Technology, Chicago, USA from 1953-1956 where he specialized in Systems and Planning Engineering.[8]

During this time, he also worked at the Commonwealth Edison Company, Chicago, which pioneered the first commercial nuclear power reactor in the United States. It was here that he took preliminary training in atomic energy from 1954-1955 as a System Planning Engineer. He proceeded to join President Eisenhower's "Atoms for

[8] Haris N. Khan, "Pakistan's Nuclear Programme: Setting the Record Straight," *Defence Journal* (Karachi), Vol. 13, No. 1, (August, 2010.)

Peace" Programme in 1956 after having being selected for specialization in Nuclear Engineering.[9] He thus joined the third batch of Nuclear Engineering trainees at the International School of Nuclear Science and Engineering, Argonne National Laboratory (ANL), and graduated in 1957.[10] He continued to serve as a Research Associate in the Nuclear Engineering Division of the ANL where he worked on the "Modifications on CP-5 Reactor," in addition to acquiring practical experience in operating reactors such as CP-5, Argonaut and Experimental Boilining Water Reactor (EBWR). Thereafter he joined the Reactor Engineering section of the American Machine Foundry Company's Atomics Division, or AMF-Atomics, Greenwich, Connecticut, USA. Here he worked on the "Thermodynamic Design of Japan Research Reactor-2" as a Reactor Design Engineer till 1958.[11]

While he was still with the AMF Atomics, Munir Khan got an offer from the first Director-General of the IAEA, Mr. Sterling Cole, to join the International Atomic Energy Agency (IAEA). In a letter addressed to Munir Khan, Cole wrote: "I welcome your interest for the reason that persons of your training and zeal are the type which are needed by the Agency."[12] After obtaining the necessary permission from Prime Minister of Pakistan, Feroz Khan Noon,[13] he joined the Nuclear Power and Reactors Division, Department of Technical Operations, IAEA, in September 1958. He thus became the first Asian to have joined the IAEA as a staff member. He continued to serve in the IAEA in different capacities in Professional Grade-P-5[14] until 1972, beginning as First Officer in the Reactor Division in 1958, followed by Senior Officer in 1961 and then as Section Chief of the Nuclear Power Reactor Technology and Application from 1964 to 1968. He then served as Director of the Nuclear Fuel Cycle and Reactor Engineering Section in the same Division, from 1968 to 1972.[15]

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[9] Ibid.
[10] Ibid ; IAEA Bulletin, Vol. 41, No. 2, 1999.
[11] Ibid.
[12] Sterling Cole, letter to Munir Ahmad Khan, Vienna, (Austria), November 5, 1957.
[13] Altaf Hussain Qureshi, Interview with Munir Ahmad Khan, *Urdu Digest,* October 1981, p.31.
[14] S.A. Hasnain, "Dr. I. H. Usmani and the Early Days of the PAEC," *The Nucleus,* Vol. 42, Nos. 1-2 (2005), p. 19.
[15] *ECHO,* Journal of the IAEA Staff- No. 202, p.33.

Moreover, while serving at the IAEA, Munir Khan's responsibilities included developing major international programmes relating to thermal and fast breeder reactors, and heavy water and gas-cooled reactors. He was also responsible for activities related to research reactor utilization in developing countries, review of design, construction and operation of demonstration power reactors in USA and Canada. He also coordinated programmes for research contracts for theoretical estimation of uranium depletion and plutonium buildup in nuclear power reactors in developed countries. Moreover, nuclear desalination, small and medium power reactors and market surveys for nuclear power plants were also part of his overall responsibilities.[16] Many of the programmes which he launched continued for several decades after his departure from the IAEA, where he came to be known as *The Reactor Khan.*[17]

During his stay at the IAEA, Munir Khan organized more than twenty technical conferences on the these subjects and served as a Scientific Secretary to the Third and Fourth UN International Geneva Conferences on the Peaceful Uses of Atomic Energy, held in 1964 and 1971 respectively. As Chairman of PAEC, he was elected as Member of the IAEA Board of Governors for twelve years and was the leader of Pakistan's delegation to nineteen IAEA General Conferences. He also served as Chairman of the IAEA Board of Governors from 1986-87[18] and was the second Pakistani to serve as in that position after Dr. I. H. Usmani.

In the immediate aftermath of the 1965 Indo-Pakistan War, Munir Ahmad Khan tried to approach President Ayub, to discuss the acquisition of a nuclear deterrent. This was done through his elder brother, Sheikh Khurshid Ahmad who was serving as Law Minister in the Federal Cabinet along with Mr. Bhutto. Apparently Munir Khan was advised to meet "my foreign minister," since the President was not very aware of "these atomic bombs."[19] Although, Munir Khan claimed to have known Bhutto since 1957, when he used to visit the United Nations. However, this meeting with Foreign Minister Bhutto would be in a different context. Therefore, when Bhutto visited Vienna and met

[16] Ibid, pp.24-25.
[17] Ibid, p.33.
[18] IAEA Bulletin, Vol. 41, No. 2, 1999.
[19] Munir Ahmad Khan quoted in Shahid-ur-Rahman, *Long Road to Chaghi,* (Islamabad: Print Wise Publications, 1999), p. 27.

Munir Khan at the Hotel Imperial, it was to be for developing a consensus for a nuclear capable Pakistan. Munir Khan recalled this meeting decades later:

> India had a weapons focused programme for acquiring nuclear weapons right from the beginning. After the 1965 war, our vulnerability increased. Now I'll take you to an important event soon after that war. In October 1965, Pakistan's Foreign Minister, a young man at that time, I call him a young man because he was two years younger than I was, Mr. Bhutto visited Vienna, where I was working, and I briefed him about all that I knew about India's nuclear programme and the facilities that I had seen myself during a visit to Trombay in 1964, consisting of a plutonium production reactor, a reprocessing plant, and all the associated facilities, which added up to one thing--bomb making capability. I told him that a nuclear India would further undermine and threaten our security, and for our survival, we needed a nuclear deterrent.[20]

Therefore, Bhutto arranged Munir Khan's meeting with President Ayub, in an attempt to convince the Field Marshal of the necessity of acquiring nuclear capability for Pakistan. In this regard, Munir Khan further claimed:

> Bhutto asked me if I had told the same to President Ayub Khan. I said 'No, I had never met him.' Then he told me that the President would like to see me on December 11, 1965 at the Rochester Hotel, London, where I had the privilege of meeting the Field Marshal for the first time. I briefed him on all that I knew and I told him that there were no restrictions on nuclear technology, it was freely available, India was soaking it up, so was Israel. The cost estimates at that time, because things were less expensive, were not more than 150 million dollars. I must say Ayub Khan listened to me very patiently, but at the end he said that Pakistan is too poor to spend that much money. Moreover, if we ever need the bomb, we will buy it off the shelf.[21]

As the two men were engaged in discussions, Bhutto was anxiously waiting in the lobby outside. When Munir Khan emerged from the meeting, Bhutto inquired about the results and was told: "The President did not agree." Bhutto replied: "Don't worry, our turn will come!"[22] Bhutto's resigned from President Ayub's cabinet in the wake of the Tashkent agreement of January 1966, following which he and Munir Khan would frequently meet in Europe and in Pakistan.[23] It was the beginning of a friendship and alliance that would go on until Bhutto's death in 1979. Therefore, the so-called "bomb coalition" had been formed outside PAEC. Bhutto's visits to Munir Khan in Vienna and Europe took place at a time when his ideological and political philosophies for the

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[20] Munir Ahmad Khan, Speech delivered at Chaghi Medal Award Ceremony, Pakistan Nuclear Society, PINSTECH Auditorium, Islamabad. March 20, 1999.
[21] Ibid.
[22] Farhatullah Babar, "Bhutto's Footprints on Nuclear Pakistan," *The News* (Islamabad), April 4, 2006.
[23] Munir Ahmad Khan, Interview with Hamid Mir and Saeed Qazi, *Daily Ausaf,* June 18, 1998.

formation of the Pakistan People's Party (PPP) were taking shape. Moreover, from 1966 onwards Munir Khan and Bhutto continued to meet in Europe and Pakistan and exchange views through letters. He also claimed that when Bhutto arrived at the United Nations Security Council during the 1971 Indo-Pakistan crisis over East Pakistan, he had another meeting with him.[24] In his speech at the inauguration of KANUPP, on November 28, 1972, Munir Khan recalled the efforts he and Bhutto had made in persuading President Ayub for acquiring the nuclear option:

> I remember the day in October 1965 when I had the opportunity of discussing with you the tremendous potential which atomic energy had and the role it could play in the development of our country. You (Bhutto) not only listened but insisted that I present my view to higher-ups. I went. But my pleadings made no impact and I was dubbed as another mad man who thought like Zulfikar Ali Bhutto. But the times have changed and so has the destiny of our country.[25]

In his presidential address, the then President Bhutto recalled his association with Munir Khan:

> Since 1965, I have been in close touch with you (Chairman, PAEC) and we have had many occasions to discuss how atomic energy can help in the development of our country. That is why soon after assuming this office, I not only placed the Atomic Energy Commission under my direct control, but asked you to return to the country and serve the nation. I am glad that this Commission is on the move with a well-defined and broad-based programme for the future. I believe that Pakistan's survival lies in using nuclear research, nuclear technology, and nuclear power for the betterment of its people. The Government will give the fullest support to the programme of the Pakistan Atomic Energy Commission and this country will make the necessary resources available to bring the promise of atomic energy to the people of Pakistan at the earliest possible time.[26]

Moreover, in the immediate wake of India's 1974 nuclear test, Prime Minister Bhutto addressed a press conference in Lahore, some parts of which were published in *Pak Atom,* the newsletter of the PAEC. While talking to the media, Bhutto stated that soon after the 1965 war, he had arranged a meeting between the President Ayub and the incumbent Chairman of PAEC in London. The Prime Minister recalled that during this meeting, Munir Khan had put forward a plausible nuclear plan. Had it been accepted

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[24] Ibid.

[25] S.K. Pasha, "Solar Energy and the Guests at KANUPP Opening," *Morning News* (Karachi), November 29, 1972.

[26] Ibid.

then, it would have cost much less (almost one fourth) to Pakistan and it would not have presented any difficulty, as there was no test ban and proliferation treaty.[27] He claimed that, "the plan was rejected by President Ayub who innocently stated that by the time India made her own bomb, so many countries would be having nuclear weapons that Pakistan could purchase it from the world market."[28]

He also added that when he met Indian Prime Minister Nehru in 1960 at the United Nations, he had come to the firm conclusion that India was determined to go nuclear. He added that he had apprised President Ayub and his cabinet of his discussions with Nehru and had pleaded for a nuclear programme, but unfortunately, no credence was given to his conclusion. He claimed that even the Karachi Nuclear Power Plant would not have seen the light of the day if he had not persisted with this project and President Ayub had only reluctantly agreed to sanction the project after great persuasion.[29] A founding member of PPP and Bhutto's Finance Minister, Dr. Mubashir Hasan recalled the widespread political support, which Munir Khan enjoyed among the top ranks of the PPP. In this regard, he claimed that he knew Munir Ahmad Khan as his student in Engineering College, Lahore:

> In the days when he was abroad, he was more political than I was. My interest in politics began in 1966. I was not politically active before but he was from the very beginning. He was interested in the Pakistan Movement and he believed in the acquisition of nuclear power for the greatness of Pakistan. He and I, like Mr. Bhutto, were nationalists. I was very happy when he was made Chairman of the Atomic Energy Commission.

Hassan claimed that he did not like Usmani and termed him a very arrogant person. However, when Munir came to him as he was the Minister of Finance and asked for his support and guidance, he was instantly forthcoming.[30] In this regard, another PPP leader, Farhatullah Babar wrote after Munir Khan's death:

> Munir Ahmad Khan was not afraid to lead and he knew the way. He knew the way as he had spent over a decade in the international atomic organization, had rich technological background and vast international contacts. He was not afraid to lead because of the enormous political support provided by Prime Minister Zulfikar Ali Bhutto. This union

[27] "When Munir Ahmad Khan Presented His Nuclear Plans," *Pak Atom* (May, 1974).
[28] Ibid.
[29] Ibid.
[30] Mubashir Hasan, Former Finance Minister of Pakistan, 1972-1974, interview by authour, tape recording, Lahore, March 17, 2007.

> of the political vision of Bhutto and the zeal of Munir Ahmad Khan proved to be the winning combination to bring Pakistan on the nuclear map. In some ways it was akin to a similar combination in India at the time of independence provided by the country's first Prime Minister, Pundit Jawahar Lal Nehru and the first head of Atomic Energy Commission Dr Homi Jehangir Bhabha.
>
> If in India Nehru's nuclear vision was shaped by Bhabha, the man who gave shape to Bhutto's nuclear vision was Munir Ahmad Khan. Munir Khan knew the Finance Minister Dr. Mubashir Hassan from their days at the Lahore Engineering College. Dr Mubashir held Munir Ahmad Khan in great respect as a committed professional and a sincere Pakistani. With the prime minister and finance minister on his side, himself driven by a passion and aided by a team of dedicated professionals there was no stopping Munir from doing what he was tasked to do. In this respect he was singularly lucky.[31]

Therefore, Munir Khan succeeded in gaining the support, confidence and respect not only of Bhutto, but other leading figures in the emerging Pakistan People's Party. This is not to suggest that he was merely a political appointee, but that he had succeeded in securing the political commitment of the political leadership needed to launch a nuclear weapons programme. This was a radical departure from the days of Dr. Usmani, who was unable to secure the support of and convince President Ayub and his advisors to for the development of the nuclear programme. He was also unable to enjoy the confidence of Z. A. Bhutto and the new political power brokers.

3.3. The Arrival of Munir Ahmad Khan

This section discusses the circumstances, events and the path leading up to Munir Khan's departure from the IAEA and his return to Pakistan that would result in his appointment as Chairman of PAEC. This event would also change the course and orientation of the nuclear programme. When Bhutto took over the reigns of power as President of Pakistan on December 17, 1971, one of the principal steps taken by him was to summon Munir Khan from the IAEA in Vienna. He made a personal call on Munir Khan on December 20, 1972,[32] who later claimed: "At the end of December, 1971, I got a message from him and he asked me to come to Pakistan."[33] On his return to Pakistan, Munir Khan was

[31] Farhatullah Babar, "A Partial Vindication on his Fifth Death Anniversary," *The News* (Islamabad), April 22, 2005.
[32] S.A. Hasnain, op. cit. p. 19.
[33] Munir Ahmad Khan. *Daily Ausaf,* op. cit.

asked to prepare a status report on Pakistan's existing infrastructure with a view to suggest ways and means to decide the future course of action.[34] He toured all PAEC establishments in the country, principally PINSTECH and obtained feedback from the scientists, engineers and staff on what was ailing PAEC and what were their expectations. One PAEC scientist, S. A. Hasnain, who witnessed those events, would thus recall several years later:

> Munir Ahmad Khan got a full month, between Zulfikar Ali Bhutto's personal call to him on 20 December 1971 and the public announcement at Multan on 21 January, 1972, to prepare for his new job. He took the time to visit most of the PAEC establishments, beginning with PINSTECH, to find out for himself what was bothering the scientists. Statements made to him by any disgruntled officers served like an audit, enabling him to find the best solution to each malaise. It soon became obvious that he was coming as Chairman. The detailed inspection of PAEC provided Munir Khan with a first-hand awareness of the major problems facing the Commission and the actions needed to solve them.[35]

Therefore, the above-mentioned report was submitted to President Bhutto prior to the Multan Conference.[36] The report provided an overview on the status of Pakistan's nuclear programme at the time and, more importantly, the state of mind of the scientists and engineers working in PAEC.

3.4. The PAEC Bomb Lobby and the Multan Meeting

This section discusses the dynamics and nature of the PAEC "Bomb Lobby" which called for the re-orientation of the nuclear programme and the removal of Dr. I.H. Usmani. This section also analyses the factors and events leading up to the strengthening of this faction. It also discusses the events leading up to the Multan Conference and how it transformed the shape and direction of Pakistan's nuclear programme.

Apparently, the young scientists and engineers, especially those working at PINSTECH, were disgruntled and unhappy over the management and implementation of various programmes in PAEC. A few days after the Multan Conference, a young scientist anonymously wrote a scathing letter in the English daily *Dawn.* It was directed

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[34] Shahid-ur-Rahman, op. cit., p. 16.
[35] S.A. Hasnain, op. cit. p. 19.
[36] Shahid-ur-Rahman, op. cit., p. 16.

against the top scientific leadership/technocrats heading up the country's nuclear programme and reflected the gloom, frustration and anger amongst the young scientists and engineers in PAEC. He wrote that the outlook for science seemed suddenly to have further darkened. The President's announcement of his already reached decision under wrong advice, at the recent scientists' meeting was an insult to the country's scientists who were called to review the working and programme of PAEC under the direction of Dr. Salam and Dr. Usmani, and with the support of a huge official delegation from the PAEC establishments. The solution of the problems of scientific research and development did not lie in the formation of a Ministry of Science, Technology and Production. The letter also claimed that the working scientists of PAEC, Universities and other scientific organizations were rather unanimous in the opinion that "the PAEC's failure during the previous 12 years had mainly been due to a wrong philosophy, planning and training programme, and wrong priorities in scientific projects under the authority and wisdom of Dr. Usmani as PAEC of Chairman." [37]

The letter alleged that Dr. Usmani, whose philosophy and planning had failed, and who had lost the confidence of the working scientists of the country and who had generated hatred and fear among the scientific community "had been promoted Secretary of the Ministry of Science and Technology to pursue his faulty policies in all scientific organizations of the country." A wave of discontent had spread through the scientific community of the country, not because a Civil Service of Pakistan (CSP) officer had been appointed Secretary of the new Ministry, but because a "CSP-scientist," whose policies and programmes had discredited the scientists in general, had been asked to continue his philosophy on a much larger scale and with infinite powers. The scientists also saw the proposal of setting up a pool of 100 scientists as a first step towards more chaos and harming the scientists working productively abroad.

It was further claimed in the letter that Dr. Salam and Dr. Usmani made a similar move in the early sixties. But when the scientists came back home, they could not keep up their standard, because proper facilities and working conditions were denied to them in a systematic manner. By continual changes, the letter claimed that in the coordination

[37] *Dawn*, January 28, 1972 (Karachi).

of work etc, the future scientific leadership was destroyed to make Dr. Usmani indispensible for many years to come. Any scientist who managed to become Chief Scientific Officer in PAEC was made to leave the Commission before he aspired to the position of a Member of PAEC. Through his wrong policies, the Chairman had only succeeded in arresting the development of any competence that could have been achieved in the vital fields of electronics, nuclear engineering, reactor physics, nuclear materials and plutonium chemistry etc.[38]

The letter further claimed that Dr. Usmani planned to spend about Rs. 500 million in the next 10 years on new buildings and training new manpower to start new, faulty, mono-discipline Institutes. The idea of establishing such institutes was totally rejected at the Peshawar Science Conference in 1971. The working scientists of the country were clear in their minds that there was no need to establish the new Ministry when their research effort and scientific manpower was so limited. Since they had very limited resources to spare for scientific or technological research and development, the solution did not lie in wasting money on a top-heavy, centrally controlled administration at the Ministry level, but at concentrating all efforts at the laboratory level so that the scientists would have more hand-drills and other equipment to make up for lost time.[39]

Therefore, in the days prior to the debacle of East Pakistan, there was considerable consternation, agitation and discontent among the scientists and engineers at PAEC. This was accentuated due to the political crisis in East Pakistan since almost half the manpower at PAEC comprised Bengalis. One young nuclear engineer, Sultan Bashiruddin Mahmood, who came back from the United Kingdom in 1969, claimed that he was posted to the Reactor Operations Division in PINSTECH when his specialization was in nuclear reactor design, stability and systems rather than reactor operations in which he had not experience.[40] He added that there was a lot of political polarization and tension between the Bengalis and other non-Bengalis working in PINSTECH, due to the

[38] Ibid.
[39] Ibid.
[40] Sultan Bashiruddin Mahmood (ex-Director-General, Nuclear Power, PAEC), interview by authour, tape recording, Islamabad, August 3, 2007; Please also see Sultan Bashiruddin Mahmood's interview with Sabir Shakir, *Waqt News Exclusive*, Waqt TV, July 23, 2009. Transcript available at: http://www.pakdef.info/forum/showthread.php?10571-SBM-Interview-on-Pakistan-s-nuclear-program&p=158942#post158942. (accessed, December 15, 2009); Shahid-ur-Rahman, op. cit. p. 18.

ongoing civil strife in East Pakistan. He also claimed that the atmosphere was not conducive for any productive work and PAEC's overall programme was devoid of any life and was directionless.[41]

Moreover, two rival "associations" or unions surfaced in PINSTECH. One signified rebellion against the PAEC establishment, especially the Chairman, Dr. I.H. Usmani, while the other seemed to support the status quo. The rebellious organization was known as the "Association of Nuclear Engineers" that would "fight the case for a Nuclear Pakistan," which was headed by Sultan Bashiruddin Mahmood. This association claimed to be the "Bomb Lobby" in PAEC.[42] The other was known as the "Association of Nuclear Scientists and Engineers" headed by Dr. Zafarullah.

Furthermore, shortly afterwards came the 1971 Indo-Pakistan war and on December 16, 1971, Pakistani forces surrendered in East Pakistan. The next day, about 250 young scientists and engineers from PINSTECH decided to protest against the government of President Yahya Khan and the fall of East Pakistan. Section 144 was imposed by the government to prevent any public protests. This forced the protesting scientists and engineers to walk in rows of two each, separated by a distance of five feet.[43] These rebellious nuclear engineers hastily prepared placards and began their protest march from Faizabad Square in Rawalpindi, moving towards Chandni Chowk and Liaquat Bagh on the Murree Road, where they had decided to hold a protest demonstration. They were stopped at Chandni Chowk where they held small speeches. They declared that what had happened in East Pakistan the day before was "not a military defeat but a technological defeat" and "India would not have dared to attack if Pakistan had the atomic bomb."[44]

This time, the PAEC establishment issued "show cause" notices to these protestors but before any disciplinary action could be taken against them, the transfer of power had taken place and Bhutto assumed the charge of Chief Martial Law Administrator and President of Pakistan. He announced that he was calling a conference

[41] Interview with Mahmood, Ibid.
[42] Ibid.
[43] Ibid.
[44] Ibid.

of senior scientists and engineers on January 10 or 12, 1972, at Quetta.[45] When the young engineers found out about the upcoming conference, the "Association of Nuclear Engineers" sent a telegram to President Bhutto, seeking permission to send some representatives of the young engineers from PINSTECH to express their views. The President responded that they could send three representatives to the conference.[46] The three included Sultan Bashiruddin Mahmood, Chaudhry Abdul Majeed and Mahmood Ahmad Shad and they were asked to reach Multan, where the venue of the conference had been shifted, on their own expense. On arrival in Multan, they went to the Shezan Hotel, where Prof. Abdus Salam and Dr. Usmani were staying.[47]

In order to preempt any agitation or undesirable act on behalf of the three young PINSTECH engineers, Dr. Usmani presented them before Prof. Abdus Salam who asked them to put their views in writing, which would be presented at the meeting. It seems as if they too understood what Prof. Salam wanted, and wrote a two-page speech in which they were full of praise for both of them.[48] Usmani viewed the newly formed Associations of PINSTECH as a plot to oust him and had started a dialogue with its office bearers by convening meetings in PINSTECH encouraging the belligerent scientists to speak out their minds.[49] Often these meetings turned into ugly confrontations. In a last ditch effort, Salam and Usmani tried to restrain the young scientists, urging and telling them to keep the interest of the organization foremost in speeches at the meeting the next day. Both advised the would-be-speakers about what ought to be said or not, but once the meeting got underway, there was no way the speakers could be controlled.[50]

The following day, the Multan conference was held in the garden of the residence of the Chief Minister of Punjab, Nawab Sadiq Hussain Qureshi, under a Shamiana or coloured canopy or tent. Mahmood Ahmad Shad, for some reason, was not allowed to attend the meeting. Hence, only S. B. Mahmood and Chaudhry Abdul Majeed went

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[45] Ibid.
[46] Ibid.
[47] Ibid; Shahid-ur-Rahman, op cit, p. 17
[48] Interview with Mahmood, op. cit.
[49] Shahid-ur-Rahman, op. cit., p. 17.
[50] Interview with Mahmood, op. cit.

there.[51] When the two reached the venue of the meeting, they found out that their names were not marked on any seat. They were able to find some place along side the media persons. The Conference began with Usmani, Salam and Bhutto seated on stage. Usmani was calling each speaker by name, from a list prepared before hand.[52] After some speakers came and went, Mahmood claims to have realized that his name would not be called, so he started raising his hand like a schoolboy. Mahmood further claims that his attempts at gaining attention of Bhutto succeeded as the President looked at him and said: "No, that young man!"[53]

Therefore, he was able to go on stage and make his speech, which symbolized the dissatisfaction among the young men at PINSTECH against Usmani and how they wanted PAEC to move ahead in the wake of the loss of East Pakistan. In this respect, Mahmood claimed to have said:

> So far the people who have spoken before me have told you that you are a very great man and that they are not less than anybody but what is missing is that no one has spoken what Pakistan should do. Sir I tell you that the conductor of the bus, which takes us to PINSTECH, knows better than these scientists sitting here about what Pakistan should do. When the bus stops there, he shouts, Nilore bomb factory, Nilore bomb factory, Nilore bomb factory. That is what the people expect from PAEC, they think a bomb is being made in that factory and that will save this country and that should be the programme of this country. If you go inside, there is no programme at all, nothing practical is being done in these labs, and only the building is there. So what we need to do is to develop a reprocessing plant, uranium enrichment program and Pakistan should acquire the capability to make fuel and ultimately make the bomb.[54]

He was followed by one more speaker who called for the setting up a nuclear medical centre in Quetta, where after Bhutto declared, "No more speakers,"[55] and went on the podium to make his speech. Mahmood claims that Bhutto made the following announcement, which ended the formal proceedings of the meeting:

> We are in a thousand year war with India and Pakistan will never rest and we have to win this war and build the atomic bomb even if we have to eat grass, Therefore, I have

[51] Ibid.
[52] Ibid.
[53] Ibid.
[54] Ibid; Shahid-ur-Rahman, op cit, p. 18; Sultan Bashir Mahmood, Interview with Sabir Shakir, *Waqt News Exclusive*, Waqt News Television, July 23, 2009. Transcript available at: http://www.pakdef.info/forum/showthread.php?10571-SBM-Interview-on-Pakistan-s-nuclear-program&p=158942#post158942. (accessed May 10, 2010).
[55] Interview with Mahmood, op. cit.

> decided to make some immediate changes in the structure of the Atomic Energy Commission. Dr. I.H. Usmani is being made Secretary, Science and Technology and I have brought a young, energetic nuclear engineer, with so many years of exposure and experience at the IAEA, who can steer up this program, Munir Ahmad Khan, who will be the new Chairman of PAEC.[56]

Another nuclear engineer, Mr. Salim Mehmud, who attended the meeting, claimed that Munir Khan was appointed Chairman of PAEC by Bhutto's verbal orders to his Cabinet Secretary. He recalled that Bhutto announced towards the end of his speech: "I hereby appoint Munir Ahmad Khan as Chairman of the Pakistan Atomic Energy Commission."[57] Once Bhutto's speech was over, the participants of the conference mixed freely with each other.[58] Another account claims that following his announcement as the new Chairman of PAEC, Munir Khan who was earlier sitting among the audience, "was asked to take the dais and Dr. Usmani was sent to sit among the audience."[59]

Mahmood also claims that after the meeting was over, Munir Khan met him over tea, and remarked: "You made the best speech today," and "God willing, we will do it!"[60] Dr. Inam-ur-Rahman, who would later build up the Centre for Nuclear Studies under Munir Khan, also attended the Conference. He claims that Usmani had asked President Bhutto not to divert the nuclear programme towards the weapons side.[61] However, Dr. Ishfaq Ahmad, Chairman of PAEC, 1991-2001, claims this was not the case, nor was the "bomb" specifically mentioned during the conference.[62] Thirty-five years later, Dr. Inam-ur-Rahman would offer an overview of the conditions in which Munir Ahmad Khan took over as Chairman of PAEC:

> In December 1971, Mr. Bhutto became President of Pakistan soon after the fall of Dhaka. The country was in a state of shock and utter confusion. The morale of the people was at the lowest ebb. In the backdrop of this situation, Munir Ahmad Khan came in, who had served in the IAEA for about 13 years where he held a very senior position at the Nuclear Power and Reactor Division. In December 1971, he visited various

[56] Ibid.
[57] Salim Mehmud, Speech delivered at the Munir Ahmad Khan Memorial Reference, Pakistan Agricultural Research Council Auditorium, April 29, 2007, Islamabad.
[58] Interview with Mahmood, op cit.
[59] Shahid-ur-Rahman, op cit, p. 18.
[60] Interview with Mahmood, op cit.
[61] Inam-ur-Rahman, Speech delivered at the Munir Ahmad Khan Memorial Reference, op. cit.
[62] Ishfaq Ahmad, Speech, Ibid.

> establishments of PAEC/PINSTECH and held detailed discussions with the scientists and engineers. At that time we did not know him or what was the purpose of his visit. After a few days of this, President Bhutto convened the Multan Conference on Jan. 20, 1972.
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> Here many senior scientists and engineers from PAEC and other organizations were invited to give their views about the future role of PAEC. We were all wondering why the President, who had so much on his hands in those trying days, was paying so much attention to the scientists and engineers in the nuclear field. There were numerous emotional addresses and Mr. Bhutto listened to what everyone had to say very calmly. Dr. I. H. Usmani spoke first. Mr. Bhutto in his speech spoke of the low morale of the people. He vowed that he would vindicate the country's honour. He mentioned that he always wanted Pakistan to go "nuclear" but no body listened to him. Mr. Bhutto in his speech said that now fate had placed him in a position to take decisions. He then announced that Pakistan will make nuclear weapons and the scientists and engineers present in Multan will do it.
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> He also announced that Munir Ahmad Khan would replace Dr. I. H Usmani as chairman of PAEC. Therefore, on that day, January 20, 1972, the defence orientation of the peaceful nuclear programme started. When the decision was taken by President Bhutto to make nuclear weapons, then we understood why Munir Khan had arrived in Pakistan from IAEA in December 1971 and why he was called and why he was holding discussions with all of us.[63]

At the end of his speech, Bhutto asked the assembled scientists: "I want to know how much time you can do it in?"[64] This triggered an outpouring of emotion and jubilation among the young scientists and engineers, many of who tried to out-do the other in giving the shortest possible timeframe for building the bomb. The atmosphere had suddenly become electric.[65] Sakhi Muhammad Bhutta stood on his seat and kept shouting "three years," Mahmood kept repeating "five years," and someone else shouted seven.[66] Another experienced scientist jumped in and broke the magic of the moment. "It isn't like making firecrackers, you know. We don't know how long it will take. It's all nonsense. It can't be done that way."[67] Bhutto, the realist and the politician was amused, when he said: "Well, much as I appreciate your enthusiasm, this is a very serious political decision, which Pakistan must make; so, can do you it?"[68]

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[63] Ibid.
[64] Weismann and Krosney, *The Islamic Bomb,* (New York: Times Books, 1981), p.45.
[65] Ibid.
[66] Interview with Mahmood, op cit.
[67] Weismann and Krosney, op cit, p. 45.
[68] Ibid.

The assembled audience responded: “Yes, we can do it, given the resources and given the facilities.” Bhutto replied: “I shall find you the resources and the facilities.”[69] He went on to say: “I want the bomb in three years.” This captured the mood of the moment and it exalted the enthusiastic scientists and engineers to do their utmost to build the bomb in the shortest possible time. Some other accounts suggest that Bhutto had given a "five year" timeframe to build the bomb.[70] Nevertheless, the deadline was more symbolic and political in nature than is widely perceived, as Pakistan was going down the path of nuclear capability for the first time.

Therefore, with the take over of Bhutto as President of Pakistan, the political support for the nuclear weapons programme was now guaranteed. Moreover, the Multan Conference was used by Bhutto to signal a change of priorities and leadership of the nuclear programme with a new Chairman of PAEC. This, coupled with the public commitment with the scientists and engineers at Multan towards acquiring nuclear capability, constituted a major triumph for the PAEC bomb lobby. Now there would be no doves at PAEC as the bomb decision became the first and foremost priority, and thus the leadership and the manpower saw a common purpose and embarked on the journey together.

3.5. Usmani’s Departure and Change of Guard at PAEC

This section explores the causes and consequences of Dr. Usmani’s replacement as Chairman of PAEC. It also discusses the reasons why Usmani chose to leave PAEC and why he lost Bhutto’s confidence to the extent that he was not invited to the inauguration of KANUPP and would also resign as Secretary, Ministry of Science and Technology. In addition, the section traces the steps taken by Munir Khan soon after assuming office, to gain the confidence of the scientists, engineers and staff and obtain their feedback. This would enable him to develop a new strategy and vision for PAEC, which was necessary in the wake of the entirely new mandate he and PAEC had received at the Multan

[69] Ibid, p. 46
[70] Interview with Mahmood, op cit.

Conference. Following his resignation from the Government of Pakistan in 1973, Usmani spoke to the authors of *The Islamic Bomb* and claimed to have refused Bhutto's directive to begin work on the nuclear option.[71]

It appears that Bhutto and Usmani didn't see eye to eye and probably developed a dislike for each other. Usmani would later claim: "Bhutto was a megalomaniac and I distrusted everything he did in Pakistan."[72] After having resigned from the position of Secretary of the newly created Ministry of Science and Technology and replaced as Chairman of PAEC, Usmani had a discussion with an official of the United States Mission at the IAEA, Vienna, en route to the Stockholm Environment Conference. Apparently, he was trying to enlist US support for his candidature of the post of Director-General, IAEA, in case Dr. Sigvard Eklund did not run again for the same. His interlocutor submitted the following report regarding his discussions with Dr. Usmani, which further adds credence to his stance against the military re-orientation of the nuclear programme as demanded by Bhutto:

> At one point in the conversation, Usmani eluded a remark by Bhutto, which implied a Bhutto criticism of Pakistan's not having done enough in its atomic energy programme to leave a possible option for development of a nuclear weapon capability. In saying this, Usmani emphasized his own personal dedication to assuring that the Pakistani programme had been limited to peaceful objectives. He hoped the programme would continue in the course he had set, with no diversion of resources to possible military applications. Usmani felt confident that Bhutto would ultimately reconsider the matter and come to the inevitable conclusion that Pakistan could not play the game of trying to be a threshold nuclear weapon power. Nonetheless, Usmani more than once hinted that one of the principal reasons he wanted to leave Pakistan was his disagreement with any policy decision, which might divert some of the resources of the Pakistani atomic energy programme away from peaceful applications.[73]

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[71] "In fact, Bhutto asked me to take our nuclear programme to its logical conclusion. But I refused. Pakistan just didn't have the infrastructure for that kind of nuclear programme. I'm not talking about the ability to get ten kilograms of plutonium. I'm talking about the real infrastructure." Weismann and Krosney, op cit, p. 46.

[72] Ibid, p.55.

[73] Paul Wolf, "Pakistan: Partition and Military Succession," Atoms for Peace-Documents from the U.S. National Archives (Discussion with I.H. Usmani, Former Chairman, Pakistan Atomic Energy Commission -Declassified AIRGRAM of the United States, IAEA Mission, Vienna, to the Department of State, June 8, 1972), Available at http://www.icdc.com/~paulwolf/pakistan/usmani8june1972.htm (accessed March 15, 2010).

Usmani also did not mince words for Munir Khan when he remarked to the authors of *The Islamic Bomb* thus: "To Usmani, whom he replaced, Munir Khan is a charlatan, a man whose ambitions were purely personal and whose intrigues in the international arena continue to bring dishonour to Pakistan."[74] Another long-time PAEC official, who served three consecutive Chairmen on their staff, S.N. Burney also recalled the events leading up-to Usmani's replacement as Chairman, PAEC. He claimed:

> The year 1972, however, brought an abrupt end to the Usmani-era. His ouster was heralded with jubilation by some, and as unfortunate by others, a confirmation of his being controversial. He, with a broken heart, left PAEC to head a newly formed Ministry of Science and Technology, an institution which he always described as a 'paper tiger,' to be tried later for prying into the affairs of a friendly country and was compulsorily retired.[75]

Nevertheless, Usmani was unable to secure PAEC's control under his Ministry. He was conspicuously absent at the landmark event in Pakistan's nuclear programme, i.e. the inauguration of KANUPP in November 1972. This demonstrated that he had fallen from grace, at least in the eyes of Bhutto. Usmani had initiated work on the 137 MWe KANUPP nuclear power plant, which was nearing completion when he was replaced as Chairman of PAEC.

When KANUPP was inaugurated, Usmani was apparently not invited at the ceremony, which continued to generate criticism and debate in subsequent years. It re-surfaced at the time of Dr. Usmani's death in 1992. On July 17, 1992, the magazine section of the English daily *Dawn*, carried an article entitled: "The Man Who Built Nuclear Temples."[76] It stated that expect by Prof. Salam, no tributes were paid to the late Dr. Usmani at KANUPP's inauguration in November 1972. In this respect, Munir Khan wrote a letter to the editor in which he gave his version of events:

> It is incorrect to state that no tributes were paid to late Dr. I. H. Usmani at KANUPP's inauguration in November 1972, except by Prof. Salam. In spite of the apparently serious difficulties Dr. Usmani had with the Pakistan government at that time, I went out of the way to state in my speech that 'I wish to pay a tribute to my predecessor for his contributions towards the building of KANUPP.' Notwithstanding any change of heart towards nuclear energy, one must acknowledge his personal contributions towards

[74] Weismann and Krosney, op cit, p. 47.
[75] S. N. Burney, "Death of a Visionary and a Man of Substance," *The News* (Islamabad), June 23, 1992.
[76] "The Man Who Built Nuclear Temples," *Dawn,* July 17, 1992.

> initiation of several important projects and training of manpower, which proved to be valuable in later years.[77]

Dr. Usmani's brother, R. H. Usmani thus responded to Munir Khan's letter:

> I had the dubious honor of being invited to the opening ceremony of KANUPP. It is true that Munir Ahmad Khan did mention the contribution made by his predecessor. Dr. Usmani's name was not mentioned except by Salam and no one was gracious enough to invite him in the opening ceremony. We are prepared to assume that Mr. Munir tried but failed. We know why. By his absence also, Dr. Usmani became conspicuous.[78]

However, the proceedings and speeches made at the inauguration of KANUPP were widely reported in the national press the day after the event. The newspapers also reported that Usmani's name was indeed mentioned by Prof. Salam, and Munir Khan did pay tributes to his predecessor. However, the Chairman of PAEC regretted that Dr. Usmani could not attend the inauguration of KANUPP due to his illness.[79] Nevertheless, the reasons behind his absence were more complex. He had been previously replaced by Bhutto as Chairman of PAEC, and was "promoted" as Secretary Science and Technology. Munir Ahmad Khan took over from Dr. Usmani as Chairman of PAEC, on March 15, 1972.[80]

Therefore, Dr. Usmani's departure from PAEC was unfortunately marked by unpleasant events. He did not enjoy the confidence and trust of the new political leadership, led by Bhutto and was seen as a dove by the PAEC bomb lobby. Consequently, they demanded and got his removal from PAEC but another "outsider" would now take Usmani's place. He was not a dove but was still someone who enjoyed the support and confidence of the majority of PAEC's staff and scientists. He tried to restore and improve the morale of the scientists and engineers. He also sought to instill a feeling of ownership among them with regard to the decisions that would be taken, as their support was crucial for the nuclear programme to meet its logical conclusion.

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[77] Munir Ahmad Khan, letter to the Editor, *Dawn* (Karachi), July 25, 1992.
[78] R.H. Usmani, letter to the Editor, *Dawn* (Karachi), August 10, 1992.
[79] S.K. Pasha, op. cit.
[80] I. H. Qureshi, "Recollections from the Early Days of the PAEC," *The Nucleus,* Vol. 42, Nos. 1-2 (2005), p.11.

3.6. Concluding Comment

From the above discussion, it is evident that Pakistan's nuclear weapons programme had its genesis in the wake of the 1965 war, and due to the consensus reached on the issue between Bhutto and Munir Ahmad Khan. The former provided the political pathway to the bomb, while the latter the roadmap for obtaining the technical means to build the bomb. They were also helped by the events leading up to the breakup of East Pakistan and the growing restlessness and anger among the young scientists and engineers in PAEC who also wanted Pakistan to become a nuclear power as soon as possible. The 1971 Indo-Pakistan war, however, sealed the fate of the civilian nuclear programme which was carefully nurtured by Dr. Usmani, who himself became the victim of the bomb lobby. The radical change in the direction and mandate of the PAEC came during the Multan Conference, and as Munir Ahmad Khan took over as Chairman, it was clear that he was preparing his would-be team for the gigantic task ahead.

From a theoretical standpoint, the above discussion has verified some of the basic assumptions of the approaches, models and paradigms outlined in the first introductory chapter. Bhutto and Munir Ahmad Khan played the roles of nuclear mythmakers for Pakistan as they had succeeded in forming a strong coalition that completely transformed the nuclear decision-making process in Pakistan. In doing so, they were helped by the bomb lobby inside PAEC, comprising the scientists and engineers who wanted Pakistan to develop nuclear weapons. Thus, an increasingly powerful segment of the national elites in Pakistan, who wished to develop nuclear weapons, emphasized the country's insecurity vis-à-vis India. They succeeded in popularizing the rationale that nuclear weapons provide military security. The events of subsequent decades proved that this rationale was based on a perception that was closer to reality. Therefore, these coalitions perpetuated a nuclear myth that enabled the decision-makers to enlist and secure the support of the manpower working in the implementation of various projects.

Moreover, talented and well-placed experts like Munir Ahmad Khan also helped create, and proliferate the thinking that Pakistan should acquire nuclear weapons. He also succeeded in building a strong coalition within the political establishment that reposed the due confidence in his technical leadership and provided him the necessary support to implement the programme. This brought an end to the bureaucratic tussling and pulling and hauling of actors between PAEC and the civil bureaucracy, which characterized the previous era. However, Dr. Usmani's departure from PAEC was the result of a breakup of shared interests and thinking amongst the junior ranks of PAEC and the emerging political elite. There was acute political polarization and bureaucratic rivalries within PAEC that caused the young scientists and engineers to revolt and openly challenge the status quo.

This rebellious group aligned itself with the bomb lobby outside PAEC. Therefore, the above discussion largely validates the assumptions of Scott. D. Sagan's domestic politics and Graham Allison's bureaucratic-politics models in addition to Lavoy's nuclear myth-making models, as outlined in the first chapter. The pulling and hauling of players in important positions resulted in a shake-up of Pakistan's nuclear orientation and led to a change at the top of the nuclear establishment. Internally, the nascent nuclear programme had already suffered as a result of the loss of East Pakistani manpower. The political crisis preceding the 1971 India-Pakistan war had polarized PAEC to the extent that two distinct rival power centers were engaged in bureaucratic tussling between themselves that it had become virtually paralyzed.

Moreover, Munir Ahmad Khan's appointment as Chairman of PAEC at the Multan Conference also proved to be the "proliferation decision" when it was decided that a latent nuclear capability shall be transformed into a weapons capability. Thus, Pakistan's nuclear weapons programme was "socially constructed" as outlined in SCOT theory, where alliances and personal associations changed the course of events and had a direct bearing on the technological dimension of the programme. Hence, the individual interests of the key players on the nuclear scene also played a key role in shaping the future development of Pakistan's nuclear programme. How the bomb lobby went about implementing its plans and the new shape and orientation of the nuclear programme shall be discussed in the following chapters in detail.

CHAPTER 4

FRONT END OF THE NUCLEAR FUEL CYCLE

The previous chapter discussed Pakistan's efforts to establish a civilian nuclear infrastructure, the government's reluctance to initiate work on the nuclear weapons programme, and the eventual ascendency of the "bomb coalition or lobby" after the Multan Conference. In the wake of this meeting, the re-orientation of Pakistan's nuclear programme became increasingly evident, which determined Pakistan's quest to master the nuclear fuel cycle as the next milestone in its nuclear endeavour. The acquisition of a fuel cycle capability enabled Pakistan to become self-reliant in peaceful applications of atomic energy and provided the country with a "nuclear option." However, this effort was littered with technical obstacles, given that Pakistan had to bring about a radical up-turn in the nuclear programme in the wake of the dismemberment of its Eastern wing. In addition, Pakistan had to face international sanctions following India's nuclear test of 1974, which effectively scuttled its efforts to acquire nuclear fuel cycle facilities from Western suppliers. Consequently, Pakistan was forced to embark on completing the development of the nuclear fuel cycle capability indigenously in the face of increasing international restrictions on technology, which is the basic theme of this chapter.

The chapter is divided into two main sections, namely: The Roadmap for Nuclear Capability and India's Nuclear Explosion; and PAEC's Quest for Indigenization in the Fuel Cycle, followed by a conclusion. Section one is further sub-divided into two sections, namely: Bhutto's Approval of the Nuclear Fuel Cycle Plan; and India's Peaceful Nuclear Explosion. Section two is further sub-divided into three main sections, namely: Uranium Prospection and Exploration; Uranium Mining and Refining; Uranium Conversion and Nuclear Fuel Fabrication. These sections shall be discussed and analyzed in detail below, while a brief discussion on the relevant theoretical approaches, paradigms and models in view of the empirical evidence presented will conclude the chapter.

4.1. The Roadmap for Nuclear Capability and India's Nuclear Explosion

This section discusses the steps taken by PAEC to formulate a comprehensive nuclear plan and pathway for the acquisition and establishment of the necessary infrastructure for self-sufficiency in the nuclear fuel cycle. It also discusses the effect, which India's so-called Peaceful Nuclear Explosion (PNE) had on Pakistan's initial plans to achieve this goal.

4.1.1. Bhutto's Approval the Nuclear Fuel Cycle Plan

When Munir Ahmad Khan took over as Chairman of PAEC, his first task was to prepare a comprehensive plan for attaining self-reliance in the nuclear fuel cycle. As he recalled several years later: "The first task of PAEC was to prepare a nuclear plan, build the necessary infrastructure, and develop the required manpower to implement it."[1] He also stated that after becoming Chairman, his first task priority was to complete the nuclear fuel cycle.[2] Therefore, within two months of taking over as Chairman, he submitted a detailed nuclear plan to the President of Pakistan, Zulfkiar Ali Bhutto. In this respect, he claimed in 1999:

> Within two months of that event, we submitted a detailed nuclear plan to the President, which envisaged complete control of the nuclear fuel cycle, and building numerous plants and facilities for the generation and application of nuclear know-how.[3]

Moreover, as uranium enrichment was not being considered at the time, a comprehensive fuel cycle development plan would probably have called for the setting up and acquisition of the following plants and facilities as these were included in PAECs subsequent procurement plans:

1) Uranium Production
    i) Uranium Prospection

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[1] Munir Ahmad Khan, "Development and Significance of Pakistan's Nuclear Capability," in *Pakistan: Founders' Aspirations and Today's Realities,* ed. Hafeez Malik, (Karachi: Oxford University Press, 2001) p. 153.
[2] Shahid-ur-Rahman, *Long Road to Chaghi* (Islamabad: Print Wise Publications, 1999), p, 29.
[3] Munir Ahmad Khan, Speech delivered at the Chaghi Medal Award Ceremony, Pakistan Nuclear Society, PINSTECH Auditorium, Islamabad. March 20, 1999.

ii) Uranium Concentration and Refining Plants.

2) Heavy Water Plant
3) Fuel Fabrication Plant
4) Reprocessing Plant for Plutonium Production
5) Nuclear Materials Laboratories, PINSTECH.

The President of Pakistan approved this nuclear plan within two hours of its submission on May 5, 1972.[4] Munir A. Khan would later claim that President Bhutto addressed Dr. Mubashir Hassan, the then Minister for Finance, and stated: "I hereby abolish all the several committees dealing with Atomic Energy in various Ministries. You give him the money as he puts in a request."[5] Initially, PAEC had planned to acquire the know-how and technology for establishing the planned nuclear fuel cycle facilities and reactors through international cooperation. These would then provide Pakistan with the nuclear option, which could later be used to generate parallel facilities for security purposes.[6]

Moreover, in this respect, Munir Khan later claimed: "Pakistan at that time was keen on acquiring necessary assistance under safeguards because the idea was to develop the essential technology and know-how and trained manpower."[7] However, all the nuclear fuel cycle facilities being acquired from supplier states were to be under IAEA safeguards. Therefore, PAEC entered into agreements with France, Canada and West Germany for the supply of a reprocessing plant, a fuel fabrication plant and a heavy water plant, all under IAEA safeguards.[8] The Chairman of PAEC, travelled to Canada in 1973 to negotiate the purchase of the nuclear fuel fabrication plant for the Canadian supplied KANUPP.[9] Whereas prospects for international cooperation in the nuclear fuel

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[4] Munir Ahmad Khan's Speech, op.cit.

[5] Ibid.

[6] "The initial plan was not to divert or misuse foreign supplied reactors and a reprocessing plant to produce nuclear weapon fuel, but rather to use the know-how gained from this cooperation to indigenously produce parallel capabilities that could yield a bomb." George Perkovich, "Could Anything Be Done To Stop Them?: Lessons from Pakistan," Nonproliferation Policy Education Center, July 26, 2006. www.npec-web.org/Essays/20060726-Perkovich CouldAnythingBeDone.pdf (accessed on December 15, 2008).

[7] Munir Ahmad Khan, "Nuclearisation of South Asia and its Regional and Global Implications," *Regional Studies,* (Islamabad) Vol.26, No. 4 (Autumn 1998).

[8] "Development and Significance of Pakistan's Nuclear Capability," op.cit., p.153.

[9] Munir Ahmad Khan, "How Pakistan Made Nuclear Fuel," *The Nation* (Islamabad), February 7, 1998.

cycle, albeit, under safeguards, still existed, PAEC tried to acquire as many facilities it could. This was being done under a well-thought out and long-term nuclear plan, which enjoyed the complete support of the political leadership. In this regard, the Chairman of PAEC claimed:

> After completing KANUPP, Mr. Bhutto decided to initiate various projects relating to the nuclear fuel cycle, including mining of uranium, fabrication of nuclear fuel, construction of a reprocessing plant and related facilities. [10]

Moreover, it was this support, which helped Pakistan to get on the path of nuclear self-reliance since it demonstrated the importance and urgency, which Bhutto attached to the plans submitted by PAEC. Bhutto also mentioned the comprehensive nuclear plan in his speech at the inauguration of KANUPP:

> Soon after assuming this office, I not only placed the Atomic Energy Commission under my direct control, but asked you to return to the country and serve the nation. I am glad that this Commission is on the move with a well defined and broad-based for the future. I believe that Pakistan's survival lies in using nuclear research, nuclear technology, and nuclear power for the betterment of its people. The Government will give the fullest support to the of the Pakistan Atomic Energy Commission and this country will make the necessary resources available to bring the promise of atomic energy to the people of Pakistan at the earliest possible time.[11]

4.1.2 India’s Peaceful Nuclear Explosion (PNE) and Pakistan’s Response

At 8.05 a.m. on the morning of May 18, 1974, India carried out its first ever test of a nuclear device at the Pokhran test site in the Rajasthan desert, only about fifty miles from the Pakistani border. India had gone nuclear by exploding a device with a yield of about 10 kilotons.[12] In response to India’s nuclear test, on May 19, 1974, the Pakistani Prime Minister Bhutto called a press conference at the Governor’s House, Lahore, to announce Pakistan’s strategy in the face of this new threat. He stated:

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[10] Munir Ahmad Khan, “Bhutto and Nuclear Programme of Pakistan,” *The Muslim* (Islamabad), April 4, 1995.

[11] S.K. Pasha, “Solar Energy and the Guests at KANUPP Opening,” *Morning News* (Karachi), November 29, 1972.

[12] Jeffrey T. Richelson, *Spying on the Bomb* (New York: W.W. Norton & Company Inc. 2006). pp. 232-234.

> There is no need to be alarmed over India's nuclear demonstration. It would indicate that we have already succumbed to the threat. This would be disastrous for our national determination and to maintain the fullness of our independence. Let me make it clear that we are determined not to be intimidated by this threat. I give a solemn pledge to all our countrymen that we will never let Pakistan be a victim of nuclear blackmail. This means not only that we will never surrender our rights or claims because of India's nuclear status, but also that we will not be deflected from our policies by this fateful development. In concrete terms, we will not compromise the right of self-determination of the people of Jammu and Kashmir. Nor will we accept Indian hegemony or domination over the Sub-continent.[13]

Mrs. Indira Gandhi wrote to Bhutto on May 22, 1974 in which she stated:

> We remain fully committed of our traditional policy of developing nuclear energy entirely for peaceful purposes. The recent underground nuclear experiment conducted by our scientists in no way alters this policy. There are no political or foreign policy implications of this test. We remain committed to settle all our differences with Pakistan peacefully through bilateral negotiations in accordance with the Simla Agreement. [14]

Bhutto responded to Indira Gandhi on June 6, 1974 in which he stated:

> It is well established that the testing of a nuclear device is no different from the detonation of a nuclear weapon. Given this indisputable fact, how is it possible for our fears to be assuaged by mere assurances, which may in any case be ignored in subsequent years? Governments change, as do national attitudes. But the acquisition of a capability, which has direct and immediate military consequences, becomes a permanent factor to be reckoned with. I need hardly recall that no non-nuclear-weapon state, including India, considered mere declarations of intent as sufficient to ensure their security in the nuclear age.[15]

In fact, years later, in 1997, one of the architects of Pokhran-1, and former Indian Atomic Energy Commission Chairman, Dr. Raja Ramanna confirmed that India's so-called Peaceful Nuclear Explosion was indeed a nuclear weapon test.[16] On the day India carried out its nuclear test in 1974, the Chairman of PAEC was in Peshawar, on an inspection for setting up of a nuclear agriculture centre and he had planned to brief the press about it as well. He was informed of India's test while he was presiding over a meeting about the proposed agriculture centre. He also got the news of the Indian test on the small transistor radio that he always carried, and as a result, cancelled the press

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[13] Zulfikar Ali Bhutto's Press Conference, May 19, 1974, Lahore; *The Pakistan Times*, May 20, 1974.

[14] George Perkovich, *India's Nuclear Bomb,* op. cit., p. 185.

[15] "The Prime Minister of Pakistan, Z.A. Bhutto's Reply" June, 5,1974, in *Pakistan Horizon*, Vol. 27, No. 3 (Third Quarter 1974), pp. 198–20, quoted in Bhumitra Chakma, " Road to Chaghi: Pakistan's Nuclear Programme, Its Sources and Motivations" *Modern Asian Studies,* Vol. 4, No. 36**,** (2002), pp. 871–912.

[16] Munir Ahmad Khan, "Nuclearization of South Asia and its Regional and Global Implications," op. cit.

conference scheduled in Peshawar. He told one of his colleagues: "you cannot expect me to be talking about onions and tomatoes when India has just exploded a nuclear device close to Pakistan's border,"[17] and refused to meet any journalists. Instead, he went to see Prime Minister Bhutto, who had summoned him in Islamabad and again in Lahore the following day. Two days later, he wrote a carefully drafted piece which articulated Pakistan's response, titled, "Challenge and Response."[18] However, the official newsletter of PAEC, *Pak Atom* thus recalled the events of the day:

> When the Chairman was with the Vice Chancellor, Peshawar University, Mr. Abdul Ali Khan in his office, he received a call from the Prime Minister, summoning him immediately to Rawalpindi in view of India's nuclear explosion carried out on that day. Accordingly he cancelled his engagements, including a press conference, which he was to address in the afternoon and returned to the capital.[19]

Following India's nuclear test, a PAEC meeting was held on May 23, 1974, with Munir Khan in the chair, at its headquarters in Islamabad. It was attended by all the six Members of PAEC, including Prof. Abdus Salam, who had especially arrived from London to attend the meeting.[20] A few days later, Munir Khan announced his reaction to India's nuclear test and pointed towards the shape of things to come in South Asia. He stated: "India's test had opened the floodgates for nuclear weapons and unless decisive action is taken, the membership of the nuclear club will not stop at six."[21] In the wake of India's nuclear test, Bhutto launched a diplomatic offensive. He also wrote to world leaders including President Richard Nixon of the United States. He thus declared: "Pakistan was exposed to a kind of nuclear threat and blackmail unparalleled elsewhere." He added: "if the world community failed to provide political insurance to Pakistan and other countries against nuclear blackmail, these countries would be constrained to launch

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[17] Farhatullah Babar, "Munir Ahmad Khan- A Splendid Contribution," *The Nation* (Islamabad), April 29, 1999.
[18] Ibid.
[19] *PakAtom,* May 1974.
[20] Ibid.
[21] Central Intelligence Agency, "Bhutto Seeks Nuclear Policy Assurances," *National Intelligence Daily*, May 24, 1974.

nuclear programmes of their own."[22] He point out that the assurances provided by the UN Security Council were not enough to allay Pakistan's security concerns.[23]

Moreover, the official newsletter of PAEC, *Pak Atom* assured the nation that: "the Commission will do its part for national welfare and will carry out the task assigned to it,"[24] and "atomic energy was necessary for our progress, economic development and survival."[25] The Chairman of PAEC made these remarks in a televised interview on Pakistan Television and added: "Our priorities were fixed taking into account India's intentions and it aims at providing Pakistan the technical know-how it needs to meet its requirements."[26] Pakistan also urged other non-nuclear states to call upon the nuclear powers and the five permanent members of the United Nations Security Council to extend a nuclear umbrella to those states that were threatened by nuclear blackmail. Prime Minister Bhutto also announced his intention to elicit strong Chinese support through a letter to Beijing for bilateral nuclear cooperation. He had hoped the Chinese would now favourably consider this in the wake of India's nuclear test. Such an agreement did in fact take place two years later in 1976.[27]

As part of the diplomatic offensive to counter India's nuclear threat, Pakistan formally presented a proposal at the United Nations for the setting up of a nuclear free zone in South Asia. The nuclear weapon states and the big powers however abstained, while this proposal did receive the support of the majority of the UN member states. Therefore, it was clear to Pakistan that the world powers had accepted the new reality of a nuclear India in the world and "Pakistan would have to face a *de facto* India alone."[28] Bhutto not only had an acute realization of this reality but also that, "Pakistan had no choice but to acquire essential nuclear technology under safeguards, if possible, without it, if necessary, in order to neutralize India's nuclear edge." [29]

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[22] Ibid.
[23] Central Intelligence Agency, Ibid. May 30, 1974.
[24] *Pak Atom,* op. cit.
[25] Ibid.
[26] Ibid.
[27] Central Intelligence Agency, May 30, 1974, op. cit.
[28] Munir Ahmad Khan, "Development and Significance of Pakistan's Nuclear Capability," op.cit, p. 155.
[29] Ibid.

Pakistan also took up the matter at the IAEA Board of Governors on June 8, 1974. Despite the initial opposition of the industrialized countries on the Board, Pakistan succeeded to have the issue placed on the agenda of the Board meeting for discussion. Even here, most of the industrialized countries did not condemn India while others remained silent. At the end of the debate on this agenda item, one senior official of the IAEA told the Chairman of PAEC: "Even though it was India which had carried out the nuclear explosion, it would be Pakistan which would be punished for that."[30] Therefore, in the wake of India's test of May 18, 1974, the supplier states cancelled agreements for the supply of these facilities. India's nuclear test of May 18, 1974 alarmed Canada to the extent that it halted the shipment of the fuel fabrication plant to Pakistan in November 1974, even as it was lying in port, ready to be shipped to Pakistan.[31]

Furthermore, Canada and other supplier states asked Pakistan to open its nuclear programme for inspections and place all its nuclear facilities under safeguards in addition to signing the NPT. This was the pre-condition which Pakistan had to accept in order to become eligible for continued cooperation in the nuclear field, even if it related to agreements which were made prior to India's 1974 test, and were already under IAEA safeguards. Therefore, in the wake of India's nuclear test, it had become abundantly clear to Pakistan that the supplier states and the international community would only be willing to offer lip-service in Pakistan's favour.

More critical for Pakistan, however, was the looming prospect of international sanctions and restrictions on the supply of nuclear fuel cycle technologies to non-NPT states, of which Pakistan was about to become the first victim. While India had committed the original sin, Pakistan had to pay the price for it. This meant that the only way forward for the country was to shift its focus from international cooperation for acquisition of nuclear fuel cycle facilities to indigenization, while the London or Nuclear Suppliers Group was still a few years away.

[30] Munir Ahmad Khan, "Nuclearization of South Asia and its Regional and Global Implications," op.cit.
[31] Ibid.

4.2. PAEC's Quest for Indigenization in the Fuel Cycle

This section discusses PAEC's plans and attempts to put Pakistan on the path of nuclear self-reliance in the nuclear fuel cycle. It discusses the various initiatives taken with regard to all the important steps needed to master the front end of the fuel cycle. These include uranium exploration, mining and refining, conversion and nuclear fuel fabrication. This section also deals with the technical challenges, which PAEC had to face in the implementation of these projects. It also discusses the bureaucratic rivalry that emerged between PAEC and KRL during the end of the 1970s on the issue of supply of the feedstock of uranium gas needed for centrifuge enrichment at Kahuta.

In the wake of India's nuclear test, PAEC had to devise plans for the completion of these projects indigenously. Therefore, On February 15, 1975, Munir Ahmad Khan obtained formal approval and funding from Prime Minister Bhutto for a US $ 450 million dollars nuclear programme, including fuel cycle facilities, which included:

(a) The building of a centrifuge plant for the enrichment of uranium.
(b) The development of a uranium mine at Baghalchur in Dera Ghazi Khan (BC-1) and Chemical Production Complex in Dera Ghazi Khan.
(c) The inception of a nuclear weapons design programme led by Dr. Riazuddin of the PAEC.[32]

In addition, Bhutto had indicated in a newspaper interview in December 1974 that Iran and the Arab countries had given Pakistan some US $ 450 million in loans, which he said, was just the beginning.[33] While the fuel cycle projects were under way, Munir Khan submitted a comprehensive status report to Prime Minister Bhutto on April 4, 1977, which spelled out that "targets for the completion of various fuel cycle

[32] Dr. Ishfaq Ahmad (Chairman PAEC 1991-2001), quoted in Shahid-ur-Rahman, *Long Road to Chaghi,* (Islamabad: Print Wise Publications, 1999), p. 50.
[33] Weismann and Krosney, *The Islamic Bomb,* (New York: Times Books, 1981), p. 162.

facilities." The latest date for the completion of these facilities was stipulated to be 1979.[34]

4.2.1. Uranium Prospection and Exploration

In 1959, the PAEC had discovered radioactivity in the Swalik Mountain Range in Dera Ghazi Khan (D. G. Khan) in the Punjab province. A 100 km belt had been identified for uranium prospection extending from areas of Rakhi, Baghalchur and Rajanpur as a result of drilling.[35] PAEC began uranium exploration and prospection in 1960, which continued till 1963. The first ever national civil award for uranium exploration was given to Mr. Khalid Aslam, who was a geologist.[36]

Furthermore, in 1970, a pilot plant with a capacity of 10,000 lbs per day for the concentration of uranium ores was designed and fabricated by the scientists and engineers of the Atomic Energy Minerals Centre (AEMC), Lahore. AEMC was the first research establishment of PAEC that was set up by Dr. I.H. Usmani, in 1961. It was a multi-disciplinary research centre for the first generation of PAEC scientists and engineers throughout the 1960s, as PINSTECH was completed and had become fully operational in late 1960s and early 1970s. The AEMC at that time was headed by Dr. Ishfaq Ahmad and the pilot plant was designed and fabricated by Dr. Muhammad Shabbir.[37] Therefore, to acquire complete mastery over the nuclear fuel cycle, the first step taken by PAEC after the 1972 Multan Conference was to expand further exploration of uranium deposits and to refine the uranium that had been already discovered in the 1960s,[38] as the Chairman of PAEC recalled several years later:

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34 Munir Ahmad Khan's Speech, op. cit.

35 Shahid-ur-Rahman, op. cit., p. 69.

36 Dr. Samar Mubarakmand, "A Science Odyssey: Pakistan's Nuclear Emergence," Speech delivered at the Khwarzimic Science Society, Centre of Excellence in Solid State Physics, Punjab University, Lahore, November 30, 1998.

37 Shahid-ur-Rahman, op. cit., pp 69-70.

38 M.A. Chaudhri, "Pakistan's Nuclear History-Separating Myth from Reality". *Defence Journal* (Karachi), Vol. 9, No.10 (May 2006).

> Our first task was to find uranium in Pakistan and master the technology for mining and refining of uranium and making it into pure oxide gas and metal and produce other nuclear minerals, which we needed. [39]

In addition, the PAEC in 1972 began geological surveys to find mine-able deposits of uranium. These were found in several locations in Pakistan, which included the Siwalik Hills, west of Dera Ghazi Khan.[40] This was also a challenge for Pakistan. On December 27, 1973, the Chairman of PAEC announced that large uranium deposits had been discovered in the southern Punjab province.[41] PAEC continued uranium exploration efforts in the early 1980s as well. It continued uranium prospection and exploration through 1981, conducting geological mapping, radiometric measurements, drilling and sub-surface excavations, which revealed the existence of uranium ores at Thatti Nasratti and Isa Khel. These areas were said to possess three zones of uranium ore below the surface.[42]

Moreover, uranium exploration continued in 1983 when PAEC conducted a uranium survey of 60,000 km and discovered significant quantities of uranium ore in the Tharparkar desert in Sind province. Similar deposits were discovered between Mansehra and Thakot in North West Frontier (NWFP) province and in Sonmiani range which indicated the presence of four metric tons of heavy minerals including uranium. Uranium bearing regions were also discovered in the Eastern Potohar region, on both sides of the Indus River.[43] Uranium exploration work continued unabated in the following years as well. Moreover, the PAEC journal *Nucleus* also detailed the development of nuclear minerals in Pakistan. [44]

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[39] Munir Ahmad Khan's Speech, op. cit.
[40] Munir Ahmad Khan, "How Pakistan Made Nuclear Fuel," op. cit.
[41] Nuclear Threat Initiative NTI: "Pakistan Nuclear Chronology" http://www.nti.org/e_research/proPapers/Pakistan/Nuclear/5593_5596.html (accessed on November 20, 2008).
[42] Ibid.
[43] Ibid.
[44] Muhammad Mansoor, "Nuclear Minerals in Pakistan," *The Nucleus,* Vol. 42, Nos. 1-2 (2005), pp. 73-82.

4.2.2. Uranium from Niger

Uranium is the lifeline of a nuclear programme. Pakistan needed uranium to fuel its civilian reactor at KANUPP, for its nuclear fuel cycle projects and its uranium enrichment and plutonium programme. In addition to uranium exploration, mining and refining efforts at home, Pakistan in the late 1970s was able to acquire 110-150 tons of uranium concentrate (yellow cake) from Niger. This consignment of yellow cake from Niger was shipped to Pakistan partly through Libya and the rest by ship from Benin to France and then on to Karachi, Pakistan.[45] The sale of yellow cake by Niger to Pakistan was made under the supervision and knowledge of the IAEA and the French Atomic Energy Commission that possessed the major share in Niger's uranium mines. Pakistan had also pledged to place the uranium obtained from Niger under IAEA safeguards.[46]

Apparently this uranium was intended for manufacturing nuclear fuel for KANUPP in the wake of the cut off of fuel and spare parts by Canada in December 1976. This was triggered by an abrupt shift in Canadian policy after India's nuclear test in 1974.[47] Therefore, from 1978 to 1980, Libya had also purchased about 1000 tons of yellow cake from Niger, and this was not under any IAEA supervision, which meant that this uranium stock was unaccounted for. As some of the uranium Pakistan had bought from Niger was transported to the country via Libya, it is possible that Libya may have added some yellow cake to the Pakistani stock before it was transported on to Pakistan. All this was carried out under the supervision of Qaddafi's trusted aide, Major Abdul Salam Jalloud. Therefore, Pakistan would be under no obligation to place this additional yellow cake under any IAEA supervision or safeguards, which may have allowed Pakistan to supplement its own stocks of yellow cake used in the production of uranium hexafluoride gas, the essential feedstock for uranium enrichment. [48]

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[45] Weismann and Krosney, op. cit., p. 210.
[46] Ibid.
[47] Jeffrey T. Richelson, *Spying on the Bomb,* (New York: W.W. Norton & Company Inc. 2006), p. 338.
[48] Weismann and Krosney, op. cit, p. 212.

Furthermore, Libya's cooperation with Pakistan began soon after Bhutto's visit to Libya in 1972 where he had established an enduring personal relationship with Qaddafi. In the summer of 1973, both Libyan and Pakistani officials were making frequent trips to Paris to shop for French military hardware, especially French Mirage aircraft for their respective air forces, which made Paris a convenient meeting place for them. It was here that Pakistani officials began meeting their Libyan counterparts and held top-secret meetings that took place under the supervision of only a handful of individuals. They reported directly to Bhutto and Munir Khan, who reportedly took Libya's leader Colonel Moammar Qaddafi to a guided tour of KANUPP.[49]

4.2.3. Uranium Mining and Refining

Prior to the 1970s, however, Pakistan had no experience in mining uranium on an industrial scale. A team of young engineers from the AEMC carried out uranium exploration and mining. This was all the more challenging given that skilled labour was scarce, and illiterate.[50] Hence, the need for developing indigenous capabilities in uranium exploration, mining and refining would become more acute after the Canadians halted supplies of nuclear fuel for KANUPP. Pakistan also needed this capability to acquire mastery over the front end of the nuclear fuel cycle and for producing the feedstock for uranium enrichment. Moreover, the quality of the extracted uranium ore posed an additional challenge to PAEC. [51]

Once PAEC was faced with international cut-off of assistance in uranium refining, it launched indigenous efforts in this field.[52] Canada had cut off supplies of

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[49] Ibid, pp. 60- 63.

[50] "How Pakistan Made Nuclear Fuel," op. cit.

[51] "The uranium ore indigenously mined by Pakistan was of relatively low grade and consisted of only a few kilograms of uranium per ton in contrast to uranium ore from Canada, which has a higher concentration of uranium per ton. Therefore, Pakistan's uranium extraction plant had to be designed more carefully, in order to reduce impurities and extract more uranium. Pakistan's uranium extraction was done entirely by chemical, mechanical, and electrical engineers from AEMC, with the assistance of Pakistani industries. As a result, Pakistan was able to complete its uranium yellow cake plant within a year of Canadian withdrawal in 1976." Ibid.

[52] Dr. Muhammad Shabbir quoted in Shahid-ur-Rahman, op. cit, p. 70.

natural uranium fuel and spare parts to KANUPP in December 1976 since Pakistan had refused to sign the NPT or place its nuclear programme under IAEA safeguards. In fact, Pakistan had to face the brunt of the international community's new non-proliferation initiatives that were triggered by India's nuclear explosion in May 1974.[53]

4.2.4. BC-I

Baghachur-1 was the site for the uranium mill, which produced the uranium yellow cake for Pakistan's nuclear programme. With regard to the birth of the Baghalchur-1 or BC-1 project, the PAEC journal *Nucleus* stated:

> Project BC-I, D.G. Khan was established in 1977 to exploit uranium ore deposits at Baghalchur. The project was required to continue exploration at the project site and to add to the known reserves and to also explore other anomalous sites for discovery of more ore deposits in D.G. Khan. Open pit and underground uranium mines were established at Baghalchur North and Baghalchur South. An ore processing plant of 300 tones per day capacity was set up at D.G. Khan to process ore from the mines. The project operations were finally closed in 2000 after completion of the heap leaching operations on the stock piled low-grade ore. In-situ Leach Mining and Processing Project (ISL&MP), Qabul Khel was set up in 1992 by the Atomic Energy Minerals Centre, Lahore. Earlier, pioneering experimental work was carried out by the Centre during 1989-92, in the lab and on the ground, on the application of a new and novel *in situ* leach mining technique.[54]

The low-grade uranium deposits found in areas around D. G. Khan, such as Baghalchur, and the development of indigenous capabilities for an uninterrupted supply of uranium were some of the major challenges, which Pakistan's nuclear programme faced by 1976. Pakistan also faced restrictions in procuring technology and equipment. Thus, to circumvent procurement bottlenecks due to restrictions, PAEC came up with a simple, yet very useful strategy in which a Post Office Box Number (P.O. Box No. 1) for the BC-1 facility was set up in D. G. Khan, through which tenders and advertisements were issued.[55] This equipment to be procured included mineralogical equipment; drilling accessories; sulfuric-acid resistant cast iron pipes; fittings for the sulphuric-acid plant at 100 degrees centigrade; MS and GI Pipes; stainless steel containers; ball and roller

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[53] "Development and Significance of Pakistan's Nuclear Capability," op. cit.
[54] Muhammad Mansoor, op. cit., p. 74.
[55] Shahid-ur-Rahman, op. cit, p. 70.

bearings; portable air compressors and accessories; and other related items. These were acquired through open tenders for delivery at D. G. Khan.[56] While elaborating on the technical challenges faced by PAEC in mining and refining of uranium, Dr. Samar Mubarakmand thus recalled after the 1998 nuclear tests:

> The discovery of uranium and its refinement is a massive, manpower intensive job. 10,000 tons of uranium ore has to be recovered and dug up from the ground to produce enriched uranium for one bomb. So you can imagine the effort that goes into the huge refinement process. The refinement plant was established in a series of smaller plants.[57]

Although BC-I was a separate facility, it may be considered to be integrated with the Chemical Production Complex in terms of its functions and responsibilities. BC-1 comprised an ore storage mill; a ball-grinding mill; a sulfuric acid plant; a solvent extraction plant; and a tunnel drier. Almost all the units of the uranium refining plant were manufactured in Pakistan.[58] It is noteworthy that the uranium refining plant at BC-I was completed within a year of the Canadians cut off of supplies of fuel for KANUPP in 1976. In addition, PAEC also held an exhibition in November 1986 known as, “Atoms for Development Exhibition-1986,” which highlighted its achievements in discovering uranium and its refinement at the uranium mill at D. G. Khan entirely through indigenous efforts.[59]

4.2.5. Uranium Conversion: The Chemical Plants/Production Complex (CPC)

Uranium has to be converted into various compounds before it is suitable to be used either for fabrication of nuclear fuel or as feedstock for uranium enrichment. Therefore, this step constitutes the most difficult technical challenge towards mastering the natural uranium fuel cycle. It also constitutes the most critical step in producing the feedstock for uranium enrichment. That is why PAEC’s Chemical Plants Complex (CPC), where

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[56] Ibid.
[57] Samar Mubarakmand Speech, op cit.
[58] Shahid-ur-Rahman, op. cit, p.71.
[59] Nuclear Threat Initiative NTI: “Pakistan Nuclear Chronology,” op. cit.

all this was accomplished, is seen as an important milestone in Pakistan's nuclear journey. In this respect, in 1999 Munir Khan recalled:

> In D.G. Khan, we built a complex, which perhaps is small by international standards, but is unique in the world, because it receives ore and sand and rocks, and ships out pure finished products of uranium, zirconium and other materials I don't want to name at this point. Like PINSTECH, it is also the pride of Pakistan. [60]

Dr. Mubarakmand also claimed that at least half the steps leading to the development of a nuclear device were completed and mastered in the two PAEC facilities located at BC-1 and CPC.[61] Therefore, Pakistan needed an indigenous yet complex uranium hexafluoride or UF6 plant where hundreds of tons of UF6 gas of very high purity could be produced as "feed" for the gas-centrifuges on a sustained basis. UF6 is the chemical form in which uranium is pumped through the gas-centrifuges and is then enriched through the ultra-high revolutions of thousands of centrifuge machines arranged together in cascades.

Thus, the production of UF6 and the establishment of the Chemical Plants Complex was from the very beginning a critical element of the front end of the nuclear fuel cycle leading up to enrichment and enrichment itself. In addition, coupled with the enrichment plant, this capability was critical to the success or failure of the entire uranium enrichment programme. Pakistan could not rely on foreign supplies of UF6, and it could also not rely on limited foreign imports of uranium hexafluoride from friendly countries, and those too were next to impossible to obtain. Without a dedicated and indigenous UF6 facility, the enrichment plant at Kahuta could never work as an industrial-scale or even a pilot-scale plant producing low or highly enriched uranium, except perhaps as a test-facility for testing the centrifuges.[62] Therefore, the hex or UF6 plant and the centrifuge plant were equally important and pivotal for the success and sustainability of the uranium enrichment programme.

Moreover, the complexity of the UF6 plant meant that it could not be procured off the shelf by Pakistan. This was so because the few companies around the world,

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[60] Munir Ahmad Khan's Speech, op. cit.

[61] Shahid-ur-Rahman, op. cit, p. 67.

[62] Weismann and Krosney, op. cit, p. 218.

which could be of some help in building such a plant, would surely know what its intended purpose would be. Therefore, it had to be built in Pakistan, by Pakistani scientists and engineers, in order to understand the challenges and master the technology involved in developing and running a hexafluoride production facility.[63] Consequently, in 1975-76, PAEC began work on a dedicated Chemical Plants Complex, located in the arid desert landscape of Southern Punjab province, close to the town of D.G. Khan. Apart from security considerations, this area was selected because of the abundance of natural uranium ore.[64] CPC would produce uranium oxide used in making nuclear fuel for KANUPP and uranium hexafluoride gas, which is the form in which uranium is enriched through gas-centrifuges, work on which was launched in early 1976.[65]

As with BC-1, a separate Post Box No 35 was set up for procurements for CPC.[66] Dr. Muhammad Shabbir who headed the CPC for seventeen years from its inception emphasized: “If there is no hex, there cannot be any enrichment and producing hex is no child’s play.” [67] The CPC comprises seven independent chemical plants where UF6 is produced.[68]

1) Uranium Mill, which extracts uranium in the form of yellow cake.
2) A plant to refine yellow cake to produce Ammonium Di-urinate (ADU).
3) Conversion of ADU to Uranium Dioxide (UO2).
4) Plant to produce Hydrofluoric Acid.
5) Plant to produce fluorine gas.

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[63] Ibid.
[64] Shahid-ur-Rahman, op. cit, pp. 65-69.
[65] “One is uranium dioxide which is a metallic powder and which is the input to the Karachi KANNUP reactor. We all know that after the Indian explosion in 1974, the Canadians stopped the supply of fuel for the research reactor. The Canadians said that the streets of Karachi would go dark. We took this as a challenge and we thought that we must be able to make our own reactor fuel. So from the CPC near DG Khan, came uranium dioxide to make fuel for the Karachi reactor. We also started making uranium hexafluoride, which came from the same campus. So the CPC was branching down into 2 products. You are sending uranium dioxide to the Karachi reactor. This is a peaceful use of uranium, a part of the nuclear fuel cycle and we are also making uranium hexafluoride from the same chemical facility, which is now the input material for the enrichment plant at Kahuta. So in the early days of about 1976, the establishment of the infrastructure for nuclear technology had begun and this was an effort we started in parallel in different facilities.” Dr. Samar Mubarakmand, Speech, op. cit.
[66] Shahid-ur-Rahman, op. cit, p. 70.

[67] Ibid, p. 67.
[68] Ibid. p 71.

6) Plant to convert UO_2 to Uranium Tetra Fluoride (UF4).
7) Conversion of UF_4 to Uranium Hexafluoride (UF6).

Therefore, PAEC scientists and engineers had to acquire complete mastery over vacuum and welding technology for precluding any possibility of a potential leak that can be fatal for any human coming in contact with hydrofluoric acids and fluorides. Those working at CPC also had to acquire complete mastery over uranium and nuclear chemistry, especially fluorine chemistry and fluorine being the most reactive of all elements in the periodic table made it a formidable challenge for them.[69] After initial refining at the uranium refining plant, uranium ore concentrate or yellow cake has to be converted into uranium dioxide. Subsequently, the dioxide is reacted with hydrogen fluoride, which involves the production of hydrofluoric acid and fluorine gas, to form uranium tetra-fluoride or UF4. Production of UF4 was a major obstacle in which Dr. Aminuddin Ahmed of PAEC was awarded the first ever Tamgha-i-Imtiaz in 1981.[70]

The UF4 thus obtained is then reacted with fluorine gas to produce uranium hexafluoride gas or UF6. In this regard, basic Research and Development was carried out at the Applied Chemistry Division of PINSTECH. Regarding the ACD, a declassified CIA assessment noted:

> We believe the Applied Chemistry Division at PINSTECH is involved in the conversion of uranium dioxide to uranium tetra-fluoride, UF4, a preliminary step to the production of uranium hexafluoride, UF6, the feed material for the Khan Research Laboratories enrichment plant. Headed by Aminuddin Ahmed, the ACD was established in 1984.[71]

While the CPC, and the development of other fuel cycle projects, was supervised by Dr. Muhammad Yunus who was then PAEC's Director Fuels and Materials.[72] While CPC was being developed in D.G. Khan, it was frequently visited by the Chairman of PAEC where a special landing strip was created. The secrecy of the facility was kept even from high-ranking officials within Pakistan. The former Director-General of Inter-Services-Intelligence (ISI), Lt. Gen. (Retd) Ghulam Jillani Khan, while serving as

[69] Ibid.
[70] Kamal Matinuddin, *Nuclearization of South Asia* (Karachi: Oxford University Press, 2002), p. 101.
[71] Central Intelligence Agency, "Pakistan's Nuclear Weapons Programme: Personnel and Organizations," *Research Paper*, November 1985.
[72] Shahid-ur-Rahman, op. cit. p. 72.

Punjab Governor was not given any information as to the exact nature of the work being carried out at CPC, and Nawaz Sharif, the Chief Minister of Punjab, was also denied access to use the airstrip specifically built for CPC. [73]

4.2.5.1. The Pilot Plant

Western reports during the early 1980s claimed that Pakistan had initially built a small pilot-scale UF6 plant, which would provide the technical basis for mastering the various difficult processes involved in the production of uranium hexafluoride gas. Due to immense complexity in handling various fluorine compounds, it was logical that Pakistani engineers would first build a small pilot-scale plant and then the larger industrial-scale facility. It was estimated that this pilot plant would have the capacity to produce enough uranium hexafluoride gas in a year for at least three Hiroshima size atomic bombs. It was reported in 1981 that this pilot-plant was built at D. G. Khan with the help of a West German chemical engineering firm, CES Kalthof, and it was asserted that with this facility, Pakistan would be able to produce the necessary feedstock for uranium enrichment that would ultimately yield a nuclear bomb. The estimated annual production capacity of CPC is reportedly 200 tons of UF6.[74]

4.2.5.2. UF6 Gas Controversy

For the enrichment programme to succeed, it is essential that the UF6 produced must be of the highest purity and free of any impurities. Some of the impurities in UF6 such as molybdenum hexafluoride or MoF_6 and other oxy-fluoride impurities in UF6 might condense and thereby trigger blockages in the valves and piping of the centrifuges cascades, thus causing the centrifuges to crash. These impurities normally appear at the stage of production of UF4 and if they are not identified and removed, they can pass on into the centrifuge cascades unchecked.[75]

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[73] Ibid, p. 68.
[74] Weismann and Krosney, op. cit, pp. 211 and 218-220.
[75] Robert J. Einhorn, "The Iran Nuclear Issue," Testimony before the Senate Foreign Relations Committee, May 17, 2006 http://www.csis.org/media/csis/congress/ts060517einhorn.pdf (accessed April 30, 2009).

However, when in late 1979, as it was rumored that CPC was having some difficulties in the production of UF6, A. Q. Khan claimed to have been ready for enrichment but was hampered due to supply shortages of UF6 on behalf of PAEC. CPC was encountering some difficulties in the production of fluorine gas. A team of PAEC scientists and engineers headed by Dr. Ishfaq Ahmad, then Member (Technical), and consisting of Dr. Samar Mubarakmand, and Parvez Butt were sent to CPC to help in overcoming any production problems. The matter was resolved through Dr. Abdus Salam's good offices, who sent Shafiq A Butt (S.A. Butt), PAEC's main procurement agent in Europe, to an Italian professor who was reputed to be an expert in fluorine gas. Another team of German experts were consulted who concluded that one fluorine production plant was faulty and needed replacement.[76]

During this time, PAEC scientists and engineers at CPC were able to rectify the problem. The first kilogram of UF6 was produced at CPC on June 30, 1980. Reportedly, Gen. Zia had given Munir Khan a six-month deadline for the production of UF6. In one of the meetings during this crisis at CPC, "one senior PAEC official asked Munir Khan to tell Gen. Zia to wait for a few more weeks, and if PAEC failed by then, he could hang the scientists also."[77] Zia had only hanged Bhutto a few months before. The six-month deadline was finally met and Dr. Ishfaq Ahmad was asked by Munir Khan to personally go to Islamabad from Multan and tell Gen. Zia that PAEC had succeeded. Zia dispatched Gen. K. M. Arif and Ghulam Ishaq Khan to verify the production of UF6 at CPC.[78] In this regard, PAEC officials at CPC claimed that this episode was designed to show that they could not produce the feed material for enrichment of the right quality and in requisite quantities.[79]

Therefore, in January 1980, Munir Khan directed Dr. Samar Mubarakmand to investigate what was wrong at CPC. There was one of the fluorine plants at CPC, built

[76] Shahid-ur-Rehman, op.cit, pp. 72-74.
[77] Ibid, p.73.
[78] Ibid.
[79] "1979-80 was the most difficult period for our project since doubts were being expressed about our ability to operate the plant and produce UF6. When we started producing UF6 and sent it to KRL they were taken by surprise as Dr. A. Q. Khan somehow had become convinced that PAEC would never be able to produce UF6 in required quantities." Ibid.

by the West Germans and it had caught fire, and the Germans had then run away. When he and other PAEC scientists were able to fix the problem with the production of CPC, they stayed there for almost a year and the first ton of UF6 was produced in June 1980. As Dr. Samar Mubarakmand claimed:

> Mr. Munir Ahmad Khan asked me to personally drive the first tone of UF6 to KRL, along with the escort. When I reached there, it was received by Dr. Mansoor of KRL. KRL people were very perturbed and surprised when the first consignment of UF6 reached KRL, they thought we could not produce UF6 on time and then they, on the orders of A. Q. Khan accused that the UF6 of had impurities, which was totally false.
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> A. Q. Khan had accused Munir Khan of deliberately not giving him UF6 and then handing sub-standard UF6 to him and President Zia was seriously concerned about this, and had continued to put pressure on Munir Khan. Once the UF6 was handed over to KRL and they again accused PAEC of wrongdoing and failure, I took Dr. F. H. Hashmi of KRL to CPC and explained the process leading up to the production of UF6 and told him that UF6 has to be pure if it is UF6; otherwise it won't be called UF6. It must have a certain degree of purity.[80]

As stated above, the UF6 supply controversy was followed by a dispute over the quality of the UF6 produced by PAEC. This was sparked by Dr. A. Q. Khan's claim that the UF6 that PAEC had produced for feeding the enrichment plant was not upto the required standards of purity required, which could destroy the centrifuges. The matter was brought to the notice of the President Zia-ul-Haq who deputed Gen. K. M. Arif to probe into the matter. Gen. Arif spoke to A. Q. Khan and KRL officials responsible for handling the UF6 after it was received from PAEC. It was decided to have a sample of the UF6 tested by a foreign laboratory, recommended by A. Q. Khan, to resolve the matter. The foreign laboratory, however, reported that the UF6 produced by CPC was indeed of the right quality.[81]

It is likely that the uranium gas controversy, first over the supply and later quality of UF6, was deliberately triggered as part of the overall intense bureaucratic rivalry between PAEC and KRL. It may have been an attempt to raise doubts about Munir Khan's leadership of PAEC in the eyes of President Zia. In addition, this issue might also have been deliberately generated to create the conditions whereby PAEC's abilities

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[80] Dr. Samar Mubarakmand, (ex-Member, Technical of PAEC), interview by authour, written notes, Islamabad, June 26. 2008.

[81] Shahid-ur-Rahman, op. cit, p.73.

could be brought under severe doubt regarding the production of feedstock for enrichment. If this hypothesis could be proven correct, eventually A. Q. Khan would be able to take control of the uranium refining and conversion projects also, just as he was able to take over the enrichment project in 1976. On the question of supply shortages and quality control, A. Q. Khan may not have been ready for enrichment and therefore may have wanted more time.

Hence, it is likely that the uranium gas controversy provided him the required time by diverting attention. Moreover, CPC produced UF6's first consignment on June 30, 1980, which was turned back by A. Q. Khan. He had complained to Gen. Zia that PAEC was not giving him enough UF6 and that it was of low quality, which turned out to be of the right standard.[82] If the enrichment plant had been fully ready by then, it would have been logical for him to immediately being operations and start feeding UF6 into the centrifuge cascades.

4.2.6. Nuclear Fuel Fabrication

The history of producing indigenous nuclear fuel in Pakistan, like other areas of the nuclear fuel cycle, symbolizes Pakistan's success in mastering critical nuclear technologies in spite of international sanctions. It shows how Pakistani scientists, engineers and technicians were able to develop indigenous technologies and expertise in the nuclear fuel cycle even though many in the West believed otherwise.

When Pakistan signed a contract with Canada in 1965 for the supply of KANUPP, Canada also offered a nuclear fuel fabrication plant, but at that time Pakistan failed to show any interest in availing this offer. KANUPP was completed with Canadian assistance and went into commercial operation in November 1972, and Canadian technical support continued till 1976. Three years earlier, the Chairman of PAEC went to Canada to try to re-negotiate the supply of a nuclear fuel plant that was on offer in

[82] Ibid.

1965.[83] When the President of Atomic Energy of Canada Ltd. expressed his willingness to supply a fuel fabrication plant to Pakistan in 1973, he had cited a similar supply to India. An agreement to this effect was signed in 1973 whereby Canada was to complete the delivery of the supply by 1975. It was also agreed that the IAEA safeguards on KANUPP could be extended to this plant as well. Canada and Pakistan were initially to co-produce nuclear fuel in this plant for the first two years whereafter Pakistan would have to produce the fuel independently. However, in the wake of India's nuclear test in May 1974, there was an abrupt shift in Canada's policy of nuclear cooperation with other countries, in view of its heightened non-proliferation concerns. It was now said that the customer state must sign the NPT and open all its facilities to safeguards to qualify for nuclear technology cooperation and support. While this policy was the result of India's actions, Pakistan had unjustifiably become the victim of India's sins.[84]

Moreover, Canada was unhappy that Pakistan was acquiring reprocessing technology from France. Canada also abruptly halted the shipment of essential equipment for the nuclear fuel plant destined for Pakistan in late 1974, as Pakistan had refused to abide by Canadian demands. Pakistan had already pledged to place this plant under the IAEA, so there seemed to no justification for additional demands to be met by Pakistan. A year later, on December 23, 1976, Canada unilaterally and abruptly cut off the supply of nuclear fuel, heavy water, spare parts and technical support to KANUPP and called back the Canadians working in KANUPP. Therefore, Pakistan had to develop an indigenous nuclear fuel capability and achieve self-reliance in this critical aspect of the nuclear fuel cycle. [85]

As mentioned above, PAEC had intensified uranium exploration efforts from 1972 onwards and had begun working on a uranium extraction and yellow cake production plant by 1976, which was completed within a year. Work on the uranium mining facility at Baghalchur (BC-1) was underway when Canada cut off supplies of nuclear fuel and a full scale uranium refining plant was also set up to obtain pure

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[83] "How Pakistan Made Nuclear Fuel," op. cit.
[84] "Development and Significance of Pakistan's Nuclear Capability," op. cit., p. 155-156.
[85] Ibid.

uranium oxide for manufacture of nuclear fuel for KANUPP from the yellow cake.[86] For the manufacture of indigenous nuclear fuel, a full-fledged nuclear fuel fabrication facility was established by PAEC at Kundian, on the banks of the Indus River. It was adjacent to the Chashma site where a reprocessing plant was being built and a nuclear power reactor was planned but built many years later. Later, this Kundian fuel facility came to be known as the Kundian Nuclear Fuel Complex (KNFC) with an annual capacity of processing 24 metric tons of natural uranium oxide fuel for KANUPP. This facility is not under IAEA safeguards. KNFC reportedly has a capacity of manufacturing 1500 fuel bundles for KANUPP.[87] It is likely that a small zirconium oxide and Zircaloy-4 production plant may also be located at KNFC.

Moreover, at Kundian, the uranium oxide was pressed into small pellets of very high density after being sealed in zircaloy cladding tubes, and then burnt as fuel in a nuclear reactor.[88] One KANUPP fuel bundle was only about half a meter long and eight cm in diameter and consisted of nineteen fuel rods containing uranium pellets, firmly held together by two end plates.[89] It contained only 16 kg of uranium oxide and produced about 8,00,000 KWh of electricity. Considering that the average per capita consumption in Pakistan at the time was 400 KWh/yr, it implied that one bundle could meet the average annual consumption of 2000 persons.[90] In terms of foreign exchange, it saved 230 tons of oil, costing over Rs.1.5m in 1999.[91] This feature of low fuelling cost of a nuclear plant provided great savings in running costs.

The heart of fuel bundle comprised a small pellet measuring roughly two cm in length and 1.5 cm in diameter.[92] This title pellet contained the energy equivalent of 0.5 ton of oil when burnt in KANUPP. Yet when it was discharged, it looked the same except that it lost about a fraction of a gram in weight due to fissioning of uranium. This small loss in weight was converted into energy. Producing this pellet was a tricky thing.

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86 "How Pakistan Made Nuclear Fuel," op. cit.
87 Shahid-ur-Rahman, op. cit., p. 97.
88 "How Pakistan Made Nuclear Fuel," op. cit.
89 Ibid.
90 Ibid.
91 Ibid.
92 Ibid.

It had to be dense and compact so that it did not crumble or disintegrate under intense heat of burning (with a temperature higher than 2000 at its centre). It was made from uranium oxide powder having very small particles of different sizes, which under pressure of compacting locked into each other to form a solid, ceramic pellet. Therefore, PAEC had to carry out considerable research and development to make this product. Originally the rejection rate was high but later on, a very high acceptance rate was achieved which was better than the recommended international standard. This had resulted in considerable saving of uranium.[93] However, this project also presented considerable technical challenges.[94]

Moreover, Pakistani scientists and engineers were also faced with the challenges of not knowing the exact specifications of some of the critical materials and machinery used in the building a fuel fabrication facility and the fuel itself, in addition to a lack of know how regarding certain manufacturing procedures. Foreign support in this regard was also not forthcoming, so Pakistan's local industry was extensively engaged in this endeavour. Pakistan also had to indigenously produce the special materials needed to manufacture the zircaloy tubes into which the uranium oxide pellets are placed and burnt as fuel in a reactor. For this purpose, sands containing heavy amounts of zirconium were discovered on the beaches of Baluchistan and with the help of PINSTECH scientists, a pilot plant was established by PAEC to separate the hafnium to obtain pure zirconium.[95]

While operating KANUPP, it was claimed that not a single fuel pellet produced by Pakistan had failed. PAEC succeeded in producing the first nuclear fuel element for KANUPP in 1978, which was just two years since Canada cut of supplies in 1976. KNFC started production in 1979, and the Chairman of PAEC, at a press conference on August 31, 1980, announced that Pakistan had achieved self-reliance in the manufacture

[93] Ibid.

[94] Recalling the technical challenges in making nuclear fuel, a former PAEC Chairman stated: "Making nuclear fuel for a power reactor on commercial and industrial basis is a very complex technical operation involving high level of competence in chemical, mechanical and materials technologies, high degree of precision and quality control and understanding of reactor physics and nuclear safety. This is why not more than 10 centuries in the world actually produce fuel for use in power reactors starting from uranium mining to complete fabrication, including all the special materials involved. Pakistan in spite of its limited industrial infrastructure is one of these countries." Ibid.

[95] Ibid.

of nuclear fuel from uranium. He also stated that Pakistani scientists had built a nuclear fuel manufacturing plant at Chashma/Kundian. According to him, fuel from the plant had been used in KANUPP during July 1981 to produce electricity for Karachi. He also claimed that the setting-up of the indigenous nuclear fuel production plant would save about US $ 40 million in foreign exchange every year since Pakistan earlier had to depend on foreign suppliers for nuclear fuel. The first Pakistani fuel bundle was loaded on to the core of KANUPP in 1980 and within ten years, the entire core was loaded with Pakistani fuel bundles. [96]

However, when Pakistan fabricated the first nuclear fuel bundle for KANUPP, no developing country was ready to test it, even at a high price.[97] Therefore, PAEC also set up a test-reactor facility during the 1970s at KANUPP to test reactor fuel elements for quality assurance prior to use in the reactor.[98] In this respect Munir Khan added: “I presented the first fuel element for KANUPP to the President of Pakistan two years after Canada cut of supplies, which, I think, is a significant achievement for any developing country.[99] He added that the success at Kundian was the result of a teamwork, which became the hallmark of all Pakistani accomplishments in nuclear science and technology.[100] He also emphasized: “Pakistan produced the first ton of purified uranium oxide and metal before it produced the first ton of copper or any other mineral using local ore and indigenously developed technologies."[101] Further, “it taught Pakistani scientists and engineers about precision engineering, quality control, inspection, and design of complicated tools and machinery.” [102]

A former Director-General, PINSTECH, Dr. N. M. Butt, also recalled that when India initiated the nuclear weapon by exploding the device in May 1974, Canada cut off supplies for KANUPP. Therefore, on the one hand the continuity of operation of nuclear

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[96] Pakistan Atomic Energy Commission-KANUPP http://www.paec.gov.pk/kanupp/ma.htm (accessed on 20 November, 2007).
[97] “Nuclear Technology at All Costs-Munir,” *Dawn* (Karachi), February 20, 1991.
[98] “How Pakistan Made Nuclear Fuel,” op. cit.
[99] Munir Ahmad Khan Speech, op. cit.
[100] Ibid.
[101] Ibid.
[102] Ibid.

reactor at Karachi (the largest city of Pakistan with population of about 10 million) for electric supply to the grid was in danger. On the other hand, the whole nuclear programme for peaceful purposes (educational, agriculture and nuclear medicine for public health) was adversely affected by western embargoes. The embargo alerted the nuclear scientists and engineers of Pakistan and they adopted the strategy of using their own expertise and skills to make things indigenously, which were previously purchased from the Western suppliers. The embargo by the West was therefore beneficial for developing in-house R & D in all high technology branches of nuclear technology.[103]

Consequently, in the next five years or so, after the stopping of reactor fuel supply by Canada for KANUPP, the reactor's fuel was fabricated to the quality specifications of the Canadian fuel. This was done at the materials laboratories of PINSTECH using the indigenous exploration of uranium and by early 1980's on this design, a uranium-fuel factory was established at Kundian. By the late 1980's, the indigenous fuel was already being used in this reactor. Thus from 1988 all the fuel charge of the reactor was locally made. Since then, the reactor, which was thought by Canada to close down within a year of the fuel-embargo, has been operated successfully with indigenous Pakistani fuel. This fuel fabrication technology gave the scientists and engineers the confidence to acquire further expertise in the area of nuclear technology. Therefore, embargoes imposed by the West in fact made Pakistan more nuclear capable rather than hindered its capability. [104]

A 1985 issue of the PAEC journal, *Nucleus*, claimed that Pakistan had joined the small group of countries that explore and mine their own uranium, as well as refine and upgrade it to the required specifications. Moreover, the journal stated that Pakistan could fabricate the refined uranium as fuel, and finally burn it in a commercial power reactor to produce electricity. It further stated:

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[103] N. M. Butt, "Nuclear Radiation Education and Nuclear Science and Technology in Pakistan," Paper presented at the 2nd International Congress on Radiation Education, Debrecen, Hungary, 20-25 August 2002.
[104] Ibid.

> Backed by extensive uranium exploration and mining, the fabrication of safe and satisfactory fuel bundles for the Karachi nuclear power plant has won for Pakistan, the distinction of mastering the technology of the front end of the nuclear fuel cycle.[105]

Thus, by manufacturing indigenous nuclear fuel, Pakistan had successfully mastered the front end of the nuclear fuel cycle. By 1980, the Kundian Nuclear Fuel Complex, the Baghalchur-I uranium mining and milling facility and the Chemical Production Complex had begun commercial-scale production operations. They had begun producing sufficient amounts of high purity yellowcake, uranium hexafluoride gas, uranium metal, uranium oxide and indigenously manufactured nuclear fuel for KANUPP. Moreover, PAEC was able to overcome the technical challenges in the nuclear fuel cycle within a period of five years, beginning in 1975. In 1990, Munir Ahmad Khan was awarded the Hilal-i-Imtiaz civil award for "bringing Pakistan closer to self-reliance in nuclear technology." He was also praised in the award's citation for agreements with China and France for the supply of nuclear power plants and "for acquiring and developing complete nuclear fuel cycle technology for the Karachi power plant."[106]

4.3. Concluding Comment

When PAEC embarked on a nuclear weapons programme in 1972, it was clear that without acquiring mastery over the nuclear fuel cycle, a vibrant and self-reliant nuclear programme, on the civil as well as the military side could not be sustained. Therefore, Pakistan initially opted to acquire fuel cycle facilities and the technology to master this goal, through international cooperation, under safeguards. However, India's nuclear test forced Pakistan to face the brunt of international non-proliferation sanctions when its nuclear programme had just begun its journey towards self-reliance. Therefore, Pakistan had no choice but to develop these facilities indigenously. It was also symbolic as the nuclear establishment had to prove to its people and to the world that it could deliver the goods and master one of the most difficult technologies, which had only been mastered

[105] Nuclear Threat Initiative NTI: "Pakistan Nuclear Chronology," op. cit.
[106] "Pakistan: PAEC Chairman Honoured," *Nucleonics Week,* 22 March 1990, p. 12.

by the developed countries. Pakistan's mastery over the fuel cycle also demonstrated its resolve to develop an indigenous fissile material capability and was therefore an integral part of its nuclear weapons programme.

From the above discussion, it is evident that the coalition amongst the technical and political hawks had succeeded in putting the nuclear programme on an irreversible path of technological development. In this respect, they were pursuing the "proliferation decision" in letter and spirit. Thus, the "technological pull," in addition to the continued ascendency of the Munir Ahmad Khan—Bhutto alliance, ensured the uninterrupted financial and political support for various projects. Moreover, nuclear decision-making on the technical side remained squarely in the hands of the Chairman of PAEC, who enjoyed the Prime Minister's confidence and support. The bomb lobby inside PAEC was also put to effective utilization, as the nuclear programme's workload required their tireless efforts. With regard to the technological momentum gained during the development of the nuclear fuel cycle, it is pertinent to re-visit the technological determinist model.

Moreover, Pakistan's response in the wake of the new international nuclear climate after India's 1974 test can be explained by the "security imperative" based on the rational-actor model. However, bureaucratic politics and the pulling and hauling of players and actors within the nuclear establishment also emerged during this phase. Bureaucratic politics was particulary evident in the case of the uranium gas controversy whereby A. Q. Khan's likely aim was to prove his rivals in PAEC to be incompetent and build a case to extend his sphere of influence over other projects outside his control. The uranium gas controversy occurred at a time when the Chairman of PAEC had lost his patron and friend, Bhutto. The latter had become ineffective as the latter had been overthrown by Gen. Zia and hanged. A new project, the centrifuge enrichment project, to which we shall turn to in greater detail in subsequent chapters, had become part of the nuclear programme. At the time of the uranium gas controversy, it was not under the control of PAEC but under A. Q. Khan.

Furthermore, this controversy also exacerbated the rivalry between two technocrats, Munir Ahmad Khan and A. Q. Khan, wherein the latter's personal ambitions became more obvious. Since heading more projects implied more resources and prestige in the nuclear establishment, it became a matter of contention for A. Q. Khan, who was only heading one project. Nevertheless, Munir Khan continued to head the PAEC and all projects of the nuclear fuel cycle, except enrichment. A. Q. Khan was unable to secure ascendency of his viewpoint, at least in the case of uranium gas controversy. Given that, it can be argued that the nuclear fuel cycle in the context of Pakistan's nuclear weapons programme also had elements of "historical sociology" at play.

Most significantly, the uranium gas controversy demonstrates that bureaucratic-politics had now become a regular feature of Pakistan's nuclear programme. This was the outcome of an intense fued between Munir Ahmad Khan and A. Q. Khan a few years earlier during the formative years of the uranium enrichment project. Thus, successes and momentary setbacks at different times extended beyond any one side's immediate sphere of influence wherein the other tried to sideline the other. However, technological determinism also played its part in propelling PAEC to master the fuel cycle in the face of international sanctions. Hence, technological determinism and bureaucratic-politics appear to be the two most prominent theoretical signposts of Pakistan's efforts to master the front end of the nuclear fuel cycle. In the next chapter, PAEC's efforts to sustain its long-term nuclear plans that were originally conceived by the Munir-Bhutto alliance shall be discussed at length.

CHAPTER 5

THE BACK END OF THE NUCLEAR FUEL CYCLE: POWER AND PRODUCTION REACTOR PROGRAMMES

Pakistan's efforts to develop the front end of the nuclear fuel cycle were discussed in the previous chapter, while this chapter attempts to explore Pakistan's efforts to master the back end of the fuel cycle. The mastery over the complete nuclear fuel cycle is considered as a fundamental pre-requisite for the success of any country's civil or military nuclear programme. This capability can only be achieved by acquiring mastery over the fuel cycle's back end as well, consisting of plutonium production and reprocessing capability, which enables a country to produce weapon or reactor-grade plutonium. Therefore, the following facilities are typically required for developing a plutonium route to nuclear weapons.[1]

In this context, the acquisition of plutonium production capability was a critical element in the long-term nuclear plans of Pakistan's nuclear decision-makers for obtaining fissile material for the atomic bomb. During the Second World War, the United States had worked on both the uranium enrichment and plutonium routes to the bomb in the Manhattan Project. Hence, it was logical that Pakistan would also follow a similar pattern in its nuclear development. This strategy was aimed at harnessing the inherent political and technical advantages of developing both routes as part of the overall nuclear fuel cycle. An additional incentive in developing plutonium capability for

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[1] "The production of plutonium requires uranium deposits; uranium mine; uranium mill (for processing uranium ore containing less than one percent uranium-oxide concentrate of uranium yellowcake); uranium purification plant (to further improve the yellowcake into reactor-grade uranium dioxide); fuel fabrication plant (to manufacture the fuel elements placed in the reactor, including the capability to fabricate zircaloy or aluminum tubing); Research or power reactor moderated by heavy water or graphite; heavy water production plant or reactor-grade production plant; and a reprocessing plant." Rodney W. Jones and Mark G. McDonough, *Tracking Nuclear Proliferation*: *A Guide in Maps and Charts, 1998*, "Appendix J: Manufacturing Nuclear Weapons," (Washington, DC: Carnegie Endowment for International Peace, 1998). (http://www.carnegieendowment.org/Papers/Tracking_AppJ.pdf (accessed on January 15, 2009).

Pakistan was opening the door for developing advanced, compact and sophisticated nuclear and potentially, thermonuclear warheads. Plutonium weapons are also considered to be free of the limitations associated with weapons based on highly enriched uranium, especially with regard to miniaturization of warheads.[2] In this context, these were the primary imperatives for Pakistan to set up a nuclear reactor for producing weapons-grade plutonium along with a reprocessing plant.

Implementation of these plans began in earnest in 1973, which were completed within twenty years. In 1994, *Critical Mass* talked about Pakistan's secret nuclear facilities in PINSTECH, Nilore, Islamabad. In this respect, it stated that Pakistan had begun work in the mid-1980s a top-secret 70 MW plutonium production reactor whose construction and assembly progress was half complete by 1992. It claimed that once complete, this plant could produce plutonium for five weapons per year.[3] Moreover, PAEC's plan since the early 1970s was to go for both routes simultaneously as part of the nuclear fuel cycle and build the infrastructure needed for a plutonium production programme,[4] as recalled by its Chairman:

> We learnt a lot from the operation of KANUPP. On the basis of that knowledge, we broadened our programme, and started building a heavy water plant, a 40 MW plutonium production reactor, and other plants for making tubes of different types, zirconium tubes, and other manufacturing facilities, which have contributed to the Chashma power reactor.[5]

Therefore, to elaborate the above-mentioned points, this chapter comprises three main parts, i.e., Road to Khushab-1; Tritium and Heavy Water Production; and Nuclear Power and Infrastructure Projects. It is primarily focused on the technical and bureaucratic challenges faced by Pakistan in acquiring mastery over the back end of the fuel cycle, the paths chosen and choices made, and the motivations of decision makers in

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[2] John Pike, "Nuclear Weapons Technology," *Militarily Critical Technologies List (MCTL) Part II: Weapons of Mass Destruction Technologies*, (Washington DC: Federation of American Scientists, 2010). www.fas.org/irp/threat/mctl98-2/p2sec05.pdf. (accessed on January 15, 2010).

[3] William E. Burrows and Robert Windrem, *Critical Mass* (London: Simon & Schuster Ltd, 1994), p. 80.

[4] Dr. Riazuddin (Director General National Centre for Physics, ex Member Technical, (PAEC), interview by authour, tape recording, Islamabad, February 15, 2007.

[5] Munir Ahmad Khan, Speech delivered at the Chaghi Medal Award Ceremony, Pakistan Nuclear Society, PINSTECH Auditorium, Islamabad. March 20, 1999.

the pursuit of this technical objective. This chapter also attempts to understand the development of a nuclear power programme, which had to face international embargoes from supplier states, even in civilian uses of atomic energy. The concluding paragraphs attempt to establish linkages between the relevant theoretical approaches, paradigms and models in respect of the empirical evidence presented in the chapter.

5.1. The Road to Khushab-1

This section discusses the preparations made and steps undertaken by Pakistan to develop the know-how and capability for embarking on the first indigenous reactor project at Khushab. Such an unsafeguarded plutonium production reactor was the logical choice for PAEC, as the 137 MWe KANUPP power reactor was under IAEA safeguards and hence its spent fuel could not be diverted for military purposes. Therefore, when PAEC began its enrichment project in 1974, its Directorate of Industrial Liaison or DIL was also asked to carry out a feasibility study for the possible indigenization potential of the future nuclear power programme. Following KANUPP's inauguration in 1972, PAEC realized the importance of indigenous design and manufacture of essential spare parts for the plant.[6]

When PAEC launched its uranium enrichment project, a separate Directorate of Industrial Liaison or DIL was set up in 1975, which was also tasked to carry out a feasibility study for the possible indigenization potential of the future nuclear power programme.[7] An independent Design and Development Division was also set up at KANUPP by Parvez Butt.[8] In this regard, the then head of DIL, Sultan Bashiruddin Mahmood, claimed:

> While we were manufacturing spare parts for KANUPP, we realized that the same skills could be used in making an indigenous reactor. In this endeavour, Mr. Parvez Butt set up a KANUPP spare parts workshop. Simultaneously, planning was also initiated on manufacturing large reactor components. In this effort, a mechanical engineer in KANUPP, Dr. Sardar Ali Khan also made good progress.[9]

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[6] M. Amjad Pervez, "Heavy Manufacturing Facilities of Pakistan Atomic Energy Commission," *The Nucleus*, Vol. 42, Nos.1-2 (2005), p. 97.
[7] Ibid.
[8] Ibid, p. 98.
[9] Sultan Bashiruddin Mahmood (ex-Director-General, Nuclear Power, PAEC), interview by authour, tape recording, Islamabad, August 3, 2007.

Moreover, in 1975, DIL's surveys concluded that sixty per cent reactor components could be manufactured in Pakistan.[10] In 1976, PAEC held a national seminar in Islamabad on indigenous development of nuclear reactors in Pakistan.[11] This seminar was organized by DIL and attended by Secretary, Ministry of Industries and Production, and other relevant bureaucrats along with representatives from industry. It aimed at demonstrating PAEC's resolve and commitment to achieve nuclear self-reliance. Mahmood claims that the Secretary, Ministry of Industries expressed his surprise that the PAEC knew more about industry than the Ministry itself.[12]

This was the first concerted effort to realize the indigenization of nuclear industry in Pakistan. Although DIL was primarily involved in the uranium enrichment project, tapping the country's indigenous, albeit limited, industrial base also had its application to the gas-centrifuge enrichment project. In 1977, this effort was stepped up and DIL published an industrial directory of more than 360 industries[13] surveyed in the past. These included Directories of Industries, Quality Assurance, Testing Laboratories, and was a "who-is-who" in engineering in Pakistan. These directories, published by DIL in 1980,[14] comprised about 1700 pages[15] and it was the first effort of its kind in Pakistan. Also, in the wake of KANUPP's start up, a serious effort was initiated in 1973 to build a large indigenous research reactor. Known as PAKNUR or Pakistan Nuclear Reactor, it was to be based on the pattern of the Canadian Indian Reactor (CIR).[16]

However, work on it was stopped at the preliminary design stage due to manpower and resource constraints. At that time the prevalent opinion within PAEC was to replicate KANUPP and double its capacity.[17] It was also believed that the best reactor technology for Pakistan to adopt as the standard reactor design was CANDU technology, which was thought to be reliable and its know-how was also available. Though this

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[10] Ibid.
[11] Ibid.
[12] Ibid.
[13] Ibid.
[14] "Heavy Manufacturing Facilities of Pakistan Atomic Energy Commission," op. cit., p. 98.
[15] Mahmood, op.cit.
[16] Ibid; Mr. Parvez Butt, Chairman, PAEC 2001-2005, interview by authour, written notes, Islamabad, August, 13, 2008.
[17] Mahmood, op. cit.

project was shelved at the design stage, it was re-activated after twelve years and its Planning Commission Proforma or PC-1 was approved on November 11, 1985.[18] Known as Kundian Chemical Plant or KCP-II, this was an improved version of the CIRUS reactor. In this regard, KCP-II's Project-Director, S. B. Mahmood claimed:

> In Khushab-1 we went to 82% local effort and if I am to look back at my life and look at any technical work, which makes me proud, it is Khushab. We made a nuclear reactor, truly indigenously, from Pakistani soil, using Pakistani manpower, resources and industry and Pakistani materials. I give a lot of credit to Munir Ahmad Khan who showed a lot of courage to go for an indigenous reactor when everyone else was telling him it could not be done. The idea of this reactor was very old, which began with the PAKNUR project in 1972-73. At that time, the idea was to set up a scaled down version of KANUPP, a 50 MWt reactor. But at that time, the nuclear programme was being expanded. The enrichment programme had also begun in 1974 and it was felt that simultaneous expansion of various projects would cause a delay in their completion.[19]

Nevertheless, in order to re-active the indigenous production reactor (PAKNUR/Khushab-1) project in 1985-86, Munir Ahmad Khan called a big meeting in the conference room of PAEC's headquarters.[20] This meeting was attended by two-dozen top directors and Members of PAEC including Dr. Ishfaq Ahmad, Mr. Shafiq, Member (Nuclear Power). The future Project-Director, of KCP-II, who attended the meeting, claimed that the Chairman opened the meeting with the remarks: "We are thinking of building a 50 MWt indigenous plutonium and tritium production reactor."[21] When he sought the opinion of each of the participants, no one in the meeting supported this idea. They were of the view that this idea was too ambitious and Pakistan lacked the capability to build a reactor.[22]

Doubts were raised about the availability of the consultants, designers and technology for the project. When it was Mahmood's turn to speak, he claims to have said: "If today even after thirty years the general consensus is that Pakistan cannot build a reactor, then we have all the reasons for closing PAEC today and it has no reason to

[18] Ibid.
[19] Ibid.
[20] Ibid.
[21] Ibid.
[22] Ibid.

exist also."[23] Following a brief exchange of questions and answers between the Chairman and himself, Mahmood claims to have stated: "Yes, I take full responsibility for the project."[24] He also claimed that some senior officials of PAEC had voiced a lot of criticism for his enthusiasm for the reactor project.[25] This reflected the predominant mood and mindset prevalent at PAEC about the launch of such an ambitious project. Mahmood claims that the skeptical scientists and engineers said that Munir Khan had taken a very wrong decision and Bashiruddin Mahmood had misled the Chairman.[26]

In his view, doubts were raised because those some senior scientists firmly believed that this project was impossible to succeed. Therefore, according to Mahmood, those opposed to the project thought that there was no need to waste money and resources over it. In this respect, Mahmood's claim that various orders for materials and equipment were sometimes delayed may have been the result of initial inertia and doubts within PAEC.[27] This bureaucratic tussling, he believed, was not particularly because of any bad intention on the part of those who were responsible for this attitude, but only for lack of confidence. In his view, cynics were some genuinely good intentioned people who expressed such skepticism of Pakistan's ability to build and complete such a complicated project.[28]

It is plausible that Mahmood's viewpoint about the bureaucratic opposition to this project from certain PAEC quarters was logical given Pakistan's relatively small and underdeveloped industrial base. Some of them may have thought that if such an ambitious project were to fail, PAEC's credibility, and all the effort that would go into its implementation, would be at stake. Therefore, such an effort could be utilized in more promising projects. It is likely that such opinions about the proposed reactor project had emerged because the scope and scale of the task seemed enormous and daunting. The reactor had to be designed, manufactured, and testing of thousands of individual components manufactured, and R & D had to be carried out indigenously. In addition

[23] Ibid.
[24] Ibid.
[25] Ibid.
[26] Ibid.
[27] Ibid.
[28] Ibid.

strict safety criteria had to be met as no single failure could be afforded. Furthermore, KCP-II's Project-Director stated that indigenization efforts were opposed by three categories of people:[29]

a. Those who believed that Pakistan could simply not do it as the country lacked the capability to undertake such a project. This could only be accomplished by the industrialized countries. They were sincere in their intentions but may have been timid in their resolve.
b. The second category comprised people who probably did not wish any indigenization to take place in Pakistan, and who may have been motivated by professional jealousies within PAEC.
c. The third category comprised scientists and engineers who were procurement enthusiasts, and did not want an end to foreign assistance with the benefits associated with such help.

5.1.1. Launch of KCP-II

Nevertheless, in spite of initial reluctance in some PAEC circles, the decision was taken by Munir Ahmad Khan to launch the Khushab-1 reactor project. The President, Gen. Zia-ul-Haq approved the project and issued instructions to PAEC for its commencement.[30] When PAEC launched the KCP-II project in 1985-86, the development strategy that was followed called for the acquisition of the essential equipment and materials even before the design was finalized. This strategy was adopted so that the reactor's design would then be conveniently tailored to the materials and equipment available. Therefore, by the beginning of 1988, much of the vital equipment and materials had been ordered and obtained.[31] A similar strategy was adopted by PAEC when the uranium enrichment project was launched in 1974.[32] Consequently, indigenization and procurements proceeded smoothly and the original plan formulated

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[29] Ibid.
[30] Mark Hibbs, "Zia Orders Pakistan AEC To Design Indigenous Nuclear Reactor," *Nucleonics Week,* November 13, 1986, pp 3-4.
[31] Interview with Mahmood, op. cit.
[32] Ibid.

was implemented upto its completion without any major or abrupt changes. Two Directorates of PAEC, namely, the Scientific Engineering Services (SES) Directorate and the Directorate of Nuclear Power (DNP) were extensively involved in the implementation of the KCP-II project.[33] The SES Directorate played a key role in the indigenous development and construction of the Khushab-1 nuclear reactor and associated facilities.[34] In order to maintain secrecy and develop and indigenous reactor, a consortium of twenty companies in Pakistan was set up that contributed to the development of the KCP-II project. These included Heavy Mechanical Complex (HMC), Heavy Foundry and Forge (HFF), Ittefaq Foundry, Star Mughal Engineering, Pakistan Electron Limited (PEL), DESCON Engineering, KSB Pumps etc.[35]

5.1.2. Manpower Development

The overall development strategy for KCP-II included recruitments of essential manpower and staff for the project. Young engineers from KANUPP and elsewhere were recruited. They included Saeed Ahmad, a mechanical engineer, and Mr. Afzal Haq Rajput,[36] who reportedly supervised the designing of the reactor.[37] The Project-Director

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[33] Central Intelligence Agency, "Pakistan Nuclear Weapons Programme: Personnel and Organizations." Research Paper, Directorate of Intelligence, Central Intelligence Agency, November 1, 1985. CIA Electronic Reading Room. http://www.foia.cia.gov/search.asp.

[34] "The PAEC conducted further studies of the engineering and manufacturing capabilities of Pakistan, and it was found that the local industry was not able to meet all the requirements of the PAEC to design and manufacture equipment and parts owing to insufficient design know-how, lack of precision engineering and adequate manufacturing facilities, flimsy quality assurance and control programmes and testing facilities, etc. Consequently, in 1984 a Scientific and Engineering Services Directorate (SES) was established at Islamabad by merging the afore-mentioned DIL and D&D Division. Besides, the PAEC authorities gave the go-ahead signal to establish workshops in other important projects such as Karachi Nuclear Power Plant, Kundian Chemical Plant-I, Kundian Chemical Plant-II, New Lab Project, Directorate of Technical Development, Optics Lab., etc. The PAEC gave the mandate to the SES to establish infrastructure facilities in design and engineering, fabrication and welding, machining and testing, quality assurance and control, and non-destructive testing to gear up the indigenous manufacturing of mechanical equipment and parts. In line with this policy the SES carried out specific studies, both in the country and abroad, so as to set up production capabilities and to develop sophisticated manufacturing technologies required to produce the requisite mechanical equipment, complex parts and sophisticated components for the PAEC. As a result, the following two projects were conceived and approved by the Government of Pakistan, i.e. Seam less Tube Plant and Nuclear Equipment Workshops." M. Amjad Pervez, "Heavy Manufacturing Facilities of Pakistan Atomic Energy Commission," *The Nucleus*, Vol. 42, Nos. 1-2 (2005), p. 98.

[35] Shahid-ur-Rahman, *Long Road to Chaghi* (Islamabad: Print Wise Publications, 1999), p.96.

[36] Interview with Mahmood, op. cit.

claimed that his vision was not to gather very experienced people, but to recruit young engineers, and then train them according to the projects' requirement. This approach proved to be very successful and the average age of the technical manpower employed in the project was between thirty to thirty-five years, and most of them were non-nuclear engineers.[38] The logic behind this strategy was that young engineers had fresh ideas, were energetic, motivated, achievements oriented and were able and willing to put in a lot of hard work. While the project was proceeding, Mahmood claims that a culture of team spirit was introduced and followed throughout the project till its completion.[39] This strategy was fully endorsed by Munir Khan.[40]

5.1.3. Site Selection and Development

Geographically Khushab was a very difficult site. It spanned an area of about 9500 acres and was envisaged to house additional reactors and related facilities for the future.[41] It was a semi-arid desert landscape. Munir Ahmad Khan had already selected the site and handed it over to Mahmood in 1986.[42] This site may have been chosen due to its proximity with consideration the Pakistan Air Force's (PAF) main air base at Sargodha. Furthermore, other nuclear facilities at Chashma/Kundian were also located close to this site, which provided an additional incentive and responsibility for PAF to defend these facilities confined in a relatively small area. Another reason for the site selection was the absence of any large population centre close by, which would ensure secrecy. In addition, in case of any accident, the site's location minimized chances of minimum loss of life. Nevertheless, the site had brackish underground water and there was little

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[37] Shahid-ur-Rahman, op. cit., p. 95.
[38] Interview with Mahmood, op. cit.
[39] Ibid.
[40] Ibid.
[41] Ibid. In fact, two additional plutonium production reactors, Khushab 2 & 3 have been completed at this site, which have recently gone critical. Please see Paul Brannan, *Steam Emitted From Second Khushab Reactor Cooling Towers; Pakistan May Be Operating Second Reactor,*" Institute for Science and International Security Report, March 24, 2010. http://isis-online.org/isis-reports/detail/steam-emitted-from-second-khushab-reactor-cooling-towers-pakistan-may-be-op/12#images.
[42] Interview with Mahmood, op. cit.

vegetation, therefore there was no shade from the intense summer sun. Temperatures would range between forty to over forty-five degree centigrade.[43]

Hence, the team working on the project was bound to lead a life reminiscent of a tent village. These were some of the geographical and climatic challenges, which the project team had to face and overcome during the construction of the reactor. The site development for the project began in January 1986 along with the design work. Ground excavation of the site began in January 1989 while the first concrete was poured on May 5, 1989.[44] Installation work on the reactor was completed in October 1996 and the reactor went critical on December 24, 1997.[45] Normally eight to ten serious casualties of different nature are suffered during the construction of a nuclear reactor. However, Mahmood claims that no such incident took place when Khushab-1 was being built.[46]

From the start of the project, Western satellites and intelligence sources had succeeded in identifying that an unsafeguarded reactor was being built in Pakistan. However, the security measures taken by PAEC kept them guessing about the real purpose and exact scale of the project. In this regard, Mahmood recalled[47] that he and his colleagues read Western media reports about the reactor and enjoyed the wild guesses and inaccurate estimates about the project made therein. Nevertheless, by 1996, news about the reactor started spreading across the international media. Therefore, Mahmood gave an interview to *Dawn* newspaper in Lahore. This, he claims, was a deliberate attempt to mislead and deceive all those who were following the reactor's development, outside Pakistan. He said that he had described the purpose of the reactor as one solely for research and irradiation of food products, for radiation facilities for making plastics of different types, for making facilities to manufacture special types of fireproof wood, clothing.[48]

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[43] Ibid.
[44] Ibid.
[45] Ibid.
[46] Ibid.
[47] Ibid.
[48] Ibid.

In addition, it was stated that the reactor would have facilities for exploring the effects of irradiation and neutron bombardment on live plants, rabbits and mice.[49] He further claims that this interview had its desired impact, as some western sources reported that it appeared that the Pakistanis did not know what they are doing. During the same time, a report in the Urdu daily *Jang* stated that the Khushab-1 project had no military applications and was not meant to produce weapons-grade plutonium.[50] The intended effect of this interview was that it showed the Project-Director as a confused person who did not know what he was doing. Mahmood claimed[51] that this was exactly his purpose, which was served by the said interview. The project was made operational as per the original plan without any difficulty. While the Khushab-1 reactor project was under construction, a prestigious international nuclear industry journal, *Nuclear Fuel,* suggested in a report in 1988 that "PAEC is 'very proud' of its present capabilities in enrichment, reactor technology, and fuel fabrication, and there was no doubt that PAEC had the means to build the Khushab plant."[52]

Nevertheless, KCP-II was a highly classified and secret project, which was never officially admitted by Pakistan until it was completed and international press reports forced Prime Minister Benazir Bhutto to concede that it was only a "research reactor." She also said that it was only for experimental purposes.[53] Nonetheless, besides a few domestic cynics, western officials and experts continued to express doubts about Pakistan's ability to build such a reactor indigenously. In this regard, in 1992, the United States Department of Defence study claimed that Pakistan lacked the necessary infrastructure to build an indigenous reactor and to test nuclear components. This report also claimed that Pakistan was not self-sufficient in the production of "most important

[49] Ibid.
[50] Daily *Jang* (Lahore), April 10, 1995.
[51] Interview with Mahmood, op. cit.
[52] Mark Hibbs, "German Firm's Exports Raise Concern about Pakistan's Nuclear Capabilities," *Nuclear Fuel*, March 6, 1989, pp. 13-14.
[53] R. Jeffery Smith and Thomas W. Lippman, "Pakistan Building Reactor That May Yield Large Quantities of Plutonium," *Washington Post,* April 8, 1995, p. A20.

nuclear materials, including beryllium, boron carbide, hafnium, zirconium, lithium, graphite and high-purity bismuth."[54]

This fuelled rumours and that Pakistan could never build such a reactor and the reactor was most likely built with active Chinese assistance. Therefore, in the wake of the project's completion and revelation, Munir Khan denied reports of foreign involvement in the project. He insisted that it was the result of indigenous efforts by PAEC scientists and engineers.[55] He also termed the successful completion and commissioning of Khushab-1 reactor as the greatest achievement of nuclear Pakistan.[56]

5.1.4. Reactor Criticality and Completion

The last phase of the reactor was its successful criticality and subsequent commissioning. This was to be the culmination of thirty million man-hours of work put in by hundreds of engineers and technicians.[57] The reactor went critical as per the theoretical calculations had been made several years ago.[58] Soon after the Khushab-1 reactor went critical, Dr. Ishfaq Ahmad, Chairman of PAEC arrived at the site along with the chiefs of the three armed forces. "Now, it was his project."[59] This was the accomplishment of a dream, which PAEC had seen since the early 1970s, so it was logical for Dr. Ishfaq Ahmad to hold the mantle of the project's success with both hands. Mahmood emphasized that Khushab-1 was not only a reactor, but also a complete fuel cycle project:

> We had in the process, made a special fuel factory for making natural uranium metal fuel for it, which was a big challenge for us. We developed hundreds of R&D projects as part of the overall reactor project, and we developed quality assurance science in this process. Even in building civil works, we invented many new techniques. We developed material sciences, and above all we were able to produce a manpower cadre which was then ready to do anything and who believed they can achieve any thing. It was all done by Pakistani manpower, and there were no foreign supervisors, contractors or advisors.[60]

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[54] *The Risk Report,* op. cit.
[55] "Pakistan Needs Help to Make Plutonium and Tritium," *The Risk Report, Wisconson Project on Nuclear Arms Control*, Vol. 1, No. 5 (June 1995), p. 9. http://www.wisconsinproject.org/countries/pakistan/pak-help-pu-tritium.html (accessed on December 15, 2008).
[56] Interview with Mahmood, op. cit.
[57] Ibid.
[58] Ibid.
[59] Ibid.
[60] Ibid.

With regard to China's involvement in the project, he stated that the uranium, the design, the construction, the fuel factory, the heavy water plant, the reactor itself were all made in Pakistan.[61] However, other sources claim that China had assisted Pakistan in building the reactor.[62] Moreover, Khushab-1 is believed to be able to produce 10-15 kg of weapon-grade plutonium or Pu-239. Given that one modern nuclear device requires 3-6 kg of Pu-239, this capacity is sufficient to build two to five weapons.[63] If tritium is used to boost these fission devices, a sophisticated design can use as little as 2-3 kg of Pu-239.[64] The success of the Khushab-1 reactor project and associated nuclear facilities, such a heavy water plant, metal fuel plant etc. was only possible because PAEC had begun basic technical groundwork for undertaking this venture at an early stage.

Therefore, Pakistan was able to launch and eventually complete the Khushab-1 project since the Chairman continued to lobby for the implementation of the original PAEC plan for plutonium production as envisaged and approved in 1972. It was temporarily shelved and suppressed once the uranium enrichment route was initiated, primarily due to financial considerations.[65] In addition, priority had shifted on a crash programme to master the nuclear fuel cycle and build the bomb-making infrastructure. Therefore, the indigenous and safeguards-free reactor project, which many in PAEC believed was far more challenging than other fuel cycle projects, had to wait.

5.2. Tritium Production

Tritium gas, also known as fusion fuel, is used in fission nuclear weapons as an initiator or a booster material for triggering fission chain reaction in atomic bombs. Only about four to five grams of it is required to substantially increase the yield of atomic bombs. [66] Therefore, at about the same time that PAEC was nearing completion of Pakistan's first

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[61] Ibid.
62 Wayne M. Morrison, "China's Proliferation of Weapons of Mass Destruction, Federation of American Scientists, Congressional Research Service Reports, July 15, 1998. http://www.fas.org/spp/starwars/crs/980717CRSWeapons.htm
63 http://www.globalsecurity.org/wmd/world/pakistan/nuke-stockpile.htm (accessed December, 15, 2008).
64 Munir Ahmad Khan, "India's Nuclear Journey," The News (Islamabad), April 5, 1998.
65 Shahid-ur-Rahman, op. cit, p. 29.
[66] Mark Hibbs, "German Firms Exported Tritium Purification Plant to Pakistan," *Nuclear Fuel,* February 6, 1989.

nuclear device in the early 1980s, it also began exploring options for the acquisition of a tritium recovery or production facility that would be able to produce pure tritium.[67] The place to look for such a facility was West Germany. However, it was in 1985 that PAEC finalized an agreement with the West German firm, Linde AG, for the supply of a tritium plant. This was done even as U.S. non-proliferation officials began issuing warnings to the Bonn government that this firm was planning to sell a tritium recovery facility to PAEC.[68]

Notwithstanding the official U.S. warnings that such a facility would enable Pakistan to obtain pure tritium, the German firm Linde AG continued to maintain that this facility would not result in a pure form of tritium, usable in nuclear weapons.[69] However, in 1985, another German firm, NTG Nukleartechnik GmbH (NTG), was given the license to export a tritium plant to Pakistan. In order to comply with West German export regulations, which prohibited the sale of tritium plants, but not heavy water purification facilities, NTG showed the tritium plant to be a "heavy water purifier."[70] Moreover, it was presumed that PAEC would obtain tritium by irradiating Lithiuum-6 targets in an unsafeguarded heavy water research reactor, pointing towards the Khushab-1 reactor.[71] Soon after the installation of the tritium facility at the Khushab Complex in 1987, one of NTG's officials Peter Finke, a forty- five year-old physicist visited Pakistan. Reportedly, he trained PAEC officials in the installation and handling of the tritium plant. In this respect, *Der Speigel* reported in 1989:

> There is no doubt that Munir Ahmad Khan, chief of the Pakistan Nuclear Authority, with whom Finke already had a cup of tea, has secretly developed his country into a nuclear power; the bomb puzzle is complete. He had many individual parts—ranging from transformer sheets to uranium conversion—supplied by small West German firms, using a network of agents to this end.[72]

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[67] Mark Hibbs, "U.S. Repeatedly Warned Germany on Nuclear Exports to Pakistan," *Nuclear Fuel,* March 6, 1989.
[68] Mark Hibbs, "Nuclear Exports to Pakistan Reported," *Der Speigel,* February 20, 1989.
[69] Ibid.
[70] Ibid.
[71] "German Firms Exported Tritium Purification Plant to Pakistan," op. cit.
[72] "Nuclear Exports to Pakistan Reported," op cit.

It further stated that this tritium facility had a capacity of producing 5000-10000 curies or 0.5-1 grams per day of pure tritium-gas per day.[73] Finke, however, later maintained that NTG had only sold a 'pure training plant' to PAEC for the purification of contaminated heavy water being used in KANUPP, and had no connection with nuclear weapons.[74] PAEC succeeded in obtaining tritium knowhow and the "Tritium Removal by Organic Compounds" or TROC system for tritium recovery with the help of NTG's chief, Rudolf Maxmilian Ortmayer. He helped obtain the system from a tritium laboratory in the Max Planck Institute of Plasma Physics, West Germany, while technology transfers were arranged by S. A. Butt and Dr. Hasibullah—PAEC's main procurements officials in Europe.[75] The German equipment, once in Pakistan, was installed and tested on site by Peter Finke on behalf of the supplier, NTG. In July 1988, he demonstrated for his PAEC clients how the complicated glove-compartment plant for the recovery of tritium was to be operated.[76]

This training continued for about two weeks. The tritium plant sold to Pakistan by NTG had a price tag of about DM 2.5-billion ($1.4-million), but a West German legislator said the total value the export was about DM 13-million ($7.2-million).[77] This estimate may have included the more expensive upstream detritiating equipment, used to obtain pure tritium gas. The tritium facility obtained by PAEC may have starting producing tritium before the 1998 nuclear tests. All the nuclear devices tested by PAEC in May 1998 at Chaghi and Kharan were 'boosted fission devices,' which meant that they had indeed used tritium for increasing their yield. [78]

Therefore, PAEC succeeded in obtaining a tritium production and recovery facility which proved to be a critical element in developing advanced, boosted fission

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[73] "German Firms Exported Tritium Purification Plant to Pakistan," op. cit.
[74] "Nuclear Exports to Pakistan Reported," op. cit.
[75] "Tritium Transfer to Nuclear Weapons Programme Detailed", *Nuclear Developments,* July 18, 1990.pp.26-30, quoted in quoted in Andrew Koch and Jennifer Topping, "Pakistan's Nuclear Related Facilities", Center for Nonproliferation Studies Data Abstracts, Monterey Institute of International Studies. 1997. www.cns.miis.edu/pubs/reports/pdfs/9707paki.pdf. (accessed on December 15, 2008).
[76] "Nuclear Exports to Pakistan Reported," op. cit.
[77] "German Firms Exported Tritium Purification Plant to Pakistan", op. cit.
[78] Carey Sublette, Nuclear Weapon Archive-Pakistan: The Year of Testing. http://nuclearweaponarchive.org/Pakistan/PakTests.html (accessed on January 15, 2009).

warheads which were tested in 1998. It has also provided Pakistan with thermonuclear capability and the ability to develop, small, compact and sophisticated warheads, suitable for missile delivery. This was only possible because PAEC had anticipated the need for having a tritium capability along with the start of preparations for launching the plutonium production reactor.

5.3. Heavy Water Plant

This section discusses PAEC's efforts to set up a heavy water plant in Pakistan when the reactor project at Khushab was launched. Heavy water is an essential element in the production of plutonium through heavy water moderated reactors, like Khushab-1, that use natural uranium fuel. That is why heavy water technology and its components are all included in the export control list of the Nuclear Supplier Group states.[79] During 1973-74, PAEC had entered into an agreement with West Germany for the supply of a small heavy water production plant, which was to be under IAEA safeguards. However, in the wake of India's 1974 test, West Germany like other countries, failed to meet its contractual obligations and refused to supply the plant to Pakistan, unless Pakistan signed the NPT.[80]

Therefore, this project was shelved for the time being, while PAEC concentrated on building other fuel cycle projects. When it was decided to re-start work on a planned plutonium production reactor, the need to build a heavy water plant became part of the overall plan as the reactor was to be heavy water moderated. PAEC was able to obtain components for the setting up of a heavy water plant from various European companies through S. A. Butt. The heavy water plant was based on Hydrogen Sulphide exchange technology, whose towers were only manufactured by a handful of companies in Europe.[81] The plant was on the trigger, or export control list of supplier states. An additional complication was that the plant could not be concealed by segregating it in

[79] Federation of American Scientists, "Nuclear Weapons Technology" Section V, www.fas.org/irp/threat/mctl98-2/p2sec05.pdf (accessed on December 18, 2008).
[80] Munir Ahmad Khan, "Nuclearization of South Asia and its Regional and Global Implications," *Regional Studies,* (Islamabad) Vol. 26, No. 4, (Autumn, 1998).
[81] Shahid-ur-Rahman,, op. cit., pp..65-66.

different parts and therefore had to be transported in one piece. For this purpose, an Arab oil magnate was requested to import the facility in the guise of a petrochemical or gas-purification plant. The plant was manufactured according to the specifications of Dr. N. A. Javed, the Project-Director for KCP-I. The size of the plant can be gauged from the fact that it had to be transported to the Karachi port on board a chartered ship of the Pakistan Naval Shipping Corporation.[82]

Once in Karachi, the plant was then transported by road to the Khushab Complex where it was modified by PAEC and installed as per the required specifications.[83] Moreover, PAEC also set up a heavy water up-gradation plant with an annual production capacity of 15 metric tonne at KANUPP.[84] This plant has been fulfilling the heavy water requirements for the power reactor in the wake of Canadian cut off of supplies of heavy water in 1976. The heavy water plant project, known as KCP-I,[85] was built adjacent to the 50 MWt Khushab-1 plutonium production reactor, as part of the Khushab Nuclear Complex. It was designed to meet the requirements of KANUPP and the Khushab-1 reactor. By 1989-90, all major and sensitive equipment had been procured and was available at site.[86] The plant was completed by the time the Khushab reactor became critical and in 1996, its Project-Director, Dr. N.A. Javed was awarded the Sitara-i-Imtiaz in recognition of making Pakistan self-sufficient in heavy water production.[87]

Shortly before completing nineteen years in office, Munir Khan visited the Khushab Nuclear Complex site where the reactor and the heavy water plant were under construction.[88] In 1997, the Urdu daily *Nawa-i-Waqt* reported: “Pakistan has broken western monopoly in the nuclear field by making indigenous heavy water.”[89] It further stated that this heavy water plant would cater to the heavy water needs of the under-

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[82] Ibid.
[83] Ibid.
[84] Ibid, p.96.
[85] Daily *Nawa-i-Waqt,* January 25, 1997.
[86] Interview with Mahmood, op. cit.
[87] Usman Shabbir, “Remembering Unsung Heroes: Munir Ahmad Khan,” *Defence Journal* (Karachi), Vol. 7, No. 10, (May, 2004)
[88] Interview with Mahmood, op. cit.
[89] Daily *Nawa-i-Waqt,* op. cit.

construction Khushab-1 heavy water reactor, KANUPP and future nuclear plants. Therefore with the setting up of a heavy water plant in Pakistan, PAEC's infrastructure for producing weapons-grade plutonium was complete. This not only helped supply KANUPP, which was also a heavy water moderated reactor, but is also likely to meet the needs of new heavy water plutonium production reactors that are presently being set up at the Khushab Nuclear Complex.

5.4. Nuclear Power in Pakistan

This section discusses the development of nuclear power in Pakistan when it was developing nuclear weapons. It traces the various initiatives taken by PAEC in setting up nuclear power reactors and analyzes the reasons for the failure of its anticipated and projected growth. It also deals with the challenges, which Pakistan had to face in developing a peaceful nuclear power programme.

Soon after the commissioning of KANUPP in November 1972, PAEC sought another identical reactor from Canada but this time the Canadians simply refused.[90] Canada had earlier supplied two similar plants to India, but Pakistan was denied any more help in nuclear power even though KANUPP was the first and only nuclear power reactor in Pakistan. Hence, Pakistan had to look for other alternatives and had to develop a sound justification for a nuclear power programme that could attract other foreign suppliers. In pursuit of its nuclear power programme, PAEC invited the IAEA to carry out a long term study for the future energy needs of Pakistan and the role nuclear power could play in fulfilling the same.[91] The IAEA study was carried out by a nuclear power specialist from the Oak Ridge National Laboratory, USA, Mr. James A Lane, who made a strong case for nuclear power in Pakistan.[92] Based on this study, PAEC came up with a long-term nuclear power plan, which envisaged the setting up of twenty-four nuclear power reactors in Pakistan by the end of the century. This would produce 16000 MW of

[90] Munir Ahmad Khan, "Significance of Chashma Plant", *Dawn* (Karachi), August 8, 1993.
[91] Ibid.
[92] Ibid.

electricity and meet two-third electricity requirement of the country.[93] In view of the joint IAEA-PAEC nuclear power plan, a suitable site for setting up another nuclear power reactor had to be selected:

> At least seven sites were selected. The high seismicity along the coastline excluded the possibility of locating new power plants there because of the revised international safety guidelines, which had become more stringent. The site had to have enough water, low population density, and accessibility by rail and roads and capable of housing a number of plants to reduce development costs and have low seismicity.[94]

Therefore, in view of the above criteria, and with the consultation of experts from the U.S, Germany, France, Italy and Spain, the left bank of the Chashma barrage, on the Indus River, was finally selected.[95] Nevertheless Chashma would not just be a site for the next nuclear power plant in Pakistan after KANUPP, but part of a larger nuclear complex:

> It was decided to establish a Nuclear Complex at Chashma consisting of not only power reactors but also fuel fabrication and reprocessing, waste handling and other supporting facilities. The size of the nuclear unit chosen was 600 MWe, which was becoming the standard unit at that time.[96]

Consequently, the next step was to find a prospective supplier for setting up a series of nuclear power plants in Pakistan. When France backed out of reprocessing plant contract, it offered to sell a 600 MWe nuclear power plant to Pakistan, perhaps as a means of compensation.[97] Moreover, while negotiations for the reprocessing plant were in progress, France had offered diverse nuclear cooperation with Pakistan as a pre-condition for Pakistan to agree to French demands with regard to the reprocessing contract.[98] Pakistan had always been interested in developing a large nuclear power programme and was keen to obtain a nuclear power reactor from France. However, both the French supplied reprocessing plant and the power reactor were to be under IAEA

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[93] "Pakistan Makes Achievements in Peaceful Use of Nuclear Energy," Xinhua General Overseas News Service, 27 October 1979; in Lexis-Nexis Academic Universe, 27 October 1979, http://web.lexis-nexis.com/. Quoted in http://www.nti.org/e_research/proPapers/Pakistan/Nuclear/5593_5678.html (accessed on January, 12, 2009).
[94] "Significance of Chashma Plant," op. cit.
[95] Ibid.
[96] Ibid.
[97] Munir Ahmad Khan, "French Nuclear Collaboration with South Asia," *The News* (Islamabad), April 4, 1998.
[98] Ibid.

safeguards. Pakistan saw this as a means to demonstrate its openness regarding the peaceful uses of atomic energy through international cooperation.[99]

The Executive Committee of the National Economic Council (ECNEC) gave its approval for setting up of a 600 MWe power reactor on March 22, 1976 and tender documents for it were to be floated in 1977.[100] However, as France unilaterally cancelled the reprocessing contract with Pakistan, it became more difficult for both countries to agree on the power reactor project. Another reason for Pakistan's failure to utilize this offer was a change of government in Pakistan in July 1977. At this stage, the new military government of Gen. Zia postponed the acquisition of the power reactor from France. In this respect, the Chairman of PAEC later blamed Gen. Zia:

> Then came the political change, which affected many things including this nuclear power plant, which was deferred. The PAEC kept on pressing for the second nuclear power plant but the internal circumstances were not conducive. We lost a great opportunity. The international opinion at that time was not so adverse to supply nuclear power plants to Pakistan and France was still not insisting on the full-scale safeguards or the NPT and had agreed to supply two plants to South Africa.[101]

However, Gen. Zia's regime changed its mind at the end of the 1970s when the oil prices began to shoot up to US $ 40 per barrel, and PAEC again increased efforts to obtain a nuclear power plant from abroad but "had to start all over again."[102] However, when PAEC obtained fresh approval from the government for a nuclear power plant, tenders were floated in 1982, but now the international climate for nuclear exports had altered altogether.[103] The result was that the tender bids attracted a very poor response. Furthermore, PAEC's efforts to get nuclear cooperation from various manufacturers in West Germany, France, Italy and Japan did not bear any fruit.[104] These countries refused to grant permission to their respective nuclear industry to cooperate with Pakistan. Nevertheless, Pakistan achieved a major success in securing nuclear cooperation when it was able to conclude a civil nuclear cooperation agreement with China in 1986. This agreement, was reached after intensive negotiations between the two countries, which

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[99] Munir Ahmad Khan, "Franco-Pakistan Nuclear Relations," *The News* (Islamabad), October 31, 1994.
[100] "Significance of Chashma Plant," op. cit.
[101] Ibid.
[102] Ibid.
[103] Ibid.
[104] Ibid.

began in 1985, and a draft agreement for cooperation in the peaceful uses of atomic energy was finalized in July 1986. The agreement was to be valid for an initial period of thirty years whereafter it could be renewed by both parties.[105]

Pakistan and China also declared this agreement subject to IAEA safeguards so as to re-affirm the peaceful nature of the agreement and dispel apprehensions about nuclear proliferation. It had been originally planned that Munir Ahmad Khan would sign on behalf of Pakistan. As the then Chinese Prime Minister Zhao Zhiang and Foreign Minister were also present at the signing ceremony, it was decided that Sahibzada Yaqub Khan, Pakistan's Foreign Minister would sign on behalf of Pakistan.[106] The signing ceremony took place on September 15, 1986, in Beijing. The Chinese Minister in-charge of the State Science and Technology Commission, Song Zian signed on behalf China. This agreement reportedly stipulated cooperation in areas ranging from power generation, medicine and agriculture and also covered exchange of experts and information.[107]

When Pakistan and China signed this agreement, China had just concluded an agreement with France for the supply of two 900 MWe nuclear power reactors, to be built at Daya Bay in China. At the same time, China had also begun work on building a 300 MWe, Pressurized Water Reactor (PWR) of indigenous design at Qinshan.[108] Thus, PAEC got the opportunity to send its scientists and engineers to visit Qinshan. Although China was not yet fully self-sufficient in the manufacture of pressure vessels, primary pumps, piping and some control equipment for the Qinshan unit, the rest of the reactor was being supplied by Chinese industry.[109] Thereafter, informal discussions began between PAEC and CNNC for the supply of a similar nuclear power reactor in Pakistan. Consequently, when Chinese Prime Minister visited Pakistan in November 1989, an

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[105] U.S. Embassy China Cable- 24244 to State Department, "Pakistan Foreign Minister Visits PRC: Nuclear Cooperation and Afghanistan," 29 September 1986, in State Department FOIA release, William Burr (ed), "China, Pakistan and the Bomb: The Declassified File on U.S. Policy, 1977-1997," *National Security Archive Electronic Briefing Book No. 114, Document No. 15,* March 5, 2004.
[106] Ibid.
[107] Ibid.
[108] "Significance of Chashma Plant," op. cit.
[109] Ibid.

agreement for the supply of a 300 MWe nuclear power plant, similar to the one being built at Qinshan, was reached with the Pakistani Prime Minister Benazir Bhutto.[110]

Mr. Li Peng, the Chinese Premier had stated that Chinese reactor technology was not as advanced as the West, but China would be happy and willing to cooperate with Pakistan for the setting up of a Qinshan-type power reactor in Pakistan.[111] Munir Khan characterized this agreement as a milestone in Pakistan's nuclear programme, as it had broken an international embargo against the supply of nuclear power plants to Pakistan.[112] Negotiations to sort out technical and contractual details began in 1990 and the contract signed on December 31, 1991 for building a 300 MWe nuclear power reactor at Chashma. By this time, China had completed and commissioned the Qinshan plant, which was China's first indigenously designed commercial nuclear power reactor.[113] China and Pakistan signed the contract for the Chashma Nuclear Power Plant-1 or CHASNUPP only sixteen days after China's Qinshan reactor went into operation.[114]

The CHASNUPP-1 or C-1 agreement also covered a significant technology transfer to PAEC and training of its manpower. Unlike KANUPP, when PAEC only sent forty-seven scientists and engineers for training to Canada, the CHASNUPP-1 deal opened the way for PAEC to send hundreds of its scientists and engineers to China for training in commercial nuclear reactor technology.[115] Moreover, PAEC also got the opportunity to involve its manpower in the "design, construction, manufacture, commissioning and operation of the plant."[116] The C-1 contract also envisaged the participation of PAEC in the local manufacture of some components of the reactor along with carrying out a sizeable portion of the civil works of the reactor. Therefore, the C-1

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[110] Ibid.
[111] Ibid.
[112] Nuclear Threat International, "Munir Assures Safety in Nuclear Radiation Utilization," *Dawn* (Karachi), 25 March 1990, p. 12. http://www.nti.org/db/nuclear (accessed on January 15, 2009).
[113] "Significance of Chashma Plant," op. cit.
[114] Parvez Butt, "Economics of Nuclear Power," *The News* (Islamabad), December 11, 1995.
[115] "Significance of Chashma Plant," op. cit.
[116] "Economics of Nuclear Power," op. cit.

deal "was the best bargain Pakistan could have in all respects and has had a profound impact on PAEC's efforts to indigenize nuclear power technology."[117]

However, this reactor deal had critics at home and abroad. Some of them objected to the higher initial investment and questioned China's ability to deliver the plant. The then Prime Minister Nawaz Sharif as well as the Ministries of Finance and Planning overruled the objections and authorized the signing of the agreement. The project had built such a momentum that it could not be stopped.[118] Moreover, prior to the signing of the contract, external pressure was exerted on China by Western countries not to proceed with the agreement. Nevertheless, China decided to go ahead with the deal and honor its commitment to Pakistan.

The Western countries, however, were not alone in opposing the construction of a nuclear power plant in Pakistan. Others inside Pakistan also sought to dissuade the government from the C-1 project and questioned the feasibility of going ahead with it. A. Q. Khan, the Project-Director of the centrifuge plant at Kahuta, visited China in 1990. Upon his return, he wrote a handwritten letter on February 18, 1990, to Prime Minister Benazir Bhutto regarding the proposed agreement between PAEC and CNNC for the supply of the 300 MWe Qinshan nuclear power plant to Pakistan. He wrote: "I believe that for rapid industrialization and to meet the shortage of power, we must concentrate initially on thermal power stations.[119] Nevertheless, PAEC proceeded with the construction of the reactor despite opposition. This was yet another example of intense bureaucratic tussling between Munir Ahmad Khan and A.Q. Khan.

Following the 1989 CHASNUPP-1 agreement between China and Pakistan, France once again showed its willingness and interest in resuming nuclear energy cooperation with Pakistan. President Mitterrand of France was impressed by the resumption of democratic rule in Pakistan in 1989 and he invited Prime Minister Benazir Bhutto to pay an official visit to Paris. During this visit held in July 1989, the Pakistani Prime Minister explained Pakistan's pressing energy requirements and France was keen

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[117] Ibid.
[118] "Significance of Chashma Plant," op. cit.
[119] A.Q. Khan, Letter to Prime Minister Benazir Bhutto, February 18, 1990, Islamabad.

to offer compensation for not being able to honor its contractual obligations with regard to the reprocessing plant deal with Pakistan. Foreign Minister Sahibzada Yaqub Khan assisted Benazir Bhutto in her talks with President Mitterrand, while Munir Ahmad Khan specially flew to Paris to participate in the negotiations.[120]

France had indicated in 1987 that it was ready to resume negotiations about fresh proposals on nuclear cooperation, if Pakistan did not press with the issue of compensation for the reprocessing plant.[121] Pakistan had argued that the issue of compensation and the supply of a nuclear power plant should be taken together. Nevertheless, during the Pakistani Prime Minister's visit, France agreed in principle for the supply of a 900 MWe nuclear power reactor to Pakistan. After being re-elected for another seven-year term, President Mitterrand of France paid an official visit to Pakistan in February 1990. In a joint press conference in Islamabad with Benazir Bhutto, he announced that France had agreed to pay compensation to Pakistan for the reprocessing plant and to supply a 900 MWe power reactor. France also did not demand full-scope safeguards for Pakistan's nuclear programme or signing the NPT as a pre-condition for nuclear cooperation.[122]

However, after President Ghulam Ishaq Khan dismissed Benazir Bhutto's government in August 1990, the supply of the French nuclear power reactor went into cold storage and the succeeding government did not pay any attention to the matter.[123] When the next Benazir Bhutto government came in power in Pakistan in 1993, she tried to re-open the matter. But by this time, President Mitterrand was not as powerful as he was earlier, as a new Prime Minister from a different political party had come into power in France.[124] Also, in 1994, France had signed the NPT and had been a founder member of the Nuclear Supplier's Group (NSG). The NSG members had jointly agreed not to supply nuclear facilities or power reactors to any country that had not signed the NPT.[125]

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[120] Arif Nizami, "France to Supply 1000 MW N-Plant," *The Nation* (Islamabad), July 17, 1989.
[121] Ibid.
[122] "Franco-Pakistan Nuclear Relations," op. cit.
[123] Ibid.
[124] Ibid.
[125] Ibid.

Since Pakistan was not willing to sign the NPT unless India did the same, it became difficult for France to honor its commitment to supply a 900 MWe reactor to Pakistan.

Therefore, despite internal opposition within from certain quarters in Pakistan, and the international non-proliferation climate, PAEC succeeded in acquiring nuclear power reactors. In 1972-73, PAEC's programme was very ambitious and widely advertised. However, India's nuclear test and Pakistan's subsequent denial to sign the NPT and its nuclear weapons programme proved to be major obstacles in its implementation. However, despite these odds, PAEC continued efforts to explore avenues for international cooperation in atomic energy for peaceful purposes, and eventually succeeded, albeit, at a limited scale in 1986.

5.5. Nuclear Infrastructure Projects

This section explores the various initiatives taken by PAEC for indigenization and self-reliance in different fields of design and engineering of nuclear facilities. These were initiated in the early 1980s and have contributed towards the indigenous completion of several projects of strategic importance. In this regard, soon after the inauguration of KANUPP, PAEC had recognized the importance of developing indigenous high-technology manufacturing capabilities to reduce dependence on foreign procurements. This was particularly necessary with regard to anticipated local design and development of spare parts for KANUPP. Therefore, market surveys of local engineering industries were carried out in 1974.[126] Subsequently, as stated above, PAEC established the Directorate of Industrial Liaison (DIL) in 1975 and Design and Development (D&D) Division in KANUPP in 1976. By 1980, the industrial surveys carried out by DIL were published in the form of a Directory. These steps proved to be useful since the Indian nuclear test of 1974 had seriously jeopardized PAEC's long-term nuclear power programme of setting up a number of nuclear power plants through international cooperation.[127]

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[126] "Heavy Manufacturing Facilities of Pakistan Atomic Energy Commission," op. cit. p. 97.
[127] Ibid, p. 98.

Moreover, Canada also cut off supplies of fuel and spare-parts for KANUPP in December 1976. Therefore, PAEC was forced to embark on a systematic indigenization programme to keep KANUPP running and to develop indigenous capabilities for the nuclear power programme.[128] Thus, PAEC continued further studies of local engineering and manufacturing potential of Pakistan, and concluded that all the requirements of PAEC could not be met by these industries. These industries lacked in precision engineering, sufficient design know-how, precision manufacturing, quality control and testing capabilities needed for a large nuclear programme.[129] Consequently, in 1984, a new Scientific and Engineering Services (SES) Directorate was established in PAEC by merging DIL and KANUPP's D&D division.[130] As stated earlier, "PAEC gave the mandate to SES to establish infrastructure facilities in design and engineering, fabrication and welding, machining and testing, quality assurance and control, and non-destructive testing to gear up the indigenous manufacturing of mechanical equipment and parts."[131] In parallel, PAEC also set up precision engineering workshops for various projects. These projects included KANUPP, Kundian Chemical Plant-I (heavy water plant), Kundian Chemical Plant-II (Khushab reactor project), New Labs project, Directorate of Technical Development (DTD) and Optic Labs etc.[132]

Furthermore, in January 1987, a high-level meeting was held, presided over by the Prime Minister of Pakistan and attended by the Chairman of PAEC, Munir Ahmad Khan. In this meeting, the Government of Pakistan approved seven infrastructure projects for enhancing self-reliance in nuclear power. In the wake of the approval of this infrastructure indigenization plan, and to carry out its mandate, SES was tasked to set up precision manufacturing facilities that met the required standards for various PAEC projects. SES was initially headed by S. B. Mahmood, and when the Khushab reactor project was launched in 1986, he was succeeded as head of SES by Parvez Butt.

[128] Ibid.
[129] Ibid.
[130] Ibid.
[131] Ibid.
[132] Ibid.

Therefore, to implement its mandate, SES initiated the development of the following important infrastructure projects:[133]

5.5.1. Seamless Tube Plant (STP), Kundian

The SES established the STP project, which is part of the Kundian Nuclear Fuel Complex and manufactures seamless tubes used in nuclear reactors in addition to catering to the needs of the engineering sector in Pakistan.

5.5.2. Nuclear Equipment Workshop (NEW) project

This project comprises the following three sub-projects:

5.5.2.1. Nuclear Equipment Workshop-1, NEW-1, Islamabad.

The NEW-1 project started serving PAEC's needs as early as 1986 but was completed and reached full operation capacity in 1992.[134] This project is equipped with manufacturing facilities that can produce small to medium sized pressure vessels, heat exchangers, storage tanks etc. It has served the "design, development, manufacturing of mechanical and process equipment, fabrication of steel structures up to twenty tons, development and promotion of welding technology, NDT training and certification, etc."[135] NEW-1 also comprises a design and development division, which is equipped with Computer Numerically Controlled (CNC) machines for precision manufacturing and assembling of equipment.[136] In addition NEW-1 comprises the following institutions:[137]

5.5.2.2. Pakistan Welding Institute (PWI)

[133] Ibid.
[134] Ibid.
[135] Ibid.
[136] Ibid.
[137] Ibid.

The PWI is "equipped with very specialized welding facilities to undertake Submerged Arc Welding, Gas Tungsten Arc Welding / Tungsten Inert Gas Welding, Shielded Metal Arc Welding, Flux Core Arc Welding, Gas Metal Arc Welding, etc." PWI is also engaged in carrying out "qualification and certification programmes for welding procedures and welders" as well as quality control and establishing standards and procedures for welding industry in Pakistan. It is also involved in research and development and manpower training in welding technology in Pakistan.

5.5.2.3. National Centre for Non-Destructive Testing (NCNDT)

PAEC has been engaged in Non-Destructive Testing since 1974 and a NDT Laboratory was established in 1985.[138]

5.5.2.4. The NEW-II, Karachi

The NEW-II project was made partially operational in 1981, and was completed in 1992. It consists of high-precision machining workshops and a specialized foundry for small and medium sized jobs. It has provided specialized components to various projects of national importance and to local industries. NEW-II can perform all types of machining operations, such as turning, milling, and drilling with a precision of ±5 microns per metre.[139]

5.5.3. NEW-III/ HMC-3 Project, Taxila.

The NEW-I and NEW-II Projects were of great significance and vital importance for the R & D and production of nuclear equipment in Pakistan. However, these were not equipped with heavy and precision manufacturing facilities. Therefore, the NEW-III project was initiated.[140] In this regard, Parvez Butt recalled that the Chairman of PAEC

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[138] Pakistan Atomic Energy Commission- National Centre for Non-Destructive Testing www.paec.gov.pk/ncndt/about.htm (accessed, January 15, 2009).
[139] "Heavy Manufacturing Facilities of Pakistan Atomic Energy Commission," op. cit., p. 99.
[140] Ibid.

was of the view that given the lack of heavy manufacturing facilities in Pakistan, it needed to build one of its own.[141] This was believed to be vital for indigenization of nuclear technology in Pakistan. The third phase of the NEW project mainly consisted of setting up a Precision and Heavy Manufacturing Worship together with the ancillary facilities of equipment design office, a welding institute, and necessary development laboratories, etc. Detailed plans for this phase were worked out in cooperation with China.[142] The NEW-III project was primarily envisaged to:

> Design and manufacture heavy equipment, sophisticated components and complex parts for nuclear set-ups of the PAEC. However, its scope was extended to design, manufacturing and testing of jobs for energy, chemical and petro-chemical, and other industrial sectors.[143]

The proposal for preparing a master plan detailed design of this project was approved on February 1 1989, by the Chairman of PAEC. This was followed by tapping different sources for the project's implementation, which led to the signing of a contract between PAEC and Shanghai Boiler Works, China, on November 9, 1991.[144] This company was tasked with the preparation of the design and master plan for the NEW-III project. Once a detailed design and implementation scheme for the establishment of NEW-III was finalized, PAEC and the State Engineering Corporation, Government of Pakistan, concluded a Joint Venture Agreement on May 17, 1992. It was intended for the construction of the NEW-III project, which was re-named as Heavy Mechanical Complex-3 or HMC-3, Taxila.[145] This project was completed in three phases, i.e Phase A, B and C, which extended from 1993-97, 1997-99 and the third phase was completed in the following years. The President of Pakistan laid the foundations of the construction of the HMC-3 project on May 6, 1996, where as the construction activities had begun in November 1992.[146]

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[141] Parvez Butt, Chairman of PAEC 2001-2005, interview by authour, written notes, Islamabad, August 13, 2008.
[142] "Heavy Manufacturing Facilities of Pakistan Atomic Energy Commission," op. cit., p. 99.
[143] Ibid, p.99.
[144] Ibid.
[145] Ibid.
[146] Ibid, p.100.

Furthermore, PAEC also entered into an agreement with the Seventh Institute of Nuclear Industries (SINI), on June 28, 1992, for the design of civil works of the large and heavy steel structures and other buildings of the project. However, the rest of the smaller buildings and structures were designed by engineers of the Works and Services Organization (WASO), PAEC and HMC-3.[147] The PAEC's SES Directorate was created with the mandate for the development of indigenous capabilities for a large variety of equipment and facilities. HMC-3 workshops began partial production activities in 1996. HMC-3 has more than 1,100 professional employees comprising graduate, post-graduate and Ph.D engineers and scientists, qualified and skilled technicians, and well-trained workers. It is one of the largest design, engineering and manufacturing projects in the heavy engineering sector of Pakistan.[148]

A study carried out in 1997 with regard to indigenization of a 900 MWe nuclear power plant suggested: "HMC-3 would be able to produce about 10 per cent of electro-mechanical equipment for conventional and nuclear islands worth US$ 72 million."[149] In order to meet international quality assurance standards, HMC-3 is ISO-9001 certified for design and manufacture of engineering products for medium and heavy industries.[150] HMC-3 comprises a Design, Engineering and Development Division, Manufacturing Division and a Quality Assurance and Control Division in addition to a Sales and Marketing Division.[151] HMC-3 was equipped and designed for heavy engineering and manufacturing capabilities.[152]

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[147] Ibid, p.99.
[148] Ibid, pp. 100-101.
[149] Ibid. p. 101.
[150] Ibid, p. 104.
[151] Ibid. p. 102.
[152] "The design, development, manufacturing and testing capability of the HMC-3 Project cover a wide range of thick-walled high-pressure vessels, sophisticated process equipment, complex machine components and heavy steel structure products for power, chemical, petro-chemical, processing and industrial projects. Some of the items included in the production programme of HMC-3 are high pressure vessels, boiler drums, chemical vessels, water and steam drums, storage flasks, cylinders and tanks, heat exchangers, high pressure heaters, air pre-heaters, columns, distillation towers, chemical reactors, CO2 absorbers, hydro-cracking reactors, condensers, high pressure piping, penstocks and hydel turbine components, heating furnaces, roller supporters, welding positioners, shot blasting equipment, electrical overhead cranes, heavy steel structures, dish ends and numerous other mechanical components, equipment and spare parts. The HMC-3 Project has the manufacturing capacity to produce mechanical equipment of various types totaling 13,000 tons per year on a single-shift basis. Heavy cutting and forming facilities,

HMC-3 has collaborated with various Pakistani science and technology and research organizations such as the National University of Science and Technology. It has also exported equipment worth millions of dollars to the European Organization of Nuclear Research (CERN), Switzerland and has also signed another memorandum of understanding to supply equipment worth US$ 10 million to CERN.[153] Therefore, the strategic planning of PAEC during the 1980s has now proven its utility for the expansion of the nuclear programme. This is so because now Pakistan is able to build a substantial percentage of components, spare-parts, engineering and heavy equipment for its existing, under-construction and planned nuclear projects and facilities. This indigenous capability has manifested itself in the indigenous completion of two additional plutonium production reactors at Khushab, and other projects being planned by PAEC.

5.6. Concluding Comment

PAEC's long-term nuclear plan of 1972 was designed to provide Pakistan self-sufficiency in complete nuclear fuel cycle technology. This was accompanied by an ambitious nuclear power programme, which would not only cater to Pakistan's nuclear power and energy requirements, but also make Pakistan capable of producing weapon-grade plutonium and tritium. A long-term nuclear power programme was also needed to justify the acquisition of nuclear fuel cycle facilities from Western suppliers. The success of both these programmes required the establishment of a strategic and high technology industrial infrastructure that would be able to support the engineering and manufacturing needs of PAEC. Therefore, all these projects were launched in parallel, or in order of priority, as and when the resources became available. These became a litmus test of Pakistan's ability to master nuclear power and reactor technology, in defiance of

large and high precision computerized numerical control machining equipment, state-of-the-art welding equipment, a large heat treatment furnace, wide range of nondestructive and destructive testing equipment, and heavy electrical overhead cranes. These facilities cover a wide range of light, medium, large-sized and heavyweight jobs." Ibid. p. 102.

[153] Ibid. p. 105.

sanctions and restrictions by supplier states. When the supplier states walked out of bilateral agreements with Pakistan, it also became a challenge to become self-reliant in the design, manufacturing, testing and production of all that is necessary for a sustainable nuclear programme.

While the military or weapon-oriented programmes and projects were launched and implemented on priority basis, other projects related to civilian nuclear energy were temporarily suspended. These also became a victim of international sanctions due to Pakistan's persistent refusal to open its nuclear programme for inspections and sign the NPT, unless India did the same. Moreover, those in favour of indigenization and self-reliance within Pakistan's nuclear establishment were ultimately successful in implementing their ambitious plans for the Khushab-1 reactor project and other associated facilities. Their commitment to making Pakistan a plutonium producing country, and acquiring the knowhow for and developing an indigenous corps of trained manpower in the design and manufacturing of nuclear reactors, heavy water and tritium production plants has proven its worth today. Following the successful commissioning of KCP-II, Pakistan is now nearing completion of two additional plutonium production reactors, and is extensively participating in the construction of CHASNUPP-2.

In military terms, these successes imply that Pakistan can now produce its own reactors and has the capability to develop and deploy advanced miniaturized warheads. Coupled with the tritium production capability, has enabled Pakistan to develop boosted fission weapons which were tested in May 1998. These projects have also enabled Pakistan to embark on a nuclear triad-based deterrent capability. The successful completion of KCP-II and CHASHNUPP-1 projects will also help Pakistan to design and develop Pressurized Water Reactors for a future nuclear submarine programme, which is seen as an assured second-strike platform.

From a theoretical perspective, the above discussed is a validation of the implementation of the "proliferation decision" and a transition from the second stage to the third stage of weaponization. It also proves that the nuclear reactor projects as part of the back end of the fuel cycle were being personally pushed and driven by Munir Khan, who proved to be the plutonium "mythmaker" for Pakistan. Thus, the "technological system" began to grow and drift as he, being a reactor man himself, had identified these projects as a top priority in the fulfillment of his plutonium ambition. These projects were floated by PAEC during the 1960s but could not secure political support at the time. Nevertheless, they continued to remain technologically alluring and retained their technological pull for PAEC throughout the subsequent decades. This led to a long-term and broad-based institutional effort to develop the infrastructure needed to achieve self-reliance in nuclear power and reactors.

In this respect, he enjoyed the support of the scientists and engineers in PAEC who were known to be indigenization enthusiasts and belonged to the bomb lobby. This validates the assumptions of the domestic and bureaucratic politics models regarding alliance formations within the decision-makers that propel nuclear projects and secure political support for them. Moreover, the historical sociology approach of Donald Mackenzie towards nuclear proliferation is also validated in so far as the origin and growth of the plutonium route and related infrastructure in Pakistan is concerned. Within PAEC, those opposed to the Khushab-1 project had their own perceptions about the future growth and allocation of scarce resources in the nuclear programme. Their beliefs were not entirely unfounded, given the ground realities and the possibilities of success for the project at the time.

However, when the project succeeded, they enthusiastically indentified themselves with it. Following Munir Khan's retirement from PAEC, the technological momentum generated by this project and that of associated projects was such that they were completed by his successor Dr. Ishfaq Ahmad and operationalized. This validates the assumptions of the "Technological Determinists" who argue that the inherent pull factor of technology creates its own momentum that sees different projects through to their fulfillment. The Chashma power reactor deal was welcome success for PAEC in this field, in the face growing criticism for not being able to launch a nuclear power programme despite several public proclamations. Thus, the Sino-Pakistan civil nuclear cooperation agreement had succeeded in breaking an international embargo on the supply of civil nuclear technology to Pakistan. The following chapter, however, focuses on the next stage of completing the nuclear fuel cycle, i.e. reprocessing, which remained PAEC’s long-standing ambition for several decades.

CHAPTER 6

NUCLEAR FUEL REPROCESSING AND PLUTONIUM PRODUCTION

Plutonium is considered to be the easiest route to nuclear weapons, provided a country has a nuclear reactor and a reprocessing plant. Plutonium was the fissile material used by the United States in the first nuclear test of an atomic bomb at Alamogordo in New Mexico, and six kilograms of this material was used to destroy Nagasaki on August 8, 1945.[1] Plutonium does not occur in nature but is produced as a by-product of irradiation of nuclear fuel in a nuclear reactor. It has to be extracted and chemically separated from other fission by-products of spent nuclear fuel, which is done through a process known as reprocessing.[2] A reprocessing or separation plant is a nuclear facility dedicated for this purpose and reprocessing is considered to be a highly sensitive and complex nuclear technology. Though the plutonium obtained through reprocessing can be re-used as nuclear fuel for power or breeder reactors, it is widely used as fissile material in nuclear and thermonuclear weapons.[3] Moreover, reprocessing capability signifies the back end of the nuclear fuel cycle, which also implies that a country with this technology has also mastered the front end of the fuel cycle and nuclear reactor technology.

Therefore, a plutonium route to nuclear weapons can easily be derived from a civilian nuclear programme, provided the facilities are outside safeguards. Should a country choose to produce plutonium in nuclear reactors dedicated for this purpose—known as heavy water or graphite moderated production reactors—it will not require a

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[1] Joel Ullom, "Enriched Uranium versus Plutonium: Proliferant Preferences in the Choice of Fissile Material," *Nonproliferation Review,* Vol. 2, No. 1 (Fall 1994), p.2.

[2] Rodney W. Jones and Mark G. McDonough, *Tracking Nuclear Proliferation*: *A Guide in Maps and Charts, 1998*, "Appendix J: Manufacturing Nuclear Weapon*s*," (Washington, DC: Carnegie Endowment for International Peace, 1998). (http://www.carnegieendowment.org/Papers/Tracking_AppJ.pdf (accessed on January 15, 2009).

[3] Jeremy Bernstein, *Nuclear Weapons: What You Need to Know* (New York: Cambridge University Press, 2008), pp. 189-223.

uranium enrichment plant as only natural uranium fuel is used in such reactors. In this case, uranium oxide produced during the uranium processing or refining phase of the fuel cycle can be directly used in a fuel fabrication plant for making nuclear fuel. A part of this fuel is then transformed into plutonium while it is used or irradiated in a nuclear reactor.[4] In this respect, when Pakistan decided to embark on a nuclear weapons programme in 1972, the detailed nuclear plan prepared by PAEC and approved by Zulfikar Ali Bhutto, on May 4 1972, provided for the establishment of all these facilities. That this plan was for acquiring complete mastery over the nuclear fuel cycle meant that plutonium production capability would eventually be its crucial component in future.[5]

Moreover, the implementation of this plan, particularly for acquiring and establishing reprocessing know-how and facilities, included the establishment of a commercial-scale reprocessing plant at Chashma, and New Laboratories or New Labs, at PINSTECH. Therefore, this chapter comprises two main sections, namely: Chashma: The Franco Pakistan Reprocessing Plant Project; and the New Labs Reprocessing Project. Their sub-sections will attempt to analyze and discuss the controversies, milestones, politics and challenges, which Pakistan faced in acquiring mastery over the reprocessing technology, and the back-end of the nuclear fuel cycle. In addition, the concluding paragraphs attempt to establish linkages between the relevant theoretical approaches, paradigms and models in respect of the empirical evidence presented in this chapter.

6.1. Chashma: The Franco-Pakistan Reprocessing Plant Project

This section attempts to explore the issues, controversies, milestones and approaches followed by PAEC in acquiring and developing a commercial reprocessing plant in Pakistan. It also throws light on the difficult and protracted negotiations that took place between Pakistan and France. These negotiations triggered a lot of controversy and debate, both in Pakistan, and at the international level. Apparently, as a result of growing

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[4] “Manufacturing Nuclear Weapons,” op. cit.

[5] Munir Ahmad Khan, Speech delivered at the Chaghi Medal Award Ceremony Speech, Pakistan Nuclear Society, PINSTECH Auditorium, Islamabad. March 20, 1999.

western proliferation concerns in the wake of India's 1974 nuclear test, France increased its demands for stringent safeguards, which Pakistan eventually agreed to. Nevertheless, the contract could not be implemented because France eventually caved in to American pressure on the issue. The following section elaborates the saga of the Franco-Pakistan reprocessing plant in detail.

6.1.1. The Contract Agreement

Pakistan had been seeking reprocessing technology since the 1960s. PAEC entered into a cooperation agreement with Commissariat a l' Energie Atomique (CEA) of France on December 14, 1962, which called for providing facilities for training and research to PAEC personnel in France. It also stipulated visits of French experts to PAEC establishments, and assistance in peaceful uses of atomic energy on a commercial basis.[6] It may be recalled that while he was still at the IAEA, Munir Ahmad Khan along with Prof. Abdus Salam had prepared "a proposal for the establishment of a nuclear fuel reprocessing plant in Pakistan in late 1960s, without safeguards and at a nominal cost." This proposal was deferred by President Ayub Khan on economic grounds.[7] It seems that PAEC under Dr. I.H. Usmani also considered the matter. However, the plan could not get the necessary financial support.

A Planning Commission document, from October 1969, entitled: "Evaluation Report on the Karachi Nuclear Power Plant," stated that the Executive Committee of the National Economic Council (ECNEC), had approved a plan for a fuel fabrication plant for KANUPP and PAEC had submitted proposals for setting up of a heavy water plant and "a plutonium extraction plant," with a proposed capacity of 100 tons.[8] In fact, during his last days in 1966 as Pakistan's Foreign Minister, Bhutto had set up a working group in the Foreign Office comprising all relevant officials, in order to evaluate the nuclear question. This group was mandated to put up recommendations to the Pakistani government that could enable it to match India's nuclear capability. The working group, which included the Chairman of PAEC, Dr. Usmani, made the unanimous

[6] P. L. Bhola, *Pakistan's Nuclear Policy* (New Delhi: Sterling Publishers, 1993), p. 43.
[7] Munir Ahmad Khan, "Salam Passes into History", *The News* (Islamabad), November 24, 1996.
[8] Shahid-ur-Rahman, *Long Road to Chaghi* (Islamabad: Print Wise Publications, 1999), p. 31.

recommendation to acquire a reprocessing plant as a first step towards nuclear capability. Usmani was also in touch with the CEA who had offered to set up a reprocessing plant at a cost of U.S. $ 25 million along with a line of financial credit.[9]

The plant would be under IAEA safeguards. However, the safeguards were not very stringent at that time, and there was no constraint on the recipient state to develop its own reprocessing technology. When the recommendations of the working group were scheduled to be presented to Bhutto, a meeting called for the purpose was cancelled at the last minute on the orders of the President's House. Following Bhutto's departure from President Ayub Khan's cabinet, the working group was disbanded and its recommendations shelved. The reprocessing plant proposal itself attracted unified opposition from the then Finance Secretary, Ghulam Ishaq Khan, who objected that the cost of US $ 25 million was prohibitive for Pakistani resources. He was supported by the Foreign Secretary, S. M. Yusuf and even the Defence Secretary, whose brief for President Ayub during the latter's state visit to France "expressly recommended that he should not ask General de Gaulle for a reprocessing plant."[10]

Nevertheless, after the Multan Conference of 1972, which re-shaped the direction of Pakistan's nuclear programme, the acquisition of the reprocessing plant from France again became an important priority for the nuclear decision-makers. As Chairman designate of PAEC, Munir Ahmad Khan was directed by President Bhutto to re-activate nuclear collaboration with France as that country was believed to have an independent nuclear policy at the time. Therefore, the matter was taken up with the French delegate to the IAEA in Vienna, who expressed willingness for the supply of a reprocessing plant to Pakistan, albeit under safeguards.[11] This led to the opening of bilateral negotiations between France and Pakistan. In this regard, PAEC and the French firm, Saint Gobain Technique Nouvelle or SGN signed two separate agreements for building an industrial-scale reprocessing plant at Chashma, in south-western part of Punjab province, with a

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[9] Iqbal Akhund, *Memories of a Bystander* (Karachi: Oxford University Press, 2006), p. 262.
[10] Ibid, pp. 262-263.
[11] Munir Ahmad Khan, "Franco-Pakistan Nuclear Relations," *The News* (Islamabad), October 31, 1994.

reported capacity of reprocessing 100 tons of used reactor fuel per year. With this capacity, Pakistan could, in theory produce 800 kilograms of plutonium annually.[12]

The first contract in this regard was signed in March 1973, which was for the "basic design" of the plant, while the second one, for "detailed design" and actual construction of the plant was signed between PAEC and SGN on 18 October 1974.[13] As per the second contract, SGN promised to not only provide blueprints, designs and specifications, but also to procure equipment from suppliers and putting the plant into operation. SGN and the French contractors were expecting profits to the tune of US $ 8-10 million and US $ 45 million respectively. The French government also hoped to secure orders for at least three to four 600 MWe power reactors, Mirage fighter-bombers and other hardware from Pakistan and other Arab states. [14]

In view of the above, it is evident that the reprocessing plant agreement was not particularly introduced in Pakistan's nuclear development programme by PAEC after 1972. It had been on the table for some time and was considered sufficiently important and necessary by the nuclear decision-makers since the 1960s. That is why it continued to be part of PAEC's overall nuclear plan.

6.1.2. India's "Peaceful Nuclear Explosion" and the French Cancellation of the Reprocessing Contract

India's nuclear test of May 1974 altogether changed the nature and direction of the on-going negotiations between Pakistan and France for the supply of the reprocessing plant. The French began to make increasingly severe demands for more stringent safeguards before agreeing to supply the plant to Pakistan. In this regard, Pakistan tried to adjust its position in view of the changed French attitude, but the net result was a protracted, long and inconclusive round of negotiations, which eventually led to the contract falling apart.

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[12] Weismann and Krosney, *The Islamic Bomb* (New York: Times Books, 1981), p. 75.

[13] Ibid. Interestingly, PAEC had initiated its centrifuge-based uranium enrichment project, which came to be known as the Kahuta project at exactly the same time, i.e. October-November, 1974, when Sultan Bashiruddin Mahmood was appointed the project's director. This clearly negates the widely held view that Pakistan launched its enrichment programme as a direct consequence of PAEC's failure to acquire the Chashma reprocessing plant, whose contract was abrogated by France four years later in August 1978, and this had nothing to do with the start of the enrichment project. For details, please see Chapters 7 and 8.

[14] Weismann and Krosney, op. cit., p. 75.

The circumstances and events leading up to the cancellation of the contract are discussed in the following paragraphs. Several years later, the Chairman of PAEC, who held extensive negotiations with the French, explained that the Chashma reprocessing plant agreement with France fell through in the wake of India's PNE.[15]

Even though India was not sufficiently reprimanded for violating safeguards agreement and undermining the global non-proliferation regime, the international community did act decisively to prevent any further destabilization of the non-proliferation regime. Alarmed by India's test, and anticipating a future Pakistani response, the industrialized countries led by the United States set up the London Suppliers Group or LSG in 1975. The LSG prohibited the transfer and export of all nuclear materials, technology and facilities to those countries, which had not accepted full-scope safeguards on their nuclear programmes and signed the NPT. By doing so, the LSG guidelines went one step ahead of the IAEA regulations, which ensured the continuity of nuclear cooperation between supplier and recipient states on all safeguarded facilities.[16]

Moreover, the CEA was closely involved with the negotiations for the reprocessing plant with Pakistan from the very beginning. However, the French did not wish to be seen as the one's who were proliferating highly sensitive nuclear technology that could yield plutonium for a whole arsenal of nuclear bombs to Pakistan. They, therefore, first entered into negotiations with Pakistan for mutually acceptable safeguards, but later under American influence began to ask for multilateral controls and international safeguards of the IAEA for the Chashma plant.[17]

When the French government asked for multilateral controls by IAEA for the Chashma facility, Munir Khan continued to remain non-committal and asked for the safeguards question to be deferred till the plant was either complete or had begun operations. The negotiations on safeguards continued throughout 1975 between Pakistan and the IAEA. The trilateral safeguards agreement was reached between the IAEA,

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[15] Ibid.
[16] Munir Ahmad Khan, "Nucleaization of South Asia and its Regional and Global Implications" *Regional Studies,* (Islamabad), Vol. 26, No. 4 (Autumn 1998).
[17] Weismann and Krosney, op. cit., pp. 76-78.

France and Pakistan, and the IAEA gave its final nod in March 1976.[18] The Chashma facility would now be under full IAEA inspection and safeguards, and Pakistan pledged not to use it for manufacturing of any nuclear explosive device or any other military purpose. However, even as negotiations for safeguards continued, the French firm SGN continued to work on building the detailed design for the reprocessing plant, and the French sounded their concern that once Pakistan had obtained the detailed design, then it would need little outside help to complete it indigenously.[19]

By the time the American pressure on the French government forced it to back out of the contract in August 1978, SGN had reportedly transferred 95 percent of all the detailed engineering designs and drawings for building the reprocessing plant to PAEC, "including the plans for the chopping machine.[20] In the wake of India's nuclear test of May 1974, in which it had used a Canadian supplied CIRUS reactor—whose heavy water had been supplied by the United States—the American policy towards the sale of nuclear technology had fundamentally changed. The Indian test and the prospect of nuclear proliferation in the world as highlighted in the Wohlstetter Report forced the United States to take the lead in stopping the spread of nuclear reprocessing technology from the nuclear haves to the have-nots.[21]

Therefore, under American influence, the French offered Pakistan a change in the design of the reprocessing plant, which would yield mixed-oxide fuel, but not plutonium. Munir Khan on his part offered another modification in the plant's design, which would in the end yield plutonium, as Pakistan had no reactors or had no prospect of acquiring or building any breeder reactors that would use this mixed-oxide fuel. Agha Shahi, the then Secretary-General, Ministry of Foreign Affairs, insisted that Pakistan had placed the facility under full IAEA safeguards, and that Pakistan would not accept any modifications to the original tripartite agreement. By the fall of 1977, the French government took over SGN and thus effectively was able to press Pakistan directly to give in to their new demands. The IAEA safeguards, however, did help Pakistan keep

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[18] Ibid, p. 78-79.
[19] Ibid, p. 79-80.
[20] Ibid, p.167.
[21] Ibid, pp. 137-157.

SGN committed to building the design of the reprocessing plant, and this was the critical knowhow that PAEC was able to acquire even though the contract was cancelled.[22]

During negotiations, the French had also demanded Pakistan to pledge that it would not replicate the technology in any other similar plant in the future, which was being transferred through the Chashma reprocessing plant. This restriction would be valid for a period of twenty years. In order to prove its peaceful intentions with regard to this project, Pakistan also accepted this condition.[23] The French insisted on this fresh condition as part of the contract agreement even though the technology was well understood worldwide and was freely available in open literature. As long-drawn-out negotiations for the plant continued, the Chairman of PAEC termed the Reprocessing Plant's construction as a "national commitment." On the eve of the military coup of Gen. Zia, he stated:

> Pakistan is resolved to go ahead with the reprocessing plant, the construction of which has become a national commitment. Recent attempts to pressurize Pakistan to abandon the deal only served to strengthen our determination to proceed speedily with our peaceful nuclear programme as announced by the Prime Minister in his statements before the National Assembly. The proposed reprocessing plant is being built under strict international safeguards, making it impossible for using it for purposes other than peaceful. The need and relevance of this plant to our requirements is well known to countries opposed to Pakistan acquiring the plant. The real issue, however, is to withhold essential modern technology from us. A technologically advanced Pakistan does not seem to fit into their scheme of things.[24]

Nevertheless, the Zia regime also took time to shelve the project, but not before it had acquired the necessary knowhow to develop the technology indigenously, if need be, albeit for the future. Gen. Zia also justified the acquisition of the reprocessing plant as follows:

> There is no justification why Pakistan should not acquire nuclear reprocessing technology, which is badly needed to boost energy production. Pakistan had accepted all international safeguards, which also included policing of the plant internationally or by France, which no country in the world accepts. The agreement was concluded with the concurrence of the International Atomic Energy Agency and also the understanding of the United States. Then all of a sudden, when the United States was to have elections, Mr. Carter talked about proliferation and the American stand was changed on the subject. They tried to recommend to us to give it up. Now this point is, is it fair to

[22]Ibid, pp. 167-171.

[23] Ashok Kapur, *Pakistan's Nuclear Development* (New York: Croom Helm, 1987), p. 196.

[24] "Reprocessing Plant Construction- A National Commitment," *Dawn* (Karachi), July 4, 1977.

> assume that with one reprocessing plant and with all the safeguards in the world, do I still make a bomb and is this one reprocessing plant going to cause proliferation? Co-processing itself is not an established technology so far. Why should I accept a technology or say my last word on a thing, the results of which even the West has not yet seen? A number of countries in the West and as well as the East possessed nuclear plants, but Pakistan was being singled out and deprived of what it badly needed for its development.[25]

Nevertheless with the abrogation of the contract, the IAEA safeguards on the facility too became ineffective, as the French had failed to honour an international agreement. Prior to the cancellation of the contract, the French President D' Estaing stated on June 14, 1978 that the plant was purely intended for peaceful uses. The recepients [Pakistan] had continually assured that it would never be used for any military purposes for which talks were underway to re-inforce safeguards.[26] However, on June 15, 1978, the French Council on Foreign Nuclear Policy took the formal decision to cancel the contract for good.[27] For purposes of damage control, the French sent Mr. Jacomet to Pakistan to see Gen. Zia in person. In fact, when the French envoy, Jacomet met Gen. Zia at the latter's residence in the presence of Agha Shahi and Munir Khan, he tried to offer nuclear power reactors but not the reprocessing plant.[28] This, he said, was part of the new French nuclear policy and was not particularly directed towards Pakistan. Gen. Zia listened patiently and replied: "You are breaking a contract. I never thought the French would do this."[29]

In spite of the unilateral cancellation of the reprocessing plant contract by France, PAEC continued to tap other European sources to complete the procurement of necessary materials and equipment for the plant.[30] In this regard, French and Italian firms also offered procurement assistance to Pakistan. Furthermore, PAEC continued to push for the completion of the project. However, the project could not be completed in the years following the French back out. In this regard, the then Chairman PAEC recalled several years later that Gen. Zia's regime did not allow PAEC to complete the

[25] "CMLA Justifies Pak Requirement of Nuclear Plant," Pakistan Times, May 11, 1978.
[26] Weismann and Krosney, op. cit., p 171..
[27] Ibid.
[28] Ibid, p. 172.
[29] Ibid, p. 173.
[30] Weismann and Krosney, op. cit., pp. 195-209.

reprocessing plant indigenously in the wake of the French cancellation of the contract. He claimed:

> Things began to change soon after Mr. Bhutto's departure. We put forward proposals to the government that that in spite of the difficulties in obtaining the equipment, we could complete the project on our own but there was reluctance. Several presentations were made before the government but at the end we were told that money could not be spared even if we wanted to do it on our own. The same fate fell on the 600 MWe nuclear power plant.[31]

Therefore, it is evident that Pakistan became the victim of circumstances arising out of India's nuclear test of May 1974, which essentially upset all plans of PAEC to develop fuel cycle capabilities. Since these facilities were to be built through international cooperation, and as acquisition of know-how and technology was the first priority for the technical decision makers, it was obvious that the realities had changed for Pakistan. Moreover, the only choice left for Pakistan, in the case of the fuel reprocessing plant issue, was to obtain maximum benefit that it could secure from the prevalent international climate, while continuing to develop indigenous capabilities in parallel. In doing so, Pakistan went out of the way to allay non-proliferation fears of the French, who under increasing American influence were reluctant to be seen as potential proliferants, while attempting to salvage what ever they could of their credibility as a reliable nuclear supplier for third world countries.

Nevertheless, the abrogation and falling through of the Franco-Pakistan Fuel Reprocessing Contract was generated the impression that bigger powers, i.e. India could get away with "sins" committed against international norms. However, smaller countries like Pakistan had to foot the bill for their actions. This may not have been entirely realisitic since the newly formed Nuclear Suppliers Group also applied nuclear-related sanctions on India. Nevertheless, PAEC was determined to develop reprocessing know-how and the reprocessing plant issue became a test case for its abilities to derive the best bargain from foreign suppliers, and continue to defy restrictions on technology. It also became a high-profile political issue for the government of Prime Minister Zulfikar Ali Bhutto. The plant had become the symbol of Pakistan's efforts to build nuclear

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[31] Munir Ahmad Khan, "Bhutto and the Nuclear Programme of Pakistan," *The Muslim* (Islamabad), April 4, 1995.

capability, with Bhutto claiming that his refusal to budge from obtaining this plant from France led to his downfall.

6.1.3. Rationale and Motivation for Chashma

It is necessary to explore the reasons why PAEC was investing so much time and effort towards obtaining the Chashma reprocessing plant from France. Was this facility to be used to produce plutonium for the nuclear weapons programme, or was it only meant for the civilian nuclear power programme? While Pakistan was engaged in protracted negotiations with France for this plant, the United States began to exert tremendous pressure on France to cancel the deal with Pakistan and also threatened Pakistan with dire consequences.

Reportedly, the visiting U.S. Secretary of State, Dr. Henry Kissinger, personally told Prime Minister Zulfikar Ali Bhutto that Pakistan should drop the idea of buying a reprocessing plant. Otherwise they would make a "horrible example" of him. Bhutto later wrote of the encounter: "He told me that I should not insult the intelligence of the United States by saying that Pakistan needed the reprocessing plant for her energy needs. In reply, I told him that I will not insult the intelligence of the U.S. by discussing the energy needs of Pakistan, but by the same token, he should not discuss the plant at all."[32] While the Government of Pakistan and PAEC consistently advocated the peaceful intent behind the reprocessing plant project, the head of the French firm SGN, which was building the Chashma reprocessing plant, also defended the peaceful intent of this facility. He was of the view that Pakistan was seeking energy independence and planned to set up more power reactors and had offered their additional reprocessing services and waste disposal for commercial purposes.[33] He also stated that Pakistan did not need such a large reprocessing plant as Chashma, for building a bomb, since that could be done by far easier and simpler means.[34]

Nevertheless, the United States remained unconvinced about the peaceful uses of the Chashma reprocessing plant and was determined to ensure that the whole contract

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[32] Zulfikar Ali Bhutto, *If I Am Assassinated,* (Delhi: Vikas Publishers, 1979), p. 140.
[33] Weismann and Krosney, op. cit., p.76.
[34] Ibid, p.77.

collapses. In this respect, one declassified US State Department report on Pakistan's nuclear programme noted:

> The economic justification for acquiring a reprocessing plant has always been questionable even if the reactors for the Chashma nuclear power project were to be built. The reason given for acquiring the plant is that it will be needed in the late 1980s and that it is cheaper to build now. The certainty that Pakistan will be unable to meet its ambitious goals for nuclear power reactors in the 1980s adds to the argument against embarking on a reprocessing venture at this time. [35]

The report further tried to link the Chashma reprocessing plant with possible use for production of weapons-grade plutonium. It stated:

> Although the capacity of the proposed plant is much larger than would be required to process KANUPP fuel from normal power operation, it is of an appropriate size to handle the KANUPP output if the reactor should be operated in a manner to maximize the production of weapons grade plutonium. This does not necessarily lead to the conclusion that the reprocessing plant is intended for weapons use but it is certainly suggestive for such use.[36]

Nor was the United States satisfied with the provision of trilateral safeguards on the proposed plant. It expressed doubts about the ability of safeguards to prevent the plant's possible military use. With regard to safeguards, the report further added:

> There are major difficulties, however, in safeguarding any reprocessing facility. Unlike power or research reactors, the design of each reprocessing plant is unique, which necessitates the determination of safeguards specific to that facility, a time consuming process that requires extensive personal inspection. In addition, the IAEA has never before been called upon to safeguard a reprocessing plant.
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> Compounding the problem of plant design, therefore, is the IAEA's general lack of experience in the area of reprocessing safeguards. Short of round-the-clock physical inspection of a reprocessing plant, it is questionable whether safeguarding such a facility is really effective. Because the time between diversion of plutonium and its conversion into nuclear weapons can be sharply reduced if a country were determined to pursue a policy of diversion, nuclear weapons could already be assembled before an effective international reaction could be mustered.[37]

Moreover, the Chashma reprocessing plant has provoked a lot of controversy, both in Pakistan and abroad. Critics at home questioned the utility of this reprocessing facility for the nuclear weapons programme when it was under full-scope IAEA

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[35] Central Intelligence Agency, "Pakistan Nuclear Study," April 26, 1978, CIA Electronic Reading Room, p.20 www.cia.gov (accessed on January 15, 2009).
[36] Ibid. p. 20.
[37] Ibid, p.22

safeguards, while others outside Pakistan expressed doubts about the efficacy of safeguards on a plant with an annual reprocessing capacity of 100 tons of spent fuel. Another contentious issue associated with the Chashma facility was that the only source of irradiated or spent nuclear fuel that could be reprocessed at this plant was the 137 MWe Karachi Nuclear Power Plant (KANUPP), which was also under IAEA safeguards.

Therefore, had Pakistan been able to acquire Chashma, with or without safeguards, would PAEC then violate international safeguards agreements applicable on KANUPP and divert spent fuel there to be reprocessed at Chashma? Theoretically at least, this was a possibility, as KANUPP's spent fuel, when reprocessed, could easily have provided enough plutonium for several atomic bombs straightaway, in case of a national emergency or a critical threat to national security. According to a 1978 Central Intelligence Agency (CIA) Analysis, KANUPP could produce between 132 and 264 pounds of reactor or weapons-grade plutonium, depending on how the reactor was optimized for operation. Also by the time this report was made, KANUPP had already produced enough reactor-grade plutonium for thirty to forty weapons.[38]

Acutely aware of the consequences of violating international safeguards and following a policy of nuclear responsibility, PAEC never intended and never did carry out any diversion of spent fuel from either KANUPP or any other safeguarded facility, such as the 5 MW PARR-1. Nor was the Chashma reprocessing plant intended for plutonium extraction for the weapons programme. Pakistan did not require a 100-ton/yr capacity industrial-scale reprocessing plant for its bomb program. For producing plutonium by reprocessing spent fuel, PAEC had launched a parallel initiative, which was the New Labs pilot-scale reprocessing plant.[39] Even while the above-mentioned assessments were being drafted in the United States and the Franco-Pakistan reprocessing agreement had been cancelled, the Chairman of PAEC persisted with the need for Pakistan to acquire reprocessing technology.[40] Nuclear power was in vogue at

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[38] Weismann and Krosney, op. cit, p. 67; Jeffrey T. Richelson, *Spying on the Bomb,* (New York: W.W. Norton & Company Inc. 2006), p. 339.

[39] Weismann and Krosney, Ibid, p. 77.

[40] "The central role of a reprocessing plant can be understood from the following facts; A power reactor normally burns 1-3 per cent of uranium after which, because of fission products produced in the fuel, the reactor loses its ability to sustain a chain reaction. The burnt fuel is, therefore, discharged and fresh fuel

that time and the West Germans and Italians were also offering reprocessing technology which would be a logical part of planned sales of a number of medium and large nuclear power reactors to countries like Brazil for example.[41] In addition Pakistan was doing exactly the same thing—planning to acquire nuclear technology for civilian purposes—with a clear economic rationale for nuclear power generation, and in doing so also acquiring the high technology nuclear reprocessing knowhow as a tradeoff.

However, short of French help for the Chashma plant, the United States doubted Pakistan's ability to develop an indigenous reprocessing capability, either at Chashma or New Labs. Power reactors are normally run at burn-up[42] rates ranging from 7200 to 34000 MWd/t[43] or higher, and Chashma was designed to reprocess fuels irradiated at these rates. While every reactor is a plutonium producer, its spent fuel contains plutonium isotopes not suitable for weapons production unless it is a plutonium production reactor dedicated to producing weapons grade plutonium. On the other hand, if the reactor is a nuclear power reactor, it will have to be operated at low burn-up levels to obtain weapons-grade plutonium. Reactors dedicated to producing weapons-grade plutonium are normally operated at burn up levels ranging from 500 to 1200 MWd/t.[44]

Moreover, operating a nuclear power reactor at low burn-up results in an enormous increase in fuel consumption and reduced power output. Therefore, using any safeguarded power reactor for any such purpose is extremely risky and dangerous from a political and diplomatic standpoint and such an act can hardly go undetected. Chashma was intended to be part of a Nuclear Complex comprising at least six Light Water

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added. We can reuse this discharged fuel provided we remove the poisonous fission products and clean up the uranium and separate the plutonium, which is produced in the reactor. A reprocessing plant is used to perform this operation. Its advantages are: a) It enables one to recover un-burnt uranium, which can be reused in new power reactors. b) It yields plutonium, which is a known appropriate fuel for breeder reactors.Without plutonium there can be no efficient breeder reactor and without breeders the full potential of nuclear power cannot be realized." Munir Ahmad Khan, "Pakistan's Nuclear Power Programme: Justification and Rationale,' *Pakistan Engineering Congress, Lahore* (Islamabad: Pakistan Publications, 1979), September 5, 1979.

[41]Weismann and Krosney, op. cit., p. 147.

[42] The *burn up* of nuclear fuel is a measure of the total amount of energy released by fission per unit mass of fuel over a period of time. It is quoted in megawatt days per metric ton of uranium fuel (MWd/t).

[43] Ioan Ursu, "Nuclear Material Recovery," *Physics and Technology of Nuclear Materials* (New York: Pergamon Press, 1985), 320.

[44] Thomas B. Cochran, Robert S. Norris and Oleg A. Bukharin, *Making the Russian Bomb: From Stalin to Yeltsin* (Oxford: Westview Press, 1995), pp. 89 & 153.

Reactors (LWR) of 600 MWe each, along with fuel fabrication and associated facilities. This was part of the overall PAEC nuclear power plan, which was endorsed by the IAEA in 1973.[45] The long-term nuclear power plan for Pakistan had called for setting up of twenty-four nuclear power reactors by the end of the twentieth century, and the reprocessing plant was to reprocess the spent fuel to be re-used in the power reactors and process nuclear waste.[46] In 1977, the Chairman of PAEC explained the rationale behind building a reprocessing plant in Pakistan. He claimed it to be for peaceful purposes:

> As for reprocessing, Pakistan is in cooperation with France in building a 100-ton per year reprocessing plant under comprehensive international safeguards approved by the IAEA Board of Governors in February 1976. This guarantees that this plant will be used solely for peaceful purposes. It will service a nuclear complex with six Light Water Reactors totaling 4,000 MWe. A careful study of the technical and economic aspects of this project has indicated that it is fully justified in the context of conditions prevailing in Pakistan. It will ensure better utilization of fuel in power reactors in the country and permit recycling of produced fissionable materials for maximum economy.[47]

Furthermore, PAEC always had the reprocessing plant project high on its agenda since the days of Dr. I. H. Usmani. However these plans could not materialize for lack of political commitment.[48] One obvious reason for prioritizing plutonium, as stated above, was clearly technical. Plutonium was the best choice for making small, efficient, compact and powerful nuclear weapons. It also opened the way for thermonuclear capability. After the 1998 tests, Munir Ahmad Khan continued to argue in favour of completing the reprocessing capability, which till then was confined to the pilot-reprocessing plant at New Labs. In this regard, he wrote:

> We must complete the nuclear fuel cycle so that we can match India in developing, compact and efficient devices based upon plutonium rather than relying on enriched uranium only with which miniaturization is more difficult.[49]

In another newspaper article, he wrote that it took only 2 kg or less of weapon-grade plutonium to build a small nuclear device using modern technology.[50] Moreover,

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[45] Munir Ahmad Khan, "Significance of Chashma Plant," *Dawn,* August 8, 1993.

[46] Allan S. Krass, et al, SIPRI, *Uranium Enrichment and Nuclear Weapon Proliferation* (London: Taylor & Francis, 1983), p. 232.

[47] Munir Ahmad Khan, "Pakistan's Experience in Transfer of Nuclear Technology," Paper presented at the Iran Conference on Transfer of Nuclear Technology, Atomic Energy Organization of Iran, Shiraz, Iran. 1977.

[48] For details, please see Chapter 2.

[49] Munir Ahmad Khan, "Things To Do After Testing," *The News* (Islamabad), June 14, 1998.

with regard to the above, it is pertinent to mention that in 1977, the United States privately shared information with France about its 1962 nuclear test, which showed that reactor-grade plutonium could be used in making nuclear weapons. This successfully dissuaded the French from proceeding with the reprocessing plant contract with Pakistan and persuaded them to unilaterally walk out of the Franco-Pakistan reprocessing agreement.[51] Therefore, Pakistan became the victim of the increasingly active and assertive non-proliferation lobby in the United States and France, which was keen not to show any weak non-proliferation credentials.

Pakistan, however, was being forced to accept a radical change in the design of the Chashma reprocessing plant, whose end product, the mixed-oxide fuel was not useful for its planned nuclear power reactors, except breeder reactors. This was only an option on paper since even today, very few countries in the world are developing or running breeder reactors, and the technology was and still is at an experimental stage. It is evident that Pakistan tried to allay the fears and apprehensions regarding safeguards for the proposed Chashma reprocessing plant. It was willing to accept additional and more rigid safeguards so as to reassure the international community about the peaceful intent and nature of this particular project. Since the Chashma project had become a high profile and politically sensitive affair—having domestic and international repercussions for France, United States and Pakistan, it became the subject of greater scrutiny—and, therefore, more controversial.

Pakistan's motivation to adhere to the French demands and continue negotiations was both technical and political, as the Chashma plant was seen as a high-technology asset that could contribute to the country's security and the growth of the peaceful nuclear programme. Hence, it was logical for Pakistan to have maintained its stance on the design of the plant, even though it was willing to accept yet more stringent safeguards. In the end, France capitulated under intense American pressure and broke an international agreement. Pakistan's nuclear weapons programme, however, was no secret to the world while Chashma was being negotiated. Therefore, its cancellation was one

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[50] Munir Ahmad Khan, "India's Nuclear Journey," *The News* (Islamabad), May 5, 1998.
[51] George Perkovich, *India's Nuclear Bomb* (California: University of California Press, 2001), p 429.

direct consequence of Pakistan's pursuit of the bomb, even though it had no direct role in the weapons programme. Whereas building a deterrent capability was Pakistan's foremost priority, PAEC was also keen to acquire and develop the most sophisticated nuclear fuel cycle and reprocessing technologies and develop a nuclear power programme. However, this was not to be, but not before PAEC was able to acquire the technical know-how for building the plant on its own.

6.2. Hot Cells to New Laboratories: Mastering Reprocessing

This section discusses the efforts made by PAEC to acquire and develop reprocessing technology, from the 1960s and following the launch of the nuclear weapons programme in 1972. It further argues that PAEC explored different and all available options for acquiring the knowhow for reprocessing technology, and began its development—first at the laboratory scale—and subsequently upgraded it to pilot-scale. As Pakistan did not have an unsafeguarded plutonium production reactor, New Laboratories or New Labs remained redundant. However, it constituted a central element in Pakistan's ability to reprocess spent fuel to obtain weapons-grade plutonium. New Labs also provided the opportunity for Pakistani scientists and engineers to acquire the necessary training and skills needed to master reprocessing technology. Initially, the New Labs project may also have been intended for training of scientists and engineers for the Chashma commercial-scale reprocessing plant. New Labs would also prepare them, in the later years, for actual reprocessing when the 50 MWt Khushab-1 plutonium production reactor would become operational in 1997. These issues and milestones are discussed in the following paragraphs.

According to Donald Avery, a senior official of the British Nuclear Fuels Limited (BNFL), the Hot Cells was designed to have a maximum production capacity of only 360 grams of plutonium per year. The British had completed the design for it by 1971.[52] PAEC wanted the British to design a much bigger plant with a capacity of reprocessing 30 tons of spent reactor fuel, which would have translated into 250 kg of plutonium per year. However, the British were not interested in any large-scale

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[52] Weismann and Krosney, op. cit., p. 81.

operations in Pakistan and refused to expand the Cell's capacity. Apparently, they had deliberately kept the design of Hot Cells restricted and small. The British were satisfied with the crowded facility situated in the basement of the Radiobiology building of PINSTECH. Consequently, handling of irradiated spent fuel became a risky proposition and very difficult.[53]

Therefore, in the early 1970s, PAEC sought another foreign firm for building a new reprocessing facility. However, Munir Ahmad Khan was not inclined towards the British, for the reasons mentioned above. Therefore, Belgonucleaire was again contacted to find out if it would be interested to be consulting engineers "for a new set of labs that would include both reprocessing and fuel re-fabrication."[54] Belgonucleaire was happy to oblige PAEC and accepted the offer. The company's Managing Director, Jean van Dievoet recalled that the New Labs itself was to be constructed by PAEC while his company's job was to prepare the design of the facility and help with purchases of necessary equipment and its specifications. The fuel re-fabrication lab was considered to be a very sensitive element of reprocessing technology as it is designed to handle the plutonium, which is used as fissile material in nuclear weapons.[55]

Therefore, when Belgonucleaire proceeded to help PAEC with the pilot-reprocessing plant, a three-member team comprising Mr. Abdul Majeed Chaudhry, Dr. Zafarullah and Dr. Khalil Qureshi were sent to the company's headquarters in Mol, Belgium. They were to participate in the designing of New Labs and obtain practical knowhow and training in reprocessing technology.[56] Mr. Majeed, a mechanical engineer, would subsequently head the New Labs project till 1992. However, New Labs was now moved out of the main PINSTECH building to a new one, adjacent to the main building. Although Belgonucleaire claimed credit in December 1977 for the fuel re-fabrication lab and the reprocessing plant for the New Labs project, Van Dievoet later clarified that his company was involved in designing the overall building and the fuel re-fabrication lab,

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[53] Ibid.
[54] Ibid, p. 82.
[55] Ibid.
[56] Shahid-ur-Rahman, op. cit., pp. 36-37.

but not the reprocessing plant. He claimed that his company wanted to design this facility as well. However the contract was given to SGN.[57]

It appears that during negotiations, which led to the signing of the preliminary and basic design contract for the large-scale Chashma reprocessing plant, PAEC also contacted SGN for the supply of equipment for a laboratory-scale reprocessing facility, which had been designed for PAEC by the UKAEA in 1969-70. According to SGN's chief M. Poincet, his company agreed for supply of equipment for this laboratory based on its own experience.[58] In a letter dated July 7, 1973, and addressed to Muhammad Afzal, "a key deputy to Munir Khan,"[59] SGN offered a "Universal Machining Unit" that could have several applications. This piece of equipment was meant for reprocessing facilities and used "to cut up and remove the cladding from the irradiated fuel rods taken from the CANDU reactor."[60] This is known to be the first step towards the reprocessing spent or irradiated nuclear fuel to obtain plutonium. Moreover the SGN letter also specified this equipment was headed for the "Reprocessing Pilot Plant"[61] or New Labs. In addition to the French and the Belgians, the West Germans also assisted in training of manpower for New Labs and providing consultancy services. In 1974, the famous German Nuclear Research Centre at Karslruhe, known as KfK and PINSTECH entered into a bilateral cooperation agreement, which was known as "Agreement on Cooperation in the Area of Peaceful Uses of Atomic Energy" [62]

As a result of this agreement, KfK experts visited PINSTECH and delivered lectures and jointly held seminars and symposia with PAEC on various aspects of the nuclear fuel cycle. Moreover, PAEC also obtained information from KfK in the fields of jet nozzle uranium enrichment, fuel reprocessing, hot cells, fuel production, and waste

[57] Weismann and Krosney, op. cit., p. 82.
[58] "We finished a lab started by a British company. The Pakistanis decided they did not want to continue with the British, and asked us to take over. This was a chemical laboratory, for nuclear chemistry, located next to PINSTECH. The British had brought it to the drawing stage and the Pakistanis had already built the walls and the building." Ibid.
[59] Ibid. p.83.
[60] Ibid.
[61] Ibid.
[62] Mark Hibbs, "Minister Wants to Stiffen Export Controls", *Der Speigel*, June 26, 1989, pp. 87-89.

treatment.[63] KfK officials such as Cornelius Keller, Director of the Nuclear Technology School, KfK, visited PINSTECH in 1983 and gave lectures on the "chemistry and technology of the nuclear fuel cycle"[64] In 1973, PAEC awarded the contract to the National Engineering Services Pakistan Limited Company, or NESPAK, to develop the design for construction and building of New Labs, construction began in 1976. This project houses the laboratories and facilities where the following activities are carried out:[65]

1) Spent fuel storage and waste handling
2) Spent fuel post-irradiation
3) Reprocessing
4) Purification
5) Plutonium metallurgy
6) Fuel re-fabrication.

It seems that the New Labs project was no secret at the time and the suppliers and PAEC were openly talking about it. While in Paris, Munir Khan had stated that "the few kilograms of plutonium necessary for an explosive device" would be produced by the pilot-reprocessing facility, which was being built in Pakistan with the help of Belgonucleaire.[66] Therefore, it is most likely that both PAEC and the French were using the existence of this project as a justification for going ahead with the much larger commercial-scale reprocessing plant being built by SGN. This would also dispel apprehensions that Pakistan was planning to use the Chashma plant for military purposes. Referring to the pilot reprocessing plant, New Labs, M. Poincet had argued: that if Pakistan wanted to make an atomic bomb, there were far easier means to do it which were also less expensive.[67]

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[63] Mark Hibbs,"Nuclear Contacts with Pakistan," *Der Speigel* (Hamburg), February 27, 1989, p.113.
[64] "Nuclear Contacts with Pakistan," op. cit.
[65] Central Intelligence Agency,"Pakistan Nuclear Weapons Programme: Personnel and Organizations," Research Paper, November 1, 1985. CIA Electronic Reading Room. www.cia.gov (accessed January 15, 2009)
[66] Weismann and Krosney, op. cit., p.83.
[67] Ibid, p.80.

Hence, it was hoped that it would make no sense for the French or anyone else, at least in SGN, to stop Pakistan from having the Chashma reprocessing plant. Nevertheless, the Belgians never insisted on any bilateral or trilateral safeguards involving the IAEA for New Labs. Thus, SGN also followed suit and never asked for any safeguards for the project.[68] However, PAEC's position was that since its contract was signed in March 1972, prior to the Chashma agreement, the pilot reprocessing plant could not be placed under safeguards. This meant that the PINSTECH pilot-reprocessing facility [New Labs] would not be under safeguards. Nevertheless, the United States remained skeptical about Pakistan's ability to develop indigenous reprocessing facilities. In 1978, a CIA assessment stated:

> If the Chashma plant is not built, Pakistan may be able to use manual methods to produce sufficient plutonium for a single device in roughly the same time scale, but is unlikely to do so. It might also try to build a small, crude reprocessing facility on its own, which when completed, could quickly produce enough plutonium for several devices. But the technical skills of the Pakistanis are still too rudimentary to permit any early success in such a venture over at least the next five years and possibly much longer.[69]

6.2.1. Cold Commissioning at New Labs

New Labs is believed to have a capacity of producing 10-20 kg[70] of plutonium per year. While the pilot reprocessing plant is believed to have been completed by 1981-82, it could not be used for reprocessing due to lack of an unsafeguarded spent fuel from an indigenous reactor. However, when the Khushab-1 reactor project was launched in 1985-86, it was thought necessary to prepare New Labs for reprocessing as soon as the reactor became operational. Therefore, in 1986, PAEC requested IAEA for permission to use a few damaged spent fuel rods for post-irradiation studies at New Labs. This was possible only because of an exemption clause under the IAEA's safeguards agreement for KANUPP. If Pakistan would ever have decided to obtain plutonium for a nuclear device

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[68] Ibid, p 84.

[69] Central Intelligence Agency, "Pakistan Nuclear Study," April 26, 1978. CIA Electronic Reading Room. pp. 24-25 http://www.foia.cia.gov (accessed January 15, 2009).

[70] Mark Hibbs, "Hot Laboratories," *Der Spiegel* (Hamburg), February 27, 1989, p. 113.

during the 1970s, this was the most likely means of producing fissile material without violating any international safeguards.

When PAEC requested this exemption from the IAEA, the United States raised serious objections, and warned Munir Khan of negative consequences if Pakistan went ahead with the request. Nevertheless, despite these objections, Munir Khan went ahead with plans to use insignificant amounts of spent fuel from KANUPP for reprocessing and R&D purposes in New Labs, within the framework of the IAEA's rules and with its permission. This signaled that New Labs was ready and equipped for reprocessing, should unsafeguarded spent fuel be made available. Thus, following these cold tests, New Labs was ready for reprocessing. However, cold commissioning or cold tests signified Pakistan's resolve to develop and master reprocessing capability as a way of obtaining plutonium, as and when the opportunity arose. This was seen with concern by the United States, which had gone out of the way to block the Chashma commercial reprocessing plant being supplied by France a decade earlier.

Back then, the United States was determined to deny reprocessing technology to Pakistan, however New Labs was a manifestation of Pakistan's resolve to deny restrictions on technology and develop indigenous capabilities in sensitive areas such a reprocessing. The CIA gave the following reaction in the wake of Pakistan's request for cold commission at New Labs:

> Pakistan has made preparations to request permission from the IAEA to remove a small quantity of spent nuclear fuel from the Karachi power reactor under an exemption provision in its safeguards agreement. Islamabad may try to use the exemption (which may allow it to accumulate one kilogram of fissile material) as a means to initiate separation of plutonium at the PINSTECH New Labs reprocessing plant for use in nuclear weapons. Without resorting to the exemption, Pakistan will face a choice when the New Labs plant is completed next year, between proceeding with its nuclear weapons programme, which could then require violation of safeguards to obtain spent fuel for reprocessing, or maintaining the security relationship with the United States and developing its weapons programme until another source of fissile material was available.
>
> A Pakistani request for a safeguards exemption would significantly heighten international suspicions that Pakistan was acquiring plutonium for nuclear weapons, increase Indian anxieties, and raise doubts about the effectiveness of the safeguards system. We believe that the expected completion next year of the New Labs reprocessing plant at the Pakistan Institute of Nuclear Science and Technology (PINSTECH) will put strong pressure on Pakistani President Zia to choose between delaying fissile material

> production indefinitely (thus risking loss of momentum in the nuclear weapons programme) or moving forward with production plans.
>
> In our view, Zia and his advisors continue to believe that they must acquire nuclear weapons because they have concluded that their existing military capabilities, including the promise of US military equipment, will not adequately protect Pakistan against Indian aggression. Since President Zia's visit to the United States in December 1982, we have detected continuation of long-standing efforts to acquire components for nuclear devices and to bring into successful operation the only two facilities capable of producing fissile material for nuclear weapons in Pakistan, the PINSTECH New Labs reprocessing plant and the Kahuta enrichment plant.[71]

In this respect, the CIA further stated:

> Pakistan has explored the possibilities of acquiring small quantities of fissile material from spent fuel legally obtained from the Karachi power reactor under an exemption clause in Islamabad's safeguards agreement with the IAEA. The Pakistani leadership may believe that as long as the safeguards agreement is not technically violated, it can bring the New Labs reprocessing plant through its shakedown period by using spent fuel from the Karachi reactor. The exemption clause would permit Pakistan to test its reprocessing plant with a quantity of spent nuclear fuel removed from the Karachi reactor which, when reprocessed, would yield up to one kilogram of plutonium for the purposes of processing, reprocessing, research or development.
>
> This provision contained in the IAEA document that establishes general conditions for safeguards in countries that have not signed the NPT, was intended to allow states to conduct limited tests and experiments, such as examining the performance of reactor fuel that did not involve enough fissionable material to make a nuclear weapon. Many countries have used this exemption for legitimate purposes. The IAEA would not require that Pakistan state the purpose of its exemption request, and according to officials in the IAEA Secretariat, the IAEA would be legally obligated to approve at least an initial Pakistani request.[72]

After the 50 MWt Khushab-1 plutonium production reactor became operational in 1997, New Labs was presumably expanded and the flow sheet changed to handle the reactor's metal fuel contained in aluminum cladding material. In the wake of the commissioning of Khushab-1 in 1998, New Labs began separating plutonium from the spent fuel of this reactor. This was confirmed by traces of $Krypton^{85}$ or Kr^{85} gas emissions were released in the atmosphere during this time.[73] The release of this

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[71] Central Intelligence Agency, *Pakistan: A Safeguards Exemption as a Backdoor To Reprocessing*, May 20, 1983, pp. 1-2.
[72] Ibid, p.3.
[73] Zia Mian and A.H. Nayyar, "An Initial Analysis of Kr-85 Production and Dispersion from Reprocessing in India and Pakistan," *Science and Global Security*, Vol. 10, No. 3, (2002). Available at:

radioactive gas into the atmosphere signifies that reprocessing activity is being carried out in the area where it is detected. Therefore, New Labs became the symbol of Pakistan's resolve, and that of PAEC, for developing and completing indigenous reprocessing facilities needed to acquire complete mastery over the nuclear fuel cycle.

Although New Labs was never fully acknowledged, at least publicly, by any Pakistani government official or scientist, until recently, it remained a part of Pakistan's nuclear programme, and the key to reprocessing technology in Pakistan. In technical terms, it was as important as the uranium enrichment capability, and perhaps more so if the thermonuclear potential inherent in plutonium production is considered. If one were to assume that plutonium provides greater flexibility in nuclear weapon design, and more explosive power per kg of fissile material compared to highly enriched uranium, New Labs is the key to developing a nuclear arsenal based on miniaturized nuclear warheads for Pakistan's nuclear deterrent. Moreover, New Labs also demonstrates that denial of technology cannot prevent a country and a corps of intelligent scientists and engineers under a dedicated leader, from building similar capabilities. It was also an indication that the policies and plans developed by PAEC in building indigenous reprocessing capabilities were well-thought out and are bearing the fruits they were originally intended for.

6.3. Concluding Comment

Pakistan had identified its priorities in terms of the plants and facilities needed to build indigenous capabilities in the nuclear fuel cycle as early as the decision to acquire the nuclear option. These facilities were intended to achieve self-sufficiency in nuclear technology and to provide a nuclear deterrent. In this respect, Chashma was conceived and all available avenues explored. While Chashma was essentially an effort aimed at acquiring state-of-the art reprocessing know-how, it was never intended to be used for

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http://www.princeton.edu/~globsec/publications/pdf/10_3%20151%20179%20Mian.pdf (accessed on December 18, 2008).

producing plutonium for the nuclear weapons programme. Pakistan's track record in this is evidence of the fact that violation of safeguards was never part of anyone's plans, either in PAEC, or in the Government of Pakistan. Nor was any diversion of fuel from KANUPP for obtaining fissile material necessary since Chashma was to be part of the civilian nuclear power programme, and not the bomb programme. Such a course of action was not feasible or possible and therefore impossible to pursue, especially in the wake of India's nuclear test of 1974 which resulted in an increasingly vigilant IAEA.

Any such act would have seriously jeapoardized Pakistan's standing as a responsible state and completely isolated it from the rest of the world, even in areas of purely civilian nuclear cooperation. However, there was one option for PAEC to obtain plutonium before the indigenous Khushab-1 reactor was built, i.e. 1970s and 1980s. This was to use spent fuel from KANUPP under an exemption clause of the KANUPP's safeguards agreement with IAEA for reprocessing. This was exactly how cold reprocessing test runs were carried out in New Labs in 1987, using KANUPP fuel. This window was always there and could have been used to produce the material for Pakistan's first nuclear device.

Moreover, even as the necessary know-how, materials and technical details for the Chashma reprocessing plant had been acquired and the civil works completed, lack of political commitment in Pakistan prevented PAEC from completing it indigenously. In this respect, bureaucratic rivalry between PAEC and KRL is likely to have played its part. President Zia did not accede to Munir Ahmad Khan's requests to complete the plant indigenously, and releasing requisite funds for the purpose. This was a time when the gas-centrifuge enrichment plant at Kahuta was about to be completed and become operational and finances were being prioritized by the Pakistani government. It is also likely that reprocessing was shelved as a priority for the time being and not seen as an immediate technical or political requirement.

It is also plausible that Ghulam Ishaq Khan, who was an increasingly influential advisor to President Zia in nuclear matters, may have prevailed over the decision not to allow PAEC to complete the plant. This may also have been so because Ishaq was head of the Project-Coordination Board for the Kahuta enrichment project headed by A. Q.

Khan. Nevertheless, New Labs had provided Pakistan with the capability to reprocess enough spent nuclear fuel for several nuclear devices per year. While it was completed and made ready as early as 1986-87, Pakistan did not use it to reprocess KANUPP's safeguarded spent fuel to produce plutonium, while the technical capability for doing so had been achieved. One reason might have been that Pakistan had pledged to uphold its commitment not to replicate the technology for reprocessing for twenty years, even though New Labs was outside safeguards, and may have been used on a different design, Therefore, the plutonium route and reprocessing was only started once PAEC had completed the 50 MWt Khushab-1 plutonium production reactor.

It is pertinent to mention that from the time the high-profile Chashma reprocessing contract was signed in October 1974, (which incidentally is precisely the time around which PAEC launched the uranium enrichment programme)—until the cancellation of the contract in August 1978—the Kahuta uranium enrichment project along with the fuel cycle facilities had all been successfully launched and were nearing completion. These comprised the uranium refining, conversion and UF6 production and nuclear fuel fabrication facilities, and the New Laboratories pilot reprocessing plant and the bomb design and development projects in PAEC. The Chashma deal therefore served to act as a decoy for the establishment of the secret nuclear infrastructure that Pakistan needed to develop a nuclear deterrent capability. Nevertheless, both New Labs and Chashma were milestones in Pakistan's nuclear history, which demonstrated Pakistan's will and the ability to develop nuclear technology in the face of stiff sanctions and opposition by critics, both at home and abroad. It was also a manifestation of Pakistan as a responsible nuclear power and the vision of the technical leaders of the nuclear programme, who led Pakistan to nuclear status, without compromising its obligations as a responsible nuclear capable state.

However, from a theoretical perspective, the pursuit of a commercial reprocessing plant validates the technological pull factor and the fact that this project was high on the technology lobbyist's agenda since 1965. It enjoyed the political support of Zulfikar Ali Bhutto and his government for whom it became as much a political issue, as a technical one. Therefore, the success or failure of this project was being compared with the Bhutto government's measure of success on the nuclear programme. His government had publicly committed itself to the project to the extent that it was no longer possible for it to modify its public stance on the matter easily. The Chashma project had become a political and technical prestige issue for the decision-makers in Pakistan, at least during Bhutto's government. In fact, Bhutto had tied his political future to the success of this nuclear project. He was not willing to get out of the contract negotiations for the plant when they began to go in the wrong direction for Pakistan inspite of having acquired all the necessary know-how and equipment to complete it on its own—without the restrictions of safeguards attached to it. Thus, it demonstrates that nuclear mythmakers can become irrevocably tied to their own myths and their stakes and stands prevent them from adjusting their strategies in decision-making as and when required.

However, this project again became the victim of bureaucratic tussling and competing alliances within the Pakistani nuclear establishment, in addition to an international non-proliferation climate. In the wake of the overthrow of Bhutto in 1977, his alliance network with Munir Khan effectively broke down. When Munir Khan had begun to regain the trust of Gen. Zia and his advisors, which took time, he was able to secure the necessary political support needed to complete the plutonium route, but not for the stalled Chashma reprocessing project. Earlier, despite the fact that the Chashma reprocessing project had become heavily politicized internationally, and associated with the Bhutto government, Gen. Zia could not immediately shelve the project. He continued to have negotiations with the French until they themselves cancelled the contract with Pakistan.

This proves that the momentum generated by the technology determinists was such that the new regime could not abruptly abandon the project. Moreover, some decision-makers in Pakistan displayed their traditional opposition to plutonium and reprocessing technology and effectively scuttled the project from being completed indigenously. Chashma was supposed to produce large amounts of fissile material, whose production capacity was to be at least twenty times more than Kahuta, even though the plant was never intended to be utilized in the weapons programme. In addition, the presence of large amounts of safeguarded plutonium could have created a very strong rationale for operationalizing the plutonium route. This could have effectively marginalized the rival centrifuge programme, which was still in its infancy. In this respect, the entire Chashma reprocessing project can also be seen in the context of the historical sociology approach in addition to bureaucratic and domestic politics models.

From a bureaucratic-politics standpoint, both Bhutto and PAEC had openly staked their position with the reprocessing plant issue and it appears that they had publicly committed themselves to it to the extent that it was not longer possible for them to change their stance easily. Moreover, successive PAEC heads had cultivated the nuclear myth of reprocessing and generated the impression that it was necessary for Pakistan's security and future of the nuclear programme. For critics, this policy was beyond comprehension at that time, but the fruits of this long-term vision are being derived today. In the next chapter, the other equally important project in the nuclear programme, uranium enrichment is discussed. This project became the breeding ground and seed of the entire bureaucratic rivalry between A. Q. Khan and PAEC that not only provided the former to enter Pakistan's nuclear programme but also establish himself as the public face of the programme.

CHAPTER 7

URANIUM ENRICHMENT IN PAKISTAN: 1974-1980

The previous chapters explored Pakistan's efforts to master the back end of the nuclear fuel cycle and the associated politics, controversies and challenges. This chapter reviews Pakistan's efforts in achieving success in uranium enrichment, which is an important part of the nuclear fuel cycle. For more than two decades, the uranium enrichment project, commonly known as the Kahuta project, became the sole symbol of Pakistan's nuclear success. This was largely because of the fame acquired by the Pakistani metallurgist, Dr. Abdul Qadeer Khan, who headed the project for more than two decades. He is widely considered as the father of Pakistan's nuclear programme and its atomic bomb, and the founder of the uranium enrichment project. However, the understanding of the evolution of this project, especially in its formative years, provides a framework to evaluate vertical nuclear proliferation in Pakistan through the bureaucratic and domestic-politics, and nuclear myth-making models. An analysis of the gensis of this project also points to the reasons that led Pakistan to embark on the path to enriching natural uranium hexafluoride, using gas-centrifuge technology. This is important because almost two years of the formative phase of this project under PAEC are shrouded in controversy and confusion, lacking in in-depth information or analysis, while a lot of indigenous work continued to play its role in the success of the project after it was taken over by A. Q. Khan.

Uranium is found in nature in the form of two isotopes, U-238 and U-235. Naturally occurring uranium ore contains only 0.7 % of the U-235 isotope, which is only fissionable and can be used to produce energy in reactors or as fissile material in atomic bombs. Therefore, the concentration of U-235 has to be increased from 0.7 percent to about 3-5 percent for use in nuclear power reactors and 90 percent and above for use in nuclear weapons as fissile material. This process of increasing the concentration of U-235 in natural uranium hexafluoride through physical separation of the U-238 and U-235 isotopes is known as enrichment.[1] Uranium can be enriched through various methods, such as gaseous-diffusion, gas-centrifuge, laser, Becker-nozzle and electro-magnetic separation. However, the only two known commercial technologies used for enrichment are gaseous-diffusion and the gas-centrifuge.[2]

Pakistan opted to go for the gas-centrifuge method in 1974[3] and succeeded in enriching uranium through it by 1978 at the experimental level. In 1984, A. Q. Khan, publicly announced that Pakistan had achieved uranium enrichment capability through this technology.[4] By 1986, it was believed that Pakistan had produced enough weapons-grade highly enriched uranium, i.e. uranium enriched to 90 percent and above, for one device. To explore these issues and events, this chapter is divided into eight main sections, namely: The 1967 Gas-centrifuge Study Group; Prelude to Uranium Enrichment: 1972-1974; Launch of the Project; Manpower Recruitment; Procurements for the Project; Building the Infrastructure: ADW, Sihala and Kahuta; Research and Development and the Prototype Centrifuge; and the Italian Connection. The conclusion draws on analysis of the relevant theoretical approaches, paradigms and models in light of the empirical evidence presented in the chapter.

7.1. The 1967 Gas-centrifuge Study Group

The origins of uranium enrichment in Pakistan can be traced to 1967 when Dr. Naeem Ahmad Khan, the then Director of Atomic Energy Centre, (AEC) Lahore, on his own initiative, formed a small study group on gas-centrifuges. The Lahore Centre, as AEC was commonly known, remained a multi-disciplinary nuclear research centre throughout

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[1] Allan S. Krass, et al, SIPRI, *Uranium Enrichment and Nuclear Weapon Proliferation* (London: Taylor & Francis, 1983).
[2] Ibid.
[3] Sultan Bashiruddin Mahmood (ex-Director-General, Nuclear Power, PAEC), interview by authour, tape recording, Islamabad, August 3, 2007; Dr. Riazuddin (Director General, National Centre for Physics, ex Member Technical, PAEC), interview by authour, tape recording, Islamabad, February 15, 2007.
[4] A. Q. Khan's interviews with, Urdu Dailies, *Nawa-i-Waqt*, February 9, 1984 and Daily *Jang*, February 10, 1984.

the 1960s. Much of the R&D work in PAEC was carried out at the Lahore Centre, as PINSTECH had not yet been made fully functional.[5]

The Director of the Lahore Centre gathered a select group of young scientists and engineers working there, and proposed that a study of gas-centrifuges and the engineering and technological features of this technology be carried out. It was intended to keep abreast with the latest developments in the field and access the publicly available knowhow available on the gas-centrifuges. The study group comprised Dr. Samar Mubarakmand, Sultan Bashiruddin Mahmood, Muhammad Hafeez Qureshi, along with a few other young colleagues.[6] The first phase of the study focused on the survey of available literature and thereafter the group planned to construct the gas-centrifuge machine itself. The second phase dealt with developing an understanding the different design features of the gas-centrifuge and its associated engineering problems. The study group also conducted occasional meetings and their activity continued for about a year.[7]

The gas-centrifuge study group also carried out experiments with prototype gas-centrifuges, which involved Samar Mubarakmand, though he denied its application for uranium enrichment at the time. However, he did acknowledge that the gas-centrifuge machine was being rotated at speeds approaching several thousand rounds per minute, after which it exploded. As a result, he narrowly escaped parts of the exploding gas-centrifuge, flying to his left and right.[8] As the important members of this gas-centrifuge study group proceeded abroad for Ph.D. studies, their work spanning almost a year came to an abrupt end.[9] This exploratory investigation on gas-centrifuges by Pakistani scientists during 1968 was also mentioned in a 1985 de-classified Central Intelligence

[5] Interview with Mahmood, op. cit; Sultan Bashiruddin Mahmood, Interview with Sabir Shakir, *Waqt News Exclusive*, Waqt News Television, July 23, 2009. Transcript available at: http://www.pakdef.info/forum/showthread.php?10571-SBM-Interview-on-Pakistan-s-nuclear-program&p=158942#post158942. (accessed May 10, 2010).

[6] Sultan Bashiruddin Mahmood, "Obituary: A Great Scientist Passes Away," *The Post* (Lahore), August 15, 2007; Farhatullah Babar, "Washing Nuclear Linen in Public," *The Muslim* (Islamabad), September 27, 1990; Samar Mubarakmand, (ex-Member, Technical, PAEC), interview by authour, written notes, Islamabad. June 26, 2008.

[7] Interview with Mahmood, op. cit; Interview with Samar Mubarakmand, Ibid.

[8] Interview with Samar Mubarakmand, op. cit.

[9] Interview with Mahmood, op cit.

Agency (CIA) assessment on Pakistan's nuclear programme.[10] Therefore, when Pakistan decided to adopt the gas-centrifuge method for enriching uranium in 1974, this technology was not totally alien or unknown to PAEC scientists and engineers. Needless to say, gas-centrifuge technology was first developed in the US Manhattan Project during World War II, and was later improved during the 1950s, and its basics were published in technical literature.

7.2. Prelude to Uranium Enrichment in Pakistan: 1972-1974

This section discusses the circumstances and events leading up to the adoption of the gas-centrifuge method for uranium enrichment by PAEC. It also explores the reasons for opting gas-centrifuge technology over other methods for uranium enrichment and the factors affecting PAEC's decisions to start the gas-centrifuge-based enrichment project.

The detailed nuclear plan submitted in May 1972, by the Chairman of PAEC, to the then President of Pakistan, Zulfikar Ali Bhutto, had envisaged complete control of the nuclear fuel cycle,[11] and enrichment is considered to be integral to any fuel cycle programme. However, no enrichment programme would be launched till India's nuclear test in 1974, but given the intention of acquiring mastery over the nuclear fuel cycle, enrichment capability would have to be developed sooner or later, if not immediately. Therefore the infrastructure that would eventually lead to the development of this capability was envisaged as early as 1972. In this regard, Munir Khan claimed after the 1998 tests: "Once a decision had been taken to build the bomb, we started looking at both routes and looked at all methods of enrichment. We had to build it through whatever means."[12]

In this context, it appears that PAEC was looking at uranium enrichment as an option in parallel with its plutonium and reprocessing programmes as early as 1973-74. During negotiations for the supply of the reprocessing plant from France, PAEC officials

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[10] Central Intelligence Agency, *Pakistan-Nuclear Decision Makers: Unanimous Opinion,* Research Paper, January 1985, Declassified September 1999, p. 10.
[11] Munir Ahmad Khan, Speech delivered at the Chaghi Medal Award Ceremony, Pakistan Nuclear Society, PINSTECH Auditorium, Islamabad. March 20, 1999.
[12] Shahid-ur-Rahman, *Long Road to Chaghi* (Islamabad: Print Wise Publications, 1999), p. 29.

expressed interest in acquiring more knowhow and understanding about uranium enrichment. PAEC asked the French Atomic Energy Commission in 1974 if it could train some Pakistani scientists in enrichment knowhow, especially the "laser and ultra gas-centrifuge technologies."[13] Predictably the French refused. However, prior to India's nuclear test of 1974, and in the following few years, abundant technical literature on centrifuge technology was publicly available. That is why when Mahmood visited Brussels in early 1975 to meet A. Q. Khan for the first time, on his way back, Munir Khan arranged a visit for him to the IAEA's library in Vienna. This was useful as he was able to bring valuable open-source technical literature on uranium enrichment technology to Pakistan.[14]

Other Pakistani expatriate scientists and engineers studying or working abroad similarly gathered openly available technical literature and sent it back home.[15] The 1974 nuclear test by India also changed many things, and in the wake of this development, PAEC was forced to re-consider its strategy. It was apparent that India's violation of its commitments with the United States and Canada in view of the diversion of the CIRUS's fuel for its first atomic test would have serious consequences. The international community would move to strengthen international safeguards considerably and restrict the availability of nuclear technology to India, and Pakistan as well. The Indian test also proved to be a catalyst for Pakistan to develop a crash programme to get the bomb as the urgency to develop a nuclear deterrent became paramount.

In this context, it was logical that Pakistan would go for enrichment in parallel with reprocessing, in order to circumvent any possible sanctions on the acquisition and sale of nuclear technology for any one route. Going for both enrichment and reprocessing would not only give Pakistan mastery over the complete nuclear fuel cycle, but also offer greater flexibility in nuclear weapon designs, with the availability of both fissile materials. Hence, throughout 1974, serious exploratory and research activities were carried out in PAEC and various options for enrichment were evaluated and some

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[13] Weismann and Krosney, *The Islamic Bomb* (New York: Times Books, 1981), p. 181.
[14] Interview with Mahmood, op. cit.
[15] Parvez Butt (ex-Chairman of PAEC, 2001-2006), interview by authour, written notes, August 13, 2008. Islamabad

laboratory scale investigations also conducted. These included gaseous-diffusion, laser, and electromagnetic separation, the Becker-nozzle and gas-centrifuge methods.[16] In this respect, Dr. Riazuddin, the then Member (Technical) PAEC, was directed by Munir Ahmad Khan to carry out a comparative study of various methods for uranium enrichment. He claimed:

> The general impression is that PAEC was not aware of uranium enrichment technologies and only A. Q. Khan was aware of it. In fact PAEC was fully aware of various enrichment methods and I studied various methods for enrichment, with their relative merits and demerits, and progress was also made in this regard." [17]

Dr. Samar Mubarakmand also recalled that various specialized groups were set up in 1974 in PAEC to explore the different methods of uranium enrichment. He headed one such group that carried out experimental studies on one enrichment method at PINSTECH.[18] PAEC scientists and engineers claim that it was logical for Pakistan to have chosen the gas-centrifuge method in place of other commercial routes to uranium enrichment, such as gaseous-diffusion, because of considerations of infrastructure, time-scale and enormous power requirements. One factor was that "the gas-centrifuge had the largest separation factor compared to other commercial methods."[19]

Therefore, it was only a question of mastering one machine's technology compared to the other complicated infrastructure associated with other enrichment methods that were more costly and time consuming. This latter consideration was also cited as reason by a former Chairman of PAEC, Parvez Butt, for abandoning plans for the time being, to build an indigenous NRX-type plutonium production reactor, PAKNUR or Pakistan Nuclear Reactor. In this respect, he claimed:

> If we had to build one such reactor, it would comprise thousands of components and for the reactor to work, every single component had to function properly, and this had to be ensured when it would be built. If any one component were to fail, the entire reactor would be put in jeopardy. On the other hand, here we had one single small machine, the gas-centrifuge, which was not a new invention and we were familiar with its design and engineering. We felt that if we can master one such machine, comprising about 100

[16] Interview with Riazuddin, op. cit.
[17] Ibid.
[18] Samar Mubarakmand, Speech delivered at the "Munir Ahmad Khan Memorial Reference," Pakistan Agricultural Research Council Auditorium, April 29, 2007, Islamabad.
[19] Interview with Riazuddin, op. cit.

> parts, the same could be produced in large numbers and a whole gas-centrifuge plant built on it. So it was a choice between mastering many individual components and machines needed to build a reactor, and mastering just one single machine. And in all this, time was of the essence.[20]

Mahmood gave similar reasons for making gas-centrifuge route to enrichment as the first choice for PAEC in 1974. He claimed:

> The actual design and complete dimensions of the Zippe-type centrifuge was available with us. It was enough for an intelligent team to understand and build. It had a rotor made of aluminium and was good enough for enrichment. It was the basis of gas-centrifuge technology. And the development by URENCO[21] was also based on the Zippe design and was its advanced version. Keeping our country's infrastructure, and the fact that we needed only some precision machines for making components used in gas-centrifuges, and because gas-centrifuges did not require large facilities and infrastructure, we felt that this technology could easily be mastered by Pakistan. It is totally wrong to say that A. Q. Khan came here and said that we should do this and that.[22]

With regard to the selection of the gas-centrifuge technology for uranium enrichment, Munir Khan also claimed: "we had decided to select the gas-centrifuge process for enrichment in preference to other processes."[23] Therefore, when PAEC decided to adopt gas-centrifuge technology for uranium enrichment, it may be presumed that the decision to go for gas-centrifuges was taken after due consideration. In this respect, the offer of information on gas-centrifuge design offered by Dr. A. Q. Khan would also prove to be a catalyst as PAEC was looking for information from different sources. These issues are discussed at length in the following paragraphs and in the subsequent chapter.

7.3. Launch of the Enrichment Project

In the fall of 1974, the Chairman of PAEC seems to have made up his mind to launch the uranium enrichment project. The future Project-Director of this project, Sultan Bashiruddin Mahmood recounted the events leading up to his appointment as its head. In

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[20] Interview with Parvez Butt, op. cit.

[21] The Uranium Enrichment Corporation or URENCO was founded in 1971 and combined West German, British and Dutch efforts to produce a steady supply of enriched uranium to their nuclear power plants. It built a gas-centrifuge based uranium enrichment plant at Almelo, the Netherlands. Please see: Weismann and Krosney, op. cit., p. 176.

[22] Interview with Mahmood, op. cit.

[23] Munir Ahmad Khan, "Bhutto and the Nuclear Programme of Pakistan," *The Muslim* (Islamabad), April 4, 1995.

October 1974, he got a transfer order from KANUPP to PAEC headquarters, Islamabad. At that time, some studies were being carried out on the Chashma nuclear power project (CHASNUPP), and he was ostensibly posted there.[24] In this regard, he claimed that in the last week of October, Munir Ahmad Khan directed him to prepare a working paper on enrichment technology, since he had to deliver a lecture on it somewhere. He was asked to take three to four days and complete the assignment in secrecy.[25] Mahmood went to PINSTECH library where was also able to find a small book on gas-centrifuges. Based upon that, based upon his discussions of 1968-69 with South Africans in Risley,[26] based upon the gas-centrifuge research work done in Lahore Centre in 1967, he was able to prepare a working paper, which he claimed to be state-of-the-art. In this paper, he discussed diffusion, Becker-nozzle, gas-centrifuge and laser technologies for enrichment.[27]

This paper was hand written and consisted of fifteen pages, which included cost estimates and technological analysis of various enrichment methods. He claims that he had absolutely no idea why the Chairman had asked him to prepare this paper.[28] The next day Mahmood was asked to prepare a classified and detailed handwritten paper on a uranium enrichment programme based on gas-centrifuges.[29] He claims that Munir Khan wanted the paper to be submitted the following day, since Brig. Imtiaz Ali, the Military Secretary of the Prime Minister was asking for it.[30] The paper was designed on the pattern of a Planning Commission Pro-forma, known as PC-1, which included cost estimates, manpower requirements, timeframe and other related details.[31] He now submitted a forty-two page handwritten project proposal with a cost estimate of US $ 35 million, which envisaged completion of the project and start of operations by 1980. The

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[24] Interview with Mahmood, op. cit. Also see Mahmood's Interview with Waqt News TV, op. cit.
[25] Ibid.
[26] Mahmood had worked with South African scientists at the British Nuclear Research Establishment at Risley where he held discussions on uranium enrichment technologies. Please see Shahid-ur-Rahman, op. cit. p. 48
[27] Interview with Mahmood, op. cit; Shahid-ur-Rahman, op. cit. p. 49.
[28] Ibid.
[29] Ibid.
[30] Ibid; S.B.Mahmood, "Munir Ahmad Khan Memorial Reference Speech," Pakistan Agricultural Research Council Auditorium, April 29, 2007, Islamabad.
[31] Interview with Mahmood, op cit.

project was given the deceptive name of Directorate of Industrial Liaison (DIL), and came to be known as Project-706 or "Special Project"[32] in PAEC.[33] However, his appointment came at the end of his meeting with the Chairman of PAEC.[34]

Mahmood also claimed that the Member (Finance) of PAEC was asked by the Chairman to honour all his requests for funds without question or delay, as the necessary financial powers for the enrichment project had now been delegated to the Project Director.[35] On the morning of February 15, 1975, he drove Munir Khan to Chaklala airport in Rawalpindi. Here a special military aircraft was waiting to take the Chairman of PAEC, to Prime Minister Bhutto's hometown of Larkana.[36] On this day, the Chairman was seeking Bhutto's formal approval for funding a US $ 450 million nuclear weapons programme, using the highly enriched uranium route for producing fissile material and the bomb. This proposal included:[37]

i- A nuclear weapon design programme headed by Dr. Riazuddin.
ii- A uranium exploration, refining and uranium conversion programme at Baghalchur (BC-1) and Dear Ghazi Khan respectively.
iii- A uranium enrichment project based on gas-centrifuge technology.

After securing the Prime Minister's approval, the Chairman of PAEC returned to Islamabad the same evening and was received by Mahmood.[38] Opposed to PAEC's

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[32] Salim Mehmud (ex-Chairman, SUPARCO), Speech delivered at the "Munir Ahmad Khan Memorial Reference," Pakistan Agricultural Research Council Auditorium, April 29, 2007, Islamabad.
[33] Interview with Mahmood, op. cit.
[34] In an interview with the author, Mahmood claimed that Munir Khan informed him of his appointment as Project-Director, thus: "He then put his transistor radio on and said 'today I am going to share a secret with you. I had given you a job and it had a purpose. I have studied the reports that you have prepared, and heard you also, and we have taken a decision that I want to share with you. This is extremely confidential and it is so confidential that you cannot share it even with your wife. We have decided to start the enrichment programme and I have already decided that you will head that programme. So you should prepare yourself and I will again say that it is a most secret project. That letter which you had sent to me from KANUPP after India's test, you can see that this is the journey towards that goal." Also see: Farhatullah Babar, "Apportioning Credit for the Bomb," *The News* (Islamabad), June 21, 1998.
[35] Interview with Mahmood, op. cit.
[36] Ibid; Farhatullah Babar, op. cit.
[37] Shahid-ur-Rahman, op. cit. p. 50.
[38] Farhatullah Babar, op. cit; in an interview with the authour, Mahmood recalled: "He then asked me to pick him up from the airport at five in the evening of the same day.[38] When he came out of the airport, he looked very happy and had a big smile on his face as if he had won a big battle. He then said to me,

version, A. Q. Khan has given a different version with regard to the inception of the enrichment project. He linked its inception with the cancellation of the commercial reprocessing plant contract with France.[39] However, as was discussed in the previous chapters, Pakistan's contract with France for the supply of the reprocessing plant was cancelled in August, 1978, and by that time, the enrichment project was at least three to four years old.

7.3. Manpower Recruitment

Trained manpower is perhaps the single most important factor for the success of any technical project. In this regard Mahmood recalled:

> When we launched this project in the fall of 1974, the most important concern was the build-up of manpower for the project. This included the selection and recruitment of the right people with the right qualifications. In addition, we were also looking for any knowhow and information in addition to what was already available with us. Our objective was not to re-invent the wheel, we just had to adopt the technology in a Pakistani setting and we wanted to keep ourselves abreast with the latest advances in technology around the world. [40]

The Chairman of PAEC did not wish to recruit everyone from within PAEC. This consideration was motivated with a view to select suitable people from anywhere within the country who could be useful for the project, who could then be easily adapted to

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'Congratulations, he (Bhutto) has signed the project proposal without even reading it. Now you go ahead and you should begin work on the infrastructure for the project.' Now looking back it seems very unusual that Bhutto sanctioned such a big project on the recommendation of Munir Khan. Credit must be given to both Bhutto and Munir Khan who conceived this project and enabled us to begin work on such a project of national importance."

[39] Dr. A. Q. Khan, "Pakistan's Nuclear Programme: Capabilities and Potentials of The Kahuta Project," Speech delivered at the Pakistan Institute of National Affairs, September 10, 1990. He stated: "To complete the humiliations of a developing and third world country, the French backed down from the agreement made under the aegis of the IAEA for the supply of a reprocessing plant. It was an international agreement made between two sovereign states with the IAEA as a referee. The Americans succeeded in arm-twisting the French and the French who normally have great pride, went back on their international agreement. The reprocessing plant was going to be under IAEA safeguards and there was not the remotest possibility of misusing this facility for non-peaceful purposes, though those who had advised the Government to buy it were under other illusions. It was at this stage that Pakistan took up the challenge and decided to go alone and be self-reliant in nuclear technology. In July 1976 our government decided to go all out to master the enrichment technology and to ensure our self-reliance on our own fuel for all further light water nuclear power reactors. The Engineering Research Laboratories (ERL) was set up on the 31st of July 1976 to undertake the enormous task of putting up an indigenous enrichment plant. Our President, Mr. Ghulam Ishaq Khan, was appointed as Chairman of the Coordination Board."

[40] Interview with Mahmood, op. cit.

PAEC's work requirement and culture.[41] One of the first engineers recruited for the project was Ashraf Chaudhry, who was a mechanical engineer, working in PINSTECH. Among the first recruits for the project was Ijaz Khokhar, who Mahmood termed as a brilliant mechanical engineer. Khokhar was working in Pakistan Industrial Technical Assistance Centre (PITAC), Lahore. He was known to be adept in building gadgets and had an R&D aptitude and gave an Einsteinian look, with long hair and big moustaches. He was the first senior-level engineer who was selected for the project and played a key role in its success by contributing in preparing designs of various components and development of the gas-centrifuges.[42] About ten people were also selected from Pakistan Ordnance Factories (POF) and out of these a few became Directors and Members in KRL in later years.[43]

DIL, the deceptive code-name used by the project, also published an advertisement in the name of PAEC, which invited engineers for industrialization of R& D technologies being developed with local industry. The policy was to select young, bright engineers and scientists, with original ideas and fresh minds, suitable for R&D. "We believed in going for the younger lot and then training them, and this was a very successful strategy in the Khushab plutonium production reactor project also." [44] Another important scientist selected during 1975 was Dr. Ghulam Dastagir (G.D.) Alam who had been working in PINSTECH and would rise to the position of Chief Scientific Officer of the enrichment project under A. Q. Khan. He became the head of the process engineering and vacuum side of the project including the B-2 laboratory at the R&D gas-centrifuge facility, the Airport Development Workshop (ADW), which was involved with the gas-centrifuge design and development effort.[45]

G. D. Alam would also lead the team that carried out the first successful enrichment through gas-centrifuges in ADW in June 1978 and remained actively involved in setting up the main plant Kahuta and in procurements after A. Q. Khan took

[41] Ibid.
[42] Ibid; Shahid-ur-Rahman, op. cit., p.57.
[43] Interview with Mahmood, op. cit.
[44] Ibid.
[45] Ibid; Shahid-ur-Rahman, op. cit. p. 57.

over the project from Mahmood.[46] Yet another important member of the team selected during 1975-76 was Dr. Javed Arshad Mirza who was given the task of developing indigenous high-frequency inverters for the gas-centrifuges.[47] Mirza would succeed A. Q. Khan as head of KRL after the latter's retirement in 2001. In July 1976, Anwar Ali was also asked by the Chairman of PAEC to cut short his Ph.D in the United Kingdom and join the project.[48] He also played a very important role in making the project a success and was responsible for Computers and Control in the project.[49]

7.4. Procurements for the Project

In order to build an indigenous uranium enrichment plant using gas-centrifuge technology, it was inevitable for Pakistan to procure high-technology machines, equipment and materials in the initial phase. This would be supplemented with the development of a parallel indigenous capability. In this respect, Mahmood claimed that the declared policy of Munir Ahmad Khan was to develop indigenous capability as far as possible, coupled with procurements where necessary. It was the Project Directors' responsibility to implement this policy so that they could get maximum benefit from minimum expenditure.[50] Secondly, on long-term basis if procurements were stalled due to sanctions, an indigenous capability would not halt the project. Thirdly, along with gas-centrifuge, other technologies could also be developed locally and its spin off could be useful in the country's industry and economy. [51]

Thus, the policy of indigenization was based on this rationale and to implement it, a comprehensive survey of local industries was carried out and many industries and their selected manpower were pre-qualified.[52] This strategy was centered on DIL's basic mandate and was also adopted in several other projects being run in PAEC. [53] The logic

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[46] Interview with Mahmood, Ibid.
[47] Ibid; Shahid-ur-Rahman, op. cit, p. 57.
[48] Anwar Ali, Chairman of PAEC, 2006-2009, interview by authour, written notes, Islamabad, February 2, 2007.
[49] Interview with Mahmood, op. cit.
[50] Ibid.
[51] Ibid.
[52] Ibid.
[53] M. Amjad Pervez, "Heavy Manufacturing Facilities of Pakistan Atomic Energy Commission," *The Nucleus*, Vol. 42**,** Nos.1-2 (2005), p. 97.

behind making large-scale procurements at a time was an anticipated embargo and more strict international export controls on nuclear materials, technology and equipment that in the wake of India's test a year ago. Therefore while the critical machinery and materials were still easily available, it was desired to be procured in bulk so as to pre-empt any future shortages or sanctions on the sale of such items, even though many of them were dual-use technologies. The Chairman of PAEC had told Mahmood in 1974 that they had only two years to complete most of the essential procurements.[54]

Hence, PAEC also began to tap its elaborate and surreptitious procurement network in Europe, for the enrichment and other fuel cycle projects.[55] The Chairman of PAEC set up this import-oriented network in the early 1970s through his trusted confidant and PAEC's procurement chief in Europe, Shafiq Ahmad Butt, or S.A. Butt. According to Mahmood, Butt not only knew procurement, he also had a degree in chemistry, "so in a way he was a procurement scientist, and he had a very good understanding of many technical issues." [56]

Butt had served in Pakistan Ordnance Factories (POF), Wah, for a long time, and by virtue of this experience, he was well versed in the field of materials also. His knowledge about non-ferrous alloys was quite good. [57] Moreover, Butt had a wonderful memory and he could communicate in some other European languages besides English. "Most importantly," claimed Mahmood, "the sources of procurement in Europe were well known to him." [58] Perhaps Butt was the most suitable man picked up for the job.[59]

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[54] M.A. Chaudhri, "Pakistan's Nuclear History-Separating Myth from Reality," *Defence Journal* (Karachi),Vol. 9, No. 10 (May 2006).

[55] Bruno Tertrais, "Not a 'Wal-Mart', but an'Imports-Exports Enterprise': Understanding the Nature of the A. Q. Khan Network," *Strategic Insights* (California), Vol. 6, No. 5 (August 2007). Available at: http://www.stanleyfoundation.org/publications/working_papers/Delory2.pdf. (accessed May 10, 2010).

[56] Interview with Mahmood, op. cit.

[57] Ibid.

[58] Ibid.

[59] S. A. Butt was described thus in *Long Road to Chaghi: "*S. A. Butt was the best man that PAEC could have picked up to procure materials and equipment for the sensitive job that had been assigned to the Pakistani scientists by Prime Minister Z. A. Bhutto in 1972. He had a Masters degree in biochemistry when selected for Pakistan Ordnance Factories, Wah, after the birth of Pakistan in 1947. He was sent for training to the United Kingdom where he had the opportunity to visit the Royal Ordnance Factories and nuclear facilities. From 1956-60, he was posted as Attaché (Technical) at the Pakistani High Commission in Britain and helped procure equipment for Pakistan Ordnance Factories. He was one of the few people at

While Munir Khan was the procurement network's "operational commander," S. A. Butt became its "tactical commander," who was responsible directly to the Chairman of PAEC.[60] This import-oriented network would be used to acquire almost everything that was needed to launch a gas-centrifuge based enrichment project in Pakistan. This is evident from the authors of *The Islamic Bomb* and other Western publications.[61][62] Moreover, with regard to the procurement of essential material and equipment, Mahmood claimed:

> The main challenge facing us was to gather all the materials for the project. Similarly, it was envisaged that all the essential machinery for the project should be collected. On the procurement side, 1975 was the best year because in this year we were able to import the entire machinery for Phase-I of the project. The major machinery included inverters, which we got from England, but the most critical machinery was German. Some materials like maraging steel were procured in large quantities. The rationale behind such a large volume purchases was that the material would remain in stock and could be used as per the needs of the project. This strategy was envisaged and supported by Munir Ahmad Khan.[63]

Interestingly, several years later, Iran is following a similar pattern of procurements and indigenization in its gas-centrifuge programme. It has reportedly

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POF familiar with nuclear technology and advocated the nuclear option for Pakistan, as early as November 1957, at the 9th Pakistan Science Conference held in Peshawar." Shahid-ur-Rahman, op. cit., pp. 2-3.

[60] Mark Fitzpatrick, ed., *Nuclear Black Markets: Pakistan, A.Q Khan and the Rise of Proliferation Networks*, IISS Strategic Dossier, (London: International Institute of Strategic Studies, May, 2007) p. 26.

[61] "Under Munir Khan's guiding hand, Butt would organize Pakistan's surreptitious purchasing network from a little office on the outskirts of Paris, running the most successful foray into nuclear espionage since the Soviet Union set out to penetrate Anglo-American nuclear efforts during and after World War II." Weismann and Krosney, op cit., pp. 47-48.

[62] "The imports network was originally a 'Khan network,' but not in reference to A. Q. Khan. A different individual was running the show: most imports from the West were supervised by Munir Ahmad Khan, the head of the Pakistani Atomic Energy Commission and arguably the true "father" of Pakistan's bomb. One of the network's key operatives, and probably its chief operating officer for Europe was S. A. Butt, a physicist turned diplomat, who was assigned to various embassies. The network began operating in earnest in 1976. Having just returned from the Netherlands, A. Q. Khan soon played a crucial role, but only in the management of imports related to the centrifugation technology. S. A. Butt managed both the uranium-related and plutonium-related imports. He remained in charge at least until the late 1980s. The imports network's *modus operandi* included a combination of several elements that ensured its success and longevity. Pakistan resorted systematically to the use of its embassies abroad, and often to Pakistani-born foreign nationals. It paid more than the market value of the items purchased. The Pakistanis played smart and were always one step ahead of the legality. As exports controls began to be reinforced in the late 1970s, they purchased individual components rather than entire units. After, they often learned how to reproduce the parts. Pakistan also sought to import "pre-forms," which are not necessarily covered by exports controls. Besides classic tricks such as multiple buyers, multiple intermediaries, front companies and false end-user certificates, Pakistan used more imaginative tactics: for instance, it sometimes hid a critical component in a long list of useless material. It also often limited its "shopping lists" to a few samples, in order to learn how to reproduce them." Bruno Tertrais, op. cit.

[63] Interview with Mahmood, op.cit.

succeeded in procuring "high-strength aluminium, maraging steel, electron beam welders, balancing machines, vacuum pumps, computer-numerically controlled machine tools, and flow-forming machines for both aluminium and maraging steel."[64] Some of the critical imports made through S. A. Butt for Pakistan's gas-centrifuge programme during 1975-76 are discussed in the following paragraphs.

7.4.1. Frequency Inverters

The essential machinery required for the gas-centrifuge project included high-frequency generators or inverters, which are used to regulate power supply to the gas-centrifuges. In this field, PAEC enlisted the support of local industry and efforts to develop them indigenously. PAEC was inclined to evaluate two types of generators. One type was stationary, i.e. electronic in which Alternate Current (AC) is converted to Direct Current (DC) and the second type was a rotary, high frequency alternator. The most commonly used inverters were stationary. Emerson Electric was a British company that was contacted through S. A. Butt.[65] In this regard, a recent study on Pakistan's gas-centrifuge enrichment project stated:

> PAEC decided to build its P1 model (gas-centrifuge) based on the designs from a Dutch gas-centrifuge, this type being considerably easier to construct than the German model gas-centrifuges for which A. Q. Khan had designs. Butt and Khan started to seek out URENCO's suppliers and began to order components. In August 1975, Butt telephoned Emerson Electric Industrial Controls Ltd., a U.S. owned company, seeking information about frequency inverters, an important component that powers a gas-centrifuge and keeps it spinning at a precisely specified speed. He told the company he worked at Belgo-Nucleaire, a famous Belgian nuclear company, and asked about buying a specialized converter.[66]

Earlier, PAEC had unsuccessfully attempted to acquire the inverters through Pakistan Embassy's commercial attaché in the United Kingdom.[67] Later, S.A. Butt was

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[64] Jack Boureston, "Fuel Cycle: Tracking the Technology," *Nuclear Engineering International*, September 30, 2004.
[65] Interview with Mahmood, op. cit.
[66] David Albright, *Peddling Peril: How the Secret Nuclear Trade Arms America's Enemies* (New York: Free Press, 2010), p.23.
[67] Shahid-ur-Rahman, op. cit., p. 62

able to find a West German supplier, Ernst Piffl for inverters, as his country was also a part of the URENCO Consortium. Butt contacted Piffl in Paris, where he had moved from Brussels in 1977 and told him that Pakistan needed a certain kind of inverter, used in a textile plant.[68] An initial order of about forty inverters was placed with Piffl's firm, Team Industries, costing about thirty to forty thousand pounds per piece. Piffl managed to arrange their supply from Emerson Electric. This firm had also supplied inverters to the United Kingdom Atomic Energy Authority's (UKAEA) gas-centrifuge plant at Capenhurst, as part of the URENCO Consortium and was being operated by British Nuclear Fuels Ltd.[69] Piffl sent the first batch of this initial order to Pakistan in December, 1977, while the entire shipment reached Pakistan in August, 1978.[70]

The engineers at Emerson Electric had assumed that these inverters would be practically useless for Pakistan, as its engineers and technicians would never be able to operate such sophisticated pieces of equipment. Very soon their doubts were proved wrong when the Pakistanis sent Emerson an elaborate list of complex modifications for subsequent shipments of inverters. Thus one Emerson engineer remarked: "With this, another Anglo-Saxon prejudice about Pakistani incompetence went down the drain."[71] Following the procurement of the first batch of inverters, Mahmood and his colleagues decided to reverse engineer these samples and to understand how they worked.[72] This sub-project was assigned to Dr. Javed Arshad Mirza. He was tasked with reverse engineering of high frequency invertors.[73] In order to develop these inverters indigenously, some local Pakistani companies were asked to develop electronic types of high frequency generators. They would be given the principal design of the generators who would then develop the generators or inverters for their customer.[74]

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[68] Weismann and Krosney, op. cit., p. 186.
[69] Ibid, pp. 186-187; Shahid-ur-Rahman, op. cit., p.62.
[70] Adrian Levy & Catherine Scott Clark, *Deception: Pakistan, the United States and the Global Nuclear Weapons Conspiracy* (New Delhi: Penguin Books, 2007), pp. 54-55.
[71] Weismann and Krosney, op. cit., p. 187.
[72] Interview with Mahmood, op. cit.
[73] Ibid; Shahid-ur-Rahman, op. cit., p. 57.
[74] Interview with Mahmood, op. cit.

While the initial order placed by S. A. Butt had been completed, the project required at least 150 more inverters.[75] Therefore, after A. Q. Khan took over the project in July 1976, another order was placed for additional inverters, but the order went to Peter Griffin, and not Ernst Piffl. Griffin had set up his own firm in Swansea, United Kingdom, known as Weargate, along with an Indian national, Abdus Salam, who was "an old friend of A. Q. Khan." [76] Nevertheless, other avenues for the procurement of inverters continued in later years. Another attempt in December 1978 to procure 200 inverters from Mitsubishi Electric Company in Japan was unsuccessful. Then in July 1980, two ERL officials, Anwar Ali, and Imtiaz Ahmad Bhatti, reached Montreal, Canada, to shop for individual inverter components such as capacitors and resistors. They wished to buy these items from the General Electric Ltd. plant in the United States. They succeeded in making eleven shipments of inverter components to Pakistan, worth $ 170,000 before the last shipment was stopped on Montreal airport by Canadian authorities.[77]

7.4.2. Electron Beam Welding and Flow Forming Machines

A major problem facing the gas-centrifuge project was the welding of various centrifuge components. This required an Electronic Beam Welding Machine, which was a very special and high technology piece of equipment, used in ultra-precision welding. PAEC got this machine from West Germany.[78] In 1976, a British gas-centrifuge expert, Trevor Edwards learned that Pakistan had also ordered a flow-forming machine from the West German firm, Leifeld.[79] With regard to the procurement of the specialized, flow-forming machines used in the manufacture of gas-centrifuge rotors, Mahmood claimed that PAEC had in the very beginning identified certain machines, without which, no work could be done. This flow-forming machine was one such machine and it was obvious that without this specialized machine, the rotors of gas-centrifuges could never be built

[75] Shahid-ur-Rahman, op. cit., p.62.
[76] Ibid.
[77] Weismann and Krosney, op. cit., pp 216-217.
[78] Shahid-ur-Rahman, op. cit., p.62.
[79] David Albright, op. cit, p. 39.

indigenously. In Dusseldorf, machines for making the rotors of gas-centrifuges were being manufactured. These were not made for gas-centrifuges per se and were called three-roller, high compression machines. These machines could squeeze the metal and converted it into the thinnest possible, highly uniform file.[80]

S. A. Butt, and Mahmood first went to Dusseldorf in March 1975, where these machines were being manufactured. Manufacturing these three-roller, high-compression machines was their [the West German firm's] specialty in the world. The German whom they met was a sharp fellow. After one or two days he said: "I'll show you a machine, may be you will like that better than this." He then brought a particular specification and said: "Why don't you buy this machine? This can make rotors for gas-centrifuge also." The customers from Pakistan knew it but did not want to acknowledge it themselves. The West German then opened up and said: "I have one such machine with me. Some other eastern country has also placed an order for it but they have not picked up this machine, so if you like, I can dispatch the machine immediately, but you have to make the payment first." This machine was for the manufacturing of aluminium rotors of centrifuges.[81]

PAEC received this machine under another name, within one and a half-month of placing the order. This was essentially its shipping time, while the ordinary delivery time for such a machine was one year. This flow-forming machine was commissioned in June-July 1975 at PAEC's gas-centrifuge R&D facility, Airport Development Workshop (ADW), Chaklala.[82] These procurements, however, had to be carried out in a discreet manner, so as to conceal the real purpose and end-user of the item being purchased. Moreover, Western companies openly engaged in the sale of such equipment to Pakistan in a surprisingly open and candid manner. It seemed like big business for them. They went about their shopping spree without fearing being exposed.

[80] Ibid.
[81] Ibid.
[82] Ibid.

In this regard, A. Q. Khan also claimed that Western companies approached Pakistani procurement agents quite candidly.[83] He also acknowledged that procurements for the gas-centrifuge project had begun while he was still in the Netherlands, i.e., 1975.[84] Therefore, the procurement of the flow-forming machine was critical to the success of an indigenous gas-centrifuge programme for Pakistan, whose importance for the project was also seconded by A. Q. Khan. In a June 1976 letter to Munir Khan on the status of the project, he stated that most of the critical materials and machines for the project had either been procured/arrived or orders had been placed for them. He stated that the project would not have had a chance of success without the Flow-turning Machine, Mass Spectrometers, Electron-Beam Welding Machine and High Frequency Inverters that had been procured and made available. The procurement of this equipment, which was more or less subject to safeguards, gave the project a very good chance of success.[85]

Moreover, the initial success at procuring flow-forming machines led to the procurement of yet another such machine, which was more powerful than the previous one. This was to be used in making maraging steel rotors as part of the next stage in gas-centrifuge development envisaged by PAEC. When the first flow-forming machine arrived, Mahmood and Butt visited West Germany again and placed an order for the more sophisticated machine with the same manufacturer. The German was happy to satisfy his customers and the machine arrived in Pakistan in June 1976.[86] When one of these flow-forming machines was being prepared for Pakistan, a British technician working at URENCO's Almelo plant visited the manufacturing firm in the Rhine Valley. He was assigned to inspect the assembly of "specialized, free-flowing lathes being

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[83] In a 2009 interview with Swiss weekly *Die Weltwoche,* A. Q. Khan claimed: "The Americans themselves sold us all kinds of computers for our use in Kahuta as well as electronic components, equipment, inverters, valves, leak detectors, materials and other nuclear-specific things. I guess that is to be classified as "business" and not as "irresponsible behaviour". Please see Urs Gehriger, "Interview with Abdul Qadeer Khan," *Die Weltwoche,* January 21, 2009.

[84] "Certain orders were placed by Pakistan in that period which indicated that an enrichment programme had been initiated, but these were all for non-classified equipment and/or materials, information for which was obtainable from the open market." "Interview with Abdul Qadeer Khan," Ibid.

[85] A. Q. Khan, handwritten letter to Chairman of PAEC, Munir Ahmad Khan, June 10, 1976.

[86] Interview with Mahmood, op. cit.

assembled for shipment to URENCO, where they would be used to manufacture centrifuge components."

When he noticed an extra lathe being assembled, identical to the other lathes, he was told that it was being prepared for a company in Pakistan.[87] These flow-forming machines would also be used in making rotors, which comprised of two or three parts, and were inter-connected with bellows. In this regard, a recent study on Pakistan's gas-centrifuge project claimed that in 1976, Pakistan had ordered a specialized machine identical in 1976. This machine was similar to the one's ordered by URENCO from the German company, Leifeld. These [flow-forming] machines were specially tailored to manufacture maraging steel tubes for bellows used in a Dutch gas-centrifuge.[88] Moreover, When Pakistan started to manufacture experimental prototype gas-centrifuges at ADW their rotors were indigenously made through these flow-forming machines procured from West Germany.[89]

7.4.3. Maraging Steel, Specialized Steel Tubes and Bellows

Maraging steel was also another essential material required in the manufacture of high-strength gas-centrifuge rotors that spin at much greater speeds than aluminium rotors, and are capable of working under very high stresses.[90] Procurement of this material marked another major success for PAEC in 1975. In this regard, Mahmood claimed that, in 1975, an order for a large quantity of maraging steel, sufficient for ten years' requirement was placed.[91] This quantity of maraging steel obtained by S. A. Butt from a

[87] Frantz & Collins, op. cit., p. 43.
[88] David Albright, op. cit., p.39.
[89] Shahid-ur-Rahman, op. cit., p. 58.
[90] The rotational speed and the length of the rotor determine the separative power of a gas gas-centrifuge. The separative power increases rapidly with rotor speed and is proportional to its length. The peripheral speed of the rotor is limited by the ratio of strength to density of the material with which it is made. Aluminum alloys are capable of maximum peripheral speeds to 425 m/s, maraging steel has an approximate maximum speed of 525 m/s, and carbon fiber can reach 700 m/s. Please see, M.J. Zentner, G.L. Coles, R.J. Talbert, *Nuclear Proliferation Technology Trends Analysis* (Pacific Northwest National Laboratory: United States Department of Energy, September, 2005), p. 15.
[91] Interview with Mahmood, op. cit.

West German firm, Rochling, and shipped to Pakistan, was sufficient for producing 532 gas-centrifuge rotors. [92]

The rotor of a gas-centrifuge was made in two or three parts, which were connected to each other by the means of bellows. The bellows act as shock absorbers and keep the rotor in place under extreme stress.[93] Therefore, the bellows had to be of very high strength alloys, preferably maraging steel. If the bellows are made from maraging steel, connecting them together with aluminum becomes a challenge, as they are two dissimilar metals. Therefore, bellows' development also became a separate sub-project within the overall gas-centrifuge project, in which Ijaz Khokhar and Colonel Abdul Rashid were tasked with the development of bellows through the process of explosive forming. Ijaz Khokar would also be tasked with heading the team that would work on the design and manufacture of the gas-centrifuges themselves. This led to extensive R&D in this field, which also had other industrial applications.[94] In this regard, mechanical and electrical workshops were set up in ERL under A. Q. Khan[95]

In the summer of 1976, S. A. Butt placed an order in Europe for a large quantity of specialized steel tubes. A Dutch firm, Van Doorne Transmissie (VDT) agreed to provide Pakistan with a certain quantity of especially hardened steel tubes, used for making gas-centrifuge rotor-casings. This was yet another major success in the procurement efforts of S. A. Butt.[96] This came to be known as the "Pakistani Pipeline." The first batch of 300 tubes was sent to Pakistan on November 2, 1976, while the entire

[92] Frantz & Collins, op. cit., p. 43.
[93] M.J. Zentner, op. cit., p. 16.
[94] Interview with Mahmood, op. cit.
[95] Shahid-ur-Rahman, op. cit., p. 57.
[96] "Only July 1, 1976, S. A. Butt sent a letter from Brussels on Pakistani Embassy letterhead that followed up on a telephone conversation with Mr. M. Niessen, the head of VDT. Butt asked for "1,000 meters" of extremely durable steel tubes to be made according to a sketch included with the letter. The initial order was enough for about 2,000 tubes, each one-half meter long. The order was subsequently expanded to 6,000 tubes. Most were shipped directly to Pakistan, while the rest were delivered to Dutch, French and English clients, as instructed by Butt in an attempt to disguise the true recipients. The tubes would be cut into sections of 60 to 100 millimeters before being machined into finished bellows. Each P1 gas-centrifuge requires three bellows, so the order was enough to make bellows for 10,000 gas-centrifuges. If all these gas-centrifuges worked, they could produce about 100 kilograms of weapon-grade uranium each year, enough for four or five nuclear weapons per year." David Albright, op. cit., pp. 32-33.

order was completed in September 1979.[97] The Dutch government tried to prevent the sale but could not invoke any legal provisions to do so and VDT was able to complete the bulk of the order.[98] In addition, between 1975 and 1977, Butt placed another order of rolled rods and 10,000 small parts. These were "especially welded according to detailed plans submitted by the Pakistanis," order worth forty million deutschmarks, initially with Aluminium Walzwerke of Singen, West Germany.[99] Butt later requested 10,000 bellows from a French firm in 1977, but only a part of the order could be shipped via Belgium along with the dies, "to enable the Pakistanis to make the rest themselves."[100] The bulk of this order, however, could not be completed since the French government forbade its sale.[101]

7.4.4. Ring Magnets and Top Bearings

Each gas-centrifuge machine is balanced through a magnetic bearing at the top and the weight of the machine is supported by the magnet. These ring magnets are designed to keep the top of the gas-centrifuge rotor stable, without any physical contact with the rotor itself. It also creates a small opening at the top of the gas-centrifuge that enables the entry and withdrawal of the feedstock UF_6 gas.[102] The procurement of these magnets also began during the formative years of the project. In this regard, Mahmood claimed:

> We saw all the catalogues of international trade items in order to ascertain which magnet would suit our requirements and where we could get them. We also thought that if we were to acquire the magnets in magnetized form, then this might entail some problems regarding their transportation. Therefore, these items had to be acquired in de-magnetized form.[103]

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[97] Weismann and Krosney, op. cit. p. 184; Frantz & Collins, op. cit., p.77.
[98] One of the middle men in the VDT deal was Henk Slebos, who had set up his own business by 1976 and had reportedly even arrived in Pakistan, presumably after A. Q. Khan took over the project Slebos and A. Q. Khan were together at the Technical University of Delft, where they both studied metallurgy. After graduation, Slebos became a technical director of a specialized welding firm in the Netherlands, which was a sub-contractor to Urenco, like A. Q. Khan's FDO, and it is most likely that the involvement of Slebos played a key role in A. Q. Khan increasing the bulk of the order substantially. Please see Frantz & Collins, op. cit., pp. 76-77.
[99] Weismann and Krosney, op. cit., p. 185.
[100] Ibid, p. 186.
[101] Ibid.
[102] M.J. Zentner, op. cit., p. 19.
[103] Interview with Mahmood, op. cit.

Hence, the magnetizing machines had to be either be procured separately, or developed locally. In the wake of anticipated long-term requirements, the high strength magnets also had to be built indigenously. Thus, a separate workshop for their development was also put in place at ADW. A magnet-charging machine was also procured during 1975.[104]

7.4.5. Uranium Hexafluoride Gas Feed and Withdrawal Systems

Although A. Q. Khan had taken over the gas-centrifuge project from Mahmood in July 1976, PAEC remained overall in-charge of the project, till the following year, and hence, S. A Butt continued to carry out procurements for it. Therefore, in the winter of 1976, S. A. Butt and G. D. Alam visited Switzerland and West Germany. They were able to procure thousands of high-vacuum valves from a small Swiss firm, Vacuum Apparat Technik, or VAT, situated near the small town of Haag, on the border with Lichtenstein. Similarly, they were looking for a uranium hexafluoride gas (UF6) handling, or a gasification and solidification plant. This unit was intended to feed the natural UF6 into the gas-centrifuge cascades at the beginning and then taking it out at the end. This plant was also ordered from CORA Engineering located in the Chur valley in Switzerland.[105]

The UF6 handling plant was a critical piece of equipment for developing a functional gas-centrifuge facility, and along with other machines, materials and equipment, this was a vital link in the success of the entire enrichment project.[106] In order

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[104] Ibid.

[105] Shahid-ur-Rahman, op. cit., pp. 60-62.

[106] David Albright, op. cit., pp. 55-56. "Each gas-centrifuge enriches only a small amount of uranium gas. A large number of gas-centrifuges are needed to reach the desired level and quantity of enriched uranium. A collection of gas-centrifuges linked together by pipes is called a cascade; a gas-centrifuge plant comprises many cascades. A specialized piping system carrying the uranium gas leads into and from the cascades. The plants starts with an oven, called an autoclave, which heats a tank of natural uranium hexafluoride. At room temperature and pressures, uranium hexafluoride is a solid. The autoclave turns the solid material into a gas, called the "feed," which then travels into the pipes to the cascades. After passing through another set of pipes to equipment that cools the gas and deposits solid enriched uranium hexafluoride, called the "product," into a transport tank. A third set of pipes leads to equipment to cool and

top procure such auxiliary equipment PAEC officials went to West Germany where they went to the Hanau-based company, Leybold Heraeus. Its sales executive in-charge for the Near, Middle and Far East was Otto Heilingbrunner, who had hired a local Pakistani firm in 1974, Arshad, Amjad, and Abid or "Triple A" as his company's agent in Pakistan. Triple A was one of the front companies involved in procurement for the country's nuclear programme. According to Heilingbrunner, his company made sales to Pakistan's gas-centrifuge programme through Triple A.[107]

Leybold-Heraeus was also well known for being a leader in manufacture of vacuum technology products, used in regulating the flow of UF6 gas in the gas-centrifuges. G. D. Alam informed the Germans that they were looking for a "box-like plant" used in handling of UF6 gas, which would also function under complete vacuum. The Leybold executives shared the design of such a plant, which they had previously supplied, to Brazil. Alam studied the design during the night and the following day, suggested modifications in the design that would meet Pakistan's requirements. Alam's hosts were eager to secure the deal and replied: "We know exactly what you want." [108]

In late 1975, Mahmood and Alam were successful in obtaining cascade design information from Italy and had prepared their own designs for the process engineering for the plant. Therefore, it is likely that this may have helped Alam put forward the requisite specifications. This issue is discussed in greater detail in the following section on the "Italian Connection." The design for the UF6 gas handling equipment, however, was not available to A. Q. Khan while he was in the Netherlands,[109] and was most likely obtained by PAEC from other sources, or built indigenously.[110] Following the footsteps of Heilingbrunner, Gotthard Lerch, a German engineer and one of the key executives of the Leybold-Haraeus Company, visited Pakistan in 1977 and claimed to have held several meetings with A. Q. Khan regarding the contract. He would supervise

collect the uranium waste, called the "tails." Collectively, the feed and withdrawal system represents a major part of an enrichment plant. Without it, a gas-centrifuge plant cannot operate."

[107] Ibid., p. 54.

[108] G.D. Alam quoted in Shahid-ur-Rahman, op. cit., pp. 60-61.

[109] David Albright, op. cit. p. 56.

[110] David Albright in *Peddling Peril* claims that Leybold-Heraeus had arranged the acquisition of suitable designs and their production for Pakistan's gas-centrifuge project from URENCO, independent of A. Q. Khan. Please see, David Albright, pp. 56-59.

completion of the contract and become a regular supplier for KRL in subsequent years and form a long-lasting business association with A. Q. Khan.[111]

G. D. Alam and S. A. Butt had originally planned to procure another flow forming machine from Leybold, which was also known to manufacture these machines. However, they only placed an order for another UF6 handling plant according to the specifications put forward by Alam.[112] Within a fortnight of Alam's return, both VAT and Leybold sent detailed drawings of the UF6 handling equipment to PAEC/DIL after which orders were placed for their supply. Eventually these units were delivered in the June 1978 and it would take three C-130 aircraft to deliver the UF6 plants to Pakistan.[113] Alam followed his initial visits to Europe to check the progress made in the orders placed by PAEC for the supply of the plants. He attended an annual exhibition of nuclear equipment in West Germany where both VAT and Leybold had set up their stalls.[114]

At this exhibition one Leybold executive asked Alam whether Pakistan had ordered a second identical UF6 handling plant from VAT like the one they had from Leybold. Alam gave them the impression that the second plant may have been prepared for the Indians.[115] The inventor of the vacuum-valve, used in controlling the UF6 gas flow in the gas-centrifuges, ordered by Alam and Butt, was a Swiss engineer, Fredrich Tinner.[116] The order of the UF6 handling plant placed with Leybold was completed a few months after Alam's visit to Europe. This plant was sent via a firm in Austria and routed through Dubai and the total order was to the tune of six million deutschemarks. Like other critical equipment procured in the last two years, this plant arrived in knocked down form and must have been assembled here in Pakistan.[117]

The Hanau-based industrial group was also contracted to assemble the procured auxiliary equipment at the main gas-centrifuge plant at Kahuta. In August 1978, the

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[111] Ibid, pp. 52-53.
[112] Shaihid-ur-Rahman, op. cit., pp. 60-61.
[113] Ibid.
[114] Ibid, p. 62.
[115] Ibid.
[116] Frantz & Collins, op. cit., p. 58.
[117] Shahid-ur-Rahman, op. cit., p. 62; David Albright, op. cit., p. 59.

Special Works Organization or SWO, which was ERL's main procurement front company, asked the Hanau group to assemble a V-3A vacuum plant or the UF6 feed and withdrawal system, including a purification system. In 1979, Triple A, which was now working for the enrichment project under A. Q. Khan, asked Hanau that A. Q. Khan had wanted to procure a larger UF6 feed and withdrawal system, which came to be known as the "Special Gas Handling Unit."[118] [119]

Moreover, in November 1980, Leybold-Heraeus offered to sell the Special Gas Handling Unit with a capacity of "100-ton per year separation work plant." Such an enormous plant was thought to be outside the capacity of Pakistan to build at the time and would have housed up to 50,000 P-1 gas-centrifuges, sufficient for several hundred kilograms of weapon-grade enriched uranium per year. Despite strong protests by the United States in 1979 and 1980, CORA Engineering as part of the Hanau-group and working with Leybold continued to prepare the Special Gas Handling Unit for Pakistan. However, a bomb attack outside CORA's managing director's house on February 20, 1981, was followed by telephonic warnings to stop all shipments of equipment to Pakistan. Consequently, CORA announced it was suspending all shipments to Pakistan despite having got a sum of 6.4 million Swiss francs.[120]

Therefore Lerch and Heilingbrunner visited a Swiss firm Metallwerke Busch AG or MWB on June 29, 1983 and made a contract worth two million Swiss francs for the supply of a complete feed and withdrawal system. The contract was eventually completed through Lerch and delivered to Pakistan around Christmas, 1985 via multiple and deceptive front companies and routes in Europe and the Middle East.[121]

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[118] David Albright, Ibid.
[119] "Supply of a larger feed and withdrawal system, including all the miles of piping needed to connect the system to thousands of gas-centrifuges. It also featured an electrical control system to run the plant. All of this equipment was destined for a new gas-centrifuge building at Kahuta. The equipment was also redesigned to be modular, simplifying its shipment and erection on-site. The cost would eventually reach over 33 million deutsche marks." Ibid.
[120] Ibid, pp. 60-61.
[121] Ibid, p. 66.

7.4.6. Indigenization Initiatives

As procurements for essential equipment and materials proceeded during 1975-76, PAEC also planned to continue efforts for their indigenous development, where possible, in parallel. Local workshops were being set up in the name of making spare parts for KANUPP.[122] In this regard, the DIL's strategy as claimed by Mahmood was to distribute the project into 100 sub-projects, to maintain its secrecy. A hand out was prepared for each sub-project that spelled out the job that was to be given to anyone who would join the project. The handout was essentially a work sheet, or an assignment that was given to each project team member, but it did not say what it was intended for. [123]

This approach was followed in developing high-value component casting for making the base of the gas-centrifuge. Moreover, while developing magnetic tops for the gas-centrifuge, the worksheet consisted of work on high-strength magnets. The same was the case with developing the ball bearings for the gas-centrifuge. The effort of the ADW team was to work in home and out of home as well and thirdly out of Pakistan as well. Mahmood envisaged the role of those working in ADW to be R&D, and of guidance and that the work should be sub-contracted to local industry. In this way, they would not need to develop a lot of manpower, and it would save them from many problems. This strategy was based on the pattern of big projects like Manhattan Project. [124] Furthermore, different codes assigned to each sub-project. These codes had cover names for spare parts and components that were being made for the enrichment programme.[125]

For example, one unit was named 'KANUPP's spare parts,' ostensibly making spare parts for KANUPP, but in reality making spare parts for the gas-centrifuge. Similarly, there were names for PINSTECH and other textile industries.[126] One such instance was reflected in the development of the base of the centrifuge machine. In this regard, Mahmood recalled that in the beginning of 1976, they were developing a high-speed electric motor to run at 60,000 rpm. A. Q. Khan had arrived by the beginning of

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[122] Shahid-ur-Rahman, op. cit., p. 62.
[123] Ibid.
[124] Interview with Mahmood, op. cit; Shahid-ur-Rahman, op. cit., p. 54.
[125] Interview with Mahmood, Ibid.
[126] Ibid.

1976 and they found out that a copper store was located somewhere in Lahore, where a famous skilled worker Bashir Ahmad worked. Mahmood claimed that they had the technology and the designs with them, but a skillful worker was needed who could implement these ideas into a practical shape.[127]

7.5. Building the Infrastructure: Airport Development Workshop, Sihala and Kahuta

This section discusses how and why experimental, pilot and production-scale sites were established for the gas-centrifuge based enrichment project in Pakistan. It discusses why certain areas were selected and the initial steps taken by PAEC to build them. Moreover, it also traces the controversial issue of site selection of the Kahuta enrichment plant, for which PAEC and A. Q. Khan both claim credit. In this respect A. Q. Khan's claims are discussed in detail in the following paragraphs, while Munir Khan claimed that PAEC had already prepared the basic infrastructure for the enrichment project, set up a laboratory at ADW and selected the Kahuta site by 1976.[128] He also claimed to have decided to select the gas-centrifuge process for enrichment in preference to other processes. He added that Bhutto approved the construction of a Research and

[127] "Therefore, discussions with the worker from Gujranwala took place, who then asked for two or three days to produce results. Before those three days, ended, he called back and said: "I have made one sample and please come and see it for yourself." Mahmood claims to have taken A. Q. Khan with him and both went to see his work. Bashir Ahmad had ostensinbly done quite a good job. The centrifuge rests on a base, which is made from aluminium, and it has the same vacuum as on the moon and this man was going to try to cast the base of the centrifuge for them. So they went back after three to four days along with their test equipment like high-vacuum measuring devices. When the prototype sample was tested, his base passed the requisite standards and requirements. A. Q. Khan asked him how he had done it, because he was also a metallurgist. The worker told him that aluminium has a flow when it melts, but copper has a better flow, so he added copper, aluminium and some other materials and increased the flow of the materials and the process and rate of cooling it after heating and melting was also very important." Ibid.

[128] Munir Ahmad Khan, Interview with Hamid Mir and Saeed Qazi, *Daily Ausaf,* June 18, 1998.

Development Laboratory for enrichment near the Chaklala Airport as well as a subsidiary facility at another location Sihala.[129]

7.5.1. Airport/Aviation Development Workshop

When Mahmood was appointed Project-Director of DIL, he claims to have been directed to begin work on building the infrastructure at the earliest. Therefore, Chaklala, Rawalpindi, was the first site where an experimental or pilot-scale gas-centrifuge facility was set up. It was also known as the Airport or Aviation Development Workshop or ADW.[130] This was followed by a pilot-scale gas-centrifuge facility at Sihala and subsequently the main plant at Kahuta. ADW was selected and made operational by February 1975.[131] This site, like Sihala and Kahuta, was selected after ensuring compliance with the security requirements. As the Chaklala barracks were located adjacent to the airport, there was very little trespassing and movement of irrelevant people. Therefore, the airport provided a natural cover without any need for elaborate extra security for the gas-centrifuge facility, which was however in place internally. [132] A B-2 laboratory in the basement of ADW was planned to be set up where a test-bed of eight gas-centrifuge prototypes would be installed, which was headed by G.D. Alam.[133]

Some members of the project, such as Col. Rashid, claimed that the ADW was "full of bats, scorpions and snakes." The team working at ADW comprised twenty persons, with eight military personnel, who were provided with only one old pick-up and a wagon in delipidated condition.[134] These conditions would later improve after A. Q. Khan took over. However, while Mahmood acknowledges that some parts of the

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[129] Munir Ahmad Khan, "Bhutto and the Nuclear Programme of Pakistan," *The Muslim* (Islamabad), April 4, 1995.
[130] Shahid-ur-Rahman, op. cit., p. 50.
[131] Interview with Mahmood, op. cit; Farhatullah Babar, op. cit.
[132] Shahid-ur-Rahman, op. cit., p.50.
[133] Interview with Mahmood, op. cit.
[134] Zahid Malik, *Dr. A. Q. Khan and the Islamic Bomb* (Islamabad: Hurmat Publications, 1992), p. 69.

barracks were indeed shanty and old, its outer approaches were deliberately kept that way to maintain secrecy and deflect unwanted attention, but the working areas inside were furnished. He also added that PAEC's management style called for obtaining results at a mimumum cost and this culture was successfully implemented in all other projects. He asserted that this strategy succeeded while he was heading up the Khushab-1 plutonium production reactor project a decade later.[135]

7.5.2. Sihala

Sihala or Phase-II of the project was the stepping-stone between the experimental R&D site at Chaklala and the main enrichment plant at Kahuta. In this respect, its selection and development was of equal significance for the gas-centrifuge project. In fact by 1979, the experimental cascades of gas-centrifuges had begun to be run at this site by ERL.[136]

With regard to setting up of the Sihala site, Mahmood claimed that PAEC were also selecting the site for the main project at the same time. ADW was the basic stepping-stone, the Phase-I of the project, where an experimental test-bed of gas-centrifuges would be set up. Phase-II would include the prototype test-bed of gas-centrifuges that would be made at ADW. In order to maintain secrecy of the project, it was said the workshop was manufacturing components for KANUPP, or for helicopters. In Sihala, another decade's old abandoned barracks was identified which was hidden among trees. PAEC was able to acquire that place due to the intervention of Lt. General Fazal-e-Muqeem [Secretary Defence] and Major-General Shafqaat [Army Engineer-in-Chief], who were well known to the Chairman. The plan was to install the first 100 centrifuge machines at Sihala, while the enrichment pilot project would go up to a maximum of ten to twelve percent of enriched uranium before the project launched into higher grades of enrichment at the main plant. Mahmood claimed that this was the strategic planning for the project and this was exactly how it proceeded even after A. Q. Khan took over as Project-Director in July 1976. [137]

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[135] Interview with Mahmood, op. cit.
[136] Adrian Levy & Catherine Scott Clark, *Deception: Pakistan, The United States and The Global Nuclear Weapons Conspiracy* (London: Penguin Books, 2007), p.79.
[137] Interview with Mahmood, op. cit.

7.5.3. Kahuta

With the launch of the gas-centrifuge enrichment project in 1974, the Chairman of PAEC had tasked the Project-Director to develop criteria for site-selection of the main enrichment plant. Thus, a detailed criterion was developed for this purpose and it was decided that only that site would be selected which met the specified criteria. This elaborate criteria envisaged: the environment should not be dusty; it should not be an earthquake zone; the water should be abundantly available; stable and multiple electricity supply must be available; the site should be attractive and conducive for the workforce; it should be suitable from a defence point of view; the infrastructure should be within easy reach; the site should be close to a big city; the site should be sufficiently isolated; suitable soil structure and load bearing capacity of the soil.[138]

With regard to the above-mentioned criterion, the entire country was seen as a potential site and there was no preference for any particular province or area. The exercise of selecting a suitable site for the main gas-centrifuge plant was termed as "criteria to build a nuclear plant so that this could be discussed with anyone, while maintaining secrecy."[139] Mahmood and the head of the Civil Works of PAEC, B. A. Shakir, who enjoyed the trust and confidence of the Chairman, claim responsibility of selecting the Kahuta site where the main gas-centrifuge plant is located today.[140] Therefore, they were directed to visit different prospective sites together, but Shakir was kept ambiguous about the exact purpose of the site selection. In January 1976, they were provided with a helicopter by Maj-Gen. Shafqaat to conduct reconnaissance and to look for sites where availability of water could be ensured. Their first stop was Sahiwal district, in Punjab province. Various sites were being marked and rated according to the

[138] Ibid.
[139] Ibid.
[140] Ibid; Private conversation with Mr. B.A Shakir, October 15, 2007. Islamabad.

criteria, and it was decided to select a site, which secured eighty percent marks as per the set criteria.[141]

Their next halt was Kala Chitta mountain range near Rawalpindi, even as they continued to travel to places like Muzaffarabad and district Mianwali, but could not find any suitable site. Then Maj-Gen. Shafqaat suggested the abandoned Rohtas fort near Jhelum. Although it was suitable in many ways, but was not secure from a defence point of view and was short of space. Shakir and Mahmood had been asked to complete the site selection job within a week by Munir Khan. Therefore, each morning, the two used to embark on the helicopter to look for a suitable site.[142] Mahmood recalled the day when they claimed to have found the Kahuta site when he and Shakir went as far as a place near the Indian border where the river Jhelum flows with great speed. They proceeded back towards Kahuta town, and after traveling for about half a kilometer out of Kahuta town, reached a hill and sat there to have lunch. It was a bright sunny day. During lunch, he claims that they noticed that the site in front of them was a cup shaped site, and they were looking for precisely such a site, in which protection and defence were easily maintainable.[143]

This particular place facing them was known as Sumbul Gah,[144] and it seemed to be close to what they were looking for, which largely conformed to the site selection criteria. Elated, they were back in Islamabad by four-o'clock in the afternoon. Mahmood claims that when an hour later, he was called in by Munir Khan to report on the progress made so far, he informed the Chairman that the most suitable site prospected so far, was the Kahuta site. The next morning Munir Khan, Lt. Gen. Fazal-e-Muqeem, and Mahmood drove to the airport where Maj-Gen. Shafqaat also arrived. The group reached the Kahuta site by helicopter by eight-thirty the same morning and the helicopter landed in a field of wheat crop. The locals were told that the visitors were evaluating the site for

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[141] Interview with Mahmood, op. cit.
[142] Ibid.
[143] Ibid.
[144] "Osama Showed Interest in N- Technology," *The Nation* (Islamabad), July 24, 2009. http://www.nation.com.pk/pakistan-news-newspaper-daily-english-online/Politics/24-Jul-2009/Osama-showed-interest-in-Ntechnology (accessed August 1, 2009).

conducting some military exercises. After scrutinizing the site from a defence point of view, the group returned to Islamabad.[145]

The next goal was the acquisition of land for the Kahuta site. Lt. Gen. Fazal-e-Muqeem and Maj-Gen. Shafqaat suggested Brig. Zahid Ali Akbar for the acquisition of land for the site, who was working in the Frontier Works Organization (FWO). He was tasked with the acquisition of land for the enrichment plant at Kahuta. The site itself was handed over to FWO and declared as one of its projects, which then turned into the Special Works Organization or SWO for the same project. An office was set up in West-ridge, Rawalpindi. The land for the Kahuta site was acquired within twelve days of the initial site selection [146] Brig. Zahid Ali Akbar also recalled the beginning of his association with the enrichment project:

> At that time I was serving as a Brigadier in the Pakistan Army. To my surprise I was told to meet General Zia-ul-Haq who had just taken over as the Army Chief. Somehow I had never met General Zia before. He told me that Prime Minister Zulfikar Ali Bhutto wants an Army officer for a very important national project and that he had selected me for this assignment. I reported to Munir Ahmad Khan who was at that time head of the Atomic Energy Commission. We started our work in an abandoned building in Rawalpindi. Our first priority was to select a suitable site for the construction of the project. Various potential sites were surveyed and ultimately Kahuta was selected. It was a difficult job to say the least.[147]

However, A. Q. Khan gives a different view with regard to the selection of the Kahuta site. He claimed that this site was selected in September 1976, which is almost two months after he had taken over as Project-Director from his predecessor:

> We had selected Kahuta for two prime factors in our mind. The site should be out of normal traffic for security reasons and it should be near the capital for full support and quick decisions. More important than these two factors was the consideration for the provision of facilities for our scientists and engineers. We never repented our decision and it was solely due to the selection of this site and my presence in the capital that we managed to rush through out programme for more than three years before the Western countries got wind of it and embarked upon concerted and coordinated efforts to kill our infant programme.
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> In August 1976, I had just been appointed project director of the Engineering Research Laboratories, an independent organization. My first priority was to find a suitable site. After visiting many places, I decided on Kahuta. We had a meeting with Mr. Bhutto

[145] Interview with Mahmood, op. cit.
[146] Ibid.
[147] Zahid Ali Akbar, "Bhutto's Vision: Dr. Khan's Genius," *The Nation* (Islamabad), September 18, 2006.

> soon after and I informed everyone present about my selection. Mr. Ghulam Ishaq Khan immediately proposed the formation of a committee to evaluate the site and then make recommendations, to which Mr. Bhutto smilingly replied: 'Khan Sahib, neither I nor you or any other person knows about the requirements of the site. If Dr. Khan is satisfied, it is fine with us. These committees for everything have made a mess of our country.' With that the matter was closed.[148]

7.6. Research & Development and the Prototype Gas-Centrifuge

As stated in the introduction, it is widely believed that Pakistan's gas-centrifuge designs were essentially copies of the URENCO designs, allegedly stolen by A. Q. Khan during his stay in the Netherlands. Although this particular aspect of Pakistan's gas-centrifuge project is discussed at length in the following chapter, the following section deals with indigenous gas-centrifuge development efforts. PAEC had begun R&D on producing indigenous gas-centrifuges as early as the beginning of 1976, and the first experimental gas-centrifuges had begun to be tested and rotated by April 1976 at ADW. A. Q. Khan acknowledged this in a handwritten letter to Munir Khan in which he stated:

> All our efforts in the past few months have been aimed at finalizing the design of our first generation machines. This has been accomplished and we are confident that the design shall meet the requirements. At this moment we are embarked upon the programme of manufacturing about five [gas-centrifuge] machines in the shortest possible time.[149]

The first of these prototype gas-centrifuge machines were Zippe-type gas-centrifuges, while the more advanced gas-centrifuge designs comprised two rotors. The latter were being rotated at 20-30,000 rounds per minute by April 1976 at ADW.[150] This effort continued unabated in the months following A. Q. Khan's appointment as head of the project, in place of Mahmood. The rotors of the gas-centrifuge were made from the flow-forming machine obtained from Germany, while the bellows were manually fitted onto the rotors. The team began their experiments with one gas-centrifuge comprising three rotor-tubes, interconnected with bellows. The gas-centrifuge with one rotor-tube rotated. But rotating gas-centrifuges with three rotor-tubes proved to be a time

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[148] A. Q. Khan, "Bhutto, GIK and Kahuta," *The News* (Islamabad), July 29, 2009.
[149] A. Q. Khan, letter to Chairman of PAEC, Munir Ahmad Khan, June 10, 1976.
[150] Interview with Mahmood, op. cit.

consuming effort. Therefore, the first three-rotor gas-centrifuge was placed in a glass casing in order to observe its rotation.[151] G. D. Alam, was heading the experimental team in ERL, along with Anwar Ali and Ijaz Khokhar. Alam was also the head of the centrifuge design and development team in the project.[152]

Alam and Anwar Ali were watching the experiment from an adjacent room. However, as they had just begun to rejoice over the prototype gas-centrifuge's rotation, and left for the computer control, the gas-centrifuge rotor exploded with a force that caused one piece of the exploding centrifuge to be permanently embedded in the roof. It remains there as a memory to the experiment.[153] Nevertheless, the team continued with these experiments. Another such gas-centrifuge machine was made and rotated which did not explode. However, when natural uranium hexafluoride gas was passed through this gas-centrifuge, the machine again exploded. Yet another experiment with UF6 was conducted, but while the gas-centrifuge machine did not explode this time, it failed to separate U-238 and U-235 isotopes. After several experiments, it was on June 4, 1978, that the gas-centrifuge succeeded in separating the uranium isotopes, i.e. enrichment of natural uranium hexafluoride gas was accomplished. [154]

G. D. Alam claimed that when they tried to make a gas-centrifuge machine according to the drawings brought by A. Q. Khan, the machine did not work. Alam asserts that when this happened, A. Q. Khan remained silent, while earlier he had given an assurance that "we have the drawings, and we can make the gas-centrifuge machine based on them, which would work perfectly." However, the gas-centrifuge prototype machine worked only after three months and a lot of indigenous R&D. As soon as the centrifuge began to spin, Alam addressed the people present there and declared: "Gentlemen, we have achieved enrichment for the first time in Pakistan."[155] Alam's claim of gaps in critical design information was apparently confirmed by a recent study

[151] Shahid-ur-Rahman, op. cit, p. 58.
[152] Ibid, p. 57; ADW/DIL was re-named Engineering Research Laboratories following A. Q. Khan's appointment as Project-Director towards the end of July, 1976. Please see following chapter for details.
[153] Shahid-ur-Rahman, op. cit., p.58.

[154] Ibid, p. 59.
[155] G.D. Alam, Interview with Urdu Daily *Asaas-o-Lashkar* (Rawalpindi), June 12, 1998.

on Pakistan's gas-centrifuge programme.[156] This study also stated that the scientists and engineers in the gas-centrifuge project were trying to come up with an indigenous design based on information obtained from URENCO.[157][158]

When the first enrichment was done at ADW, an engineer, Muhammad Ashraf told Alam: "Dr. Sahib please write down today's date on a piece of paper and put your signature on it" [159] Alam picked up a paper and wrote June 4, 1978 and signed the paper. Anwar Ali was also part of this event he signed this paper as well. [160] Another source claims it was Javed Mirza who got a piece got a piece of paper, and all present, including Anwar Ali and Ijaz Khokar, signed it and put the date on it.[161] A. Q. Khan, as Project-Director, informed the ERL Board about this important success through a letter on June 10, 1978.[162] Gen. Zia who had overthrown Bhutto in a coup in July 1977 replied: "I congratulate you all. Please come and see me."[163] A. Q. Khan wrote to his friend in Canada, Abdul Aziz Khan and thus mentioned this historic event:

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[156] "Although Khan stole a wide variety of gas-centrifuge designs, he missed information for some critical components. In the early Dutch designs, one of the "scoops," which extract uranium gas from the rotating cylinder, vibrated excessively. The Dutch designed parts to fix this problem, but they did not include sketches for these parts with the others. As a result, Khan's first P-1 gas-centrifuges frequently broke or "crashed." A former senior URENCO official who saw the Pakistani gas-centrifuge designs first-hand noted Khan's earliest gas-centrifuges even had pieces designed to hold one of the new Dutch components, but the Pakistani designers did not know actual parts were supposed to go where. This problem, and likely others, explain early media reports that the Pakistani gas-centrifuge programme was struggling. Eventually, Khan's team came up with a solution similar to the Dutch one either through invention or espionage, but his programme would never have succeeded if he had relied only on his FDO contacts." David Albright, op. cit., p. 34.

[157] "PAEC decided to build its P-1 model based on the designs from a Dutch gas-centrifuge, this type being considerably easier to construct than the German model gas-centrifuges for which Khan had designs." Ibid, p. 23.

[158] "Pakistan was using secret URENCO designs to procure highly sensitive gas-centrifuge components and the means to manufacture them. The Pakistanis were buying the parts to build a CNOR modified gas-centrifuge. The modified model had four tubes connected by three bellows, one less tube and bellows than the original model, but it had a SNOR rotor tube and an improved CNOR bottom bearing. It also had an inward pointing bellows, which were more advanced and harder to make than an outward pointed bellows. In essence, Khan was copying what he stole, but building a composite, simpler design that he believed was more suited for Pakistan." Ibid, p. 40.

[159] G. D. Alam Interview, op. cit.

[160] Ibid.

[161] Shahid-ur-Rahman, op. cit., p. 59.

[162] "We in the project like to inform the Board that a machine has been developed and tested which has resulted in predicted performance. We have succeeded in producing laboratory samples in which natural uranium hexafluoride was enriched into U-235 in any developing country of the world. Indeed we are now probably the 5th country in the world, which has succeeded in enriching uranium." Ibid.

[163] Ibid.

> June four was a historic day for us. On that day we put 'Air' in the machine and the first time we got the right product and its efficiency was the same as the theoretical. We had to see our big bosses so that we could get some money for the budget. When this news was given to them they were quite happy and congratulated us. [164]

Munir Ahmad Khan in his capacity as Chairman of PAEC and Member of the ERL Project-Board,[165] informed an imprisoned Bhutto, of this success.[166] Munir Khan would visit the deposed Prime Minister in jail on the pretext of giving him vitamins and fruits and share the status of various ongoing projects with him.[167] A. Q. Khan also acknowledged that the R&D work on gas-centrifuges started at ADW where the first enrichment was achieved:

> We had an office near Rawalpindi in the beginning. My colleagues advised me to shift the office to a better place, but I wanted to start the work without wasting time. There were some old sheds there, which were the property of the Royal Pakistan Air Force; we started our work there; however, we shifted our office to Kahuta after having selected the location. We started developing gas-centrifuges in our Rawalpindi office. It was April 6, 1978 when we achieved our first centrifugal enrichment of uranium. It was of low grade; however, it was enough to confirm the viability of the project. We had become capable of uranium enrichment by that time.[168]

Mahmood claims that it was the core group of scientists and engineers selected during 1975-76 that made the enrichment project a success and carried it forward: "Those appointed by me as Assistant-Engineers, the same men went on to become Directors and Directors-General in Kahuta or Khan Research Laboratories (KRL) under A. Q. Khan."[169] Dr. Samar Mubarakmand also aired similar views in an interview in 2004. He stated: "Dr. A. Q. Khan had a very competent team in KRL and many of them had gone there from the PAEC and it was essentially this team that designed, developed and installed the facilities through which uranium is enriched."[170] Apparentely, A. Q.

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[164] Levy & Clark, op. cit., p.53.
[165] For details, please see the next chapter.
[166] Benazir Bhutto quoted in Levy & Clark, op. cit., p. 52.
[167] Ibid, p. 50.
[168] A. Q. Khan, Interview with AAJ TV, op. cit.
[169] Interview with Mahmood, op. cit.
[170] Samar Mubarakmand, Interview with Hamid Mir. *Capital Talk,* Geo TV, March 05, 2004.

Khan also acknowledged this.[171] With regard to the importance of this team to the success of the project, the Chairman of PAEC claimed:

> The enrichment project succeeded because the scientists and engineers working there had a very high degree of technical expertise and these were provided by the PAEC. We gave this project the best brains of PAEC.[172]

Nonetheless, A. Q. Khan presents a narrative of the evolution and success of the centrifuge project, which is at stark variance to the claims made by his rivals. He states that he had just returned from Europe after almost fifteen years when he joined the project and had studied at the famous Technical University of West Berlin, at the prestigious Technological University of Delft, the Netherlands, and at the famous and old University of Leuven, Belgium. He had worked for a number of years in the Netherlands and had specialized in the Uranium Enrichment Technology.[173] He also emphasizes that he was young, had a Doctorate of Engineering in Physical Metallurgy—which he claimed was the most suitable discipline for handling sophisticated technological projects—had relevant experience and was thus well equipped to deal with the job. He accepted the challenge and got down to business, gathered a team of highly dedicated, efficient and patriotic scientists and engineers and went all out to finish the job as quickly as possible. He claimed that the scientists and engineers whom he had recruited had never heard of a centrifuge, even though some of them were Ph.Ds. [174]

However, G. D. Alam, who worked in the project from its inception till 1981, again gives a competing and variant opinion on the project's formative phase. He appears to denigrate A. Q. Khan's personal contribution as a scientist to the success of the gas-centrifuge effort, even though he acknowledged the latter's administrative skills the project in an interview soon after the 1998 nuclear tests. He claims that prior to joining the project, A. Q. Khan had no direct knowledge of or participated in the manufacture or operation of a gas-centrifuge machine, which was why even in 1998, he

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[171] A. Q. Khan, Interview with Nadeem Malik, *Islamabad Tonight,* AAJ, TV, August 31, 2009.
[172] Munir Ahmad Khan, Interview with Hamid Mir and Saeed Qazi, *Daily Ausaf* (Islamabad), June 18, 1998.
[173] A. Q. Khan, *Pakistan Institute of International Affairs,* op. cit.
[174] Ibid.

was in no position to play any practical role in uranium enrichment. Alam acknowledged that undoubtedly, A. Q. Khan had obtained the drawings of gas-centrifuge machine for uranium enrichment in Pakistan's wider national interest from the Netherlands. Yet, he asserted that it was a fact that the centrifuge machines were developed and operated by other members of the project and not Dr. Khan. [175]

Moreover, with regard to the utility and significance of the URENCO gas-centrifuge designs that were purloined by A. Q. Khan, Alam claimed that the upper part of the drawing of the Dutch gas-centrifuge machine that A. Q. Khan had copied was incorrect and incomplete.[176] When he pointed this to A. Q. Khan, he first showed his amazement, but soon after acknowleged it thus: "there was no upper part in the Dutch gas-centrifuge design; and the design for this part of the machine was made by him, due to which there was a mistake in the drawing."[177] Alam claimed that if five staff members of the project from PAEC had left him in the early days, he would become handicapped. He added that in event of their going back to the Atomic Energy Commission, it was impossible for A. Q. Khan to run the project all by himself.[178]

For his part, A. Q. Khan also highlighted the importance of the team working in the project to his friend Abdul Aziz Khan in a letter in 1978, who was living in Canada. He wrote that the team working with him in the project were "crazy people" and were "working day and night."[179] More importantly he declared that Kahuta was an all-out Pakistani effort and was a symbol of Pakistan's determination to refuse to submit to blackmail and bullying. It was not only a great source of personal satisfaction to him, but was also a symbol of pride for his colleagues.[180] In this context, he recognized the multi-disciplinary effort that goes into the making of a successful gas-centrifuge plant for uranium enrichment.[181] With regard to the site selection of Kahuta, he claimed that his

[175] G. D. Alam Interview, op. cit.
[176] As stated above, this claim is apparentely endorsed by David Albright, in *Peddling Peril.* David Albright, op. cit., p. 34.
[177] Ibid.
[178] Ibid.
[179] Frantz & Collins, op. cit., p.82
[180] A. Q. Khan, Speech delivered at Pakistan Institute of International Affairs*,* op. cit.
[181] Ibid. He stated: "The gas-centrifuge technology involves top-notch expertise in metallurgy, mechanical engineering, chemical engineering, process technology, electronics, automation and control, nuclear

long stay in Europe and intimate knowledge of various countries and their manufacturing firms was an asset. Within two years, the team working on centrifuges had put up working prototypes of gas-centrifuges and was going at full speed to build the facilities at Kahuta. While preliminary work was being undertaken at Rawalpindi and procurement was being done for the most essential and sophisticated equipment and materials. Simultaneously, they were manufacturing the first prototypes of gas-centrifuges and were setting up a pilot plant at Sihala and were preparing blueprints for and starting the construction of the main facility at Kahuta. It was a revolutionary and bold step and it virtually ensured success in a record time.[182]

Moreover, the various development stages in the project can be seen from letters, which A. Q. Khan wrote to Abdul Aziz Khan. [183] He again wrote to his friend in the fall of 1978: "If our two units are ready, then myself and Dr. Mirza would come for thanks and maybe we could meet you."[184] The two units were probably the two air-conditioning plants that were purchased from an American firm. In one of these letters on February 2, 1979, A. Q. Khan told his friend that the first attempts were being made to link up groups of gas-centrifuges in cascades. He said: "Everybody is working like mad. The first eight are working fine, after that we started the four together… they worked alright, then we distributed the sweets."[185] He also revealed that: "Work on the big plant was also speeding up, with the main laboratory buildings, gas-centrifuge hall B-1 and administration block almost finished."[186]

He added: "We hope by April, many groups of gas-centrifuges would be transferred there,"[187] and expressed his desire to have more staff, as the work was increasing. In a clear sign of growing bureaucratic tussling with Munir Ahmad Khan, he

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physics, vacuum technology etc. A gas-centrifuge runs at 70000-80000 rpm and one can imagine the problems arising from demands on materials, the tolerances, bearings, imbalance of the rotating components etc. It is a Herculean task and an ultra-gas-centrifuge in undoubtedly a mechanical miracle."

[182] Ibid.

[183] Frantz & Collins, op. cit., p. 93.

[184] Sreedhar, *Pakistan's Bomb, a Documentary Study* (New Delhi: ABC Books,1986), quoted in

[185] Levy & Clark, op. cit., p. 471n.

[186] Ibid, p. 56.

[187] Ibid.

proclaimed: "Unless this work is completed, I am not going to budge from here."[188] Nonetheless, construction work on the Kahuta plant continued unabated, and by February 1979, the pilot gas-centrifuge plant at Sihala was running a test-cascade of fifty-four machines successfully. The outer ring of the Kahuta plant was completed by 1981 and the gas-centrifuge halls were being prepared for installing hundreds of gas-centrifuges.[189] During this time, Munir Khan also informed his Iranian counterpart, Dr. Akbar Etamad that Kahuta was on the verge of starting up by the fall of 1981.[190] This implies that the first functioning cascade of gas-centrifuges had begun operation by this time.

A. Q. Khan claimed that Kahuta started producing weapon-grade highly enriched uranium in 1982,[191] and in 1984, he announced for the first time that Pakistan had succeeded in enriching uranium and could do so to any level required.[192] However, independent experts do not entirely agree with these assessments in HEU production time-scales and capacities.[193] [194] During the 1980s, KRL led by A. Q. Khan also

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[188] Ibid, p. 471.n
[189] Ibid, p. 79.
[190] Weismann and Krosney, op. cit., p. 214.
[191] Rauf Siddiqi, "Khan Boasts Pakistan Mastered Uranium Enrichment by 1982," *Nucleonics Week*, May 20, 1999.

[192] Levy & Clark, op. cit., pp 101-102.
[193] "However, these were presumably small-scale samples. A 1983 U.S. State department briefing paper noted that Pakistan had "not yet produced significant quantities of enriched uranium." Large-scale enrichment using cascades of P-1 centrifuges apparently proved problematic for Pakistan. Their experience with the German design G-2 machines (termed P-2 in the Pakistani context) appears to have been better and they were in mass production by the mid 1980s. A 1986 report claims that at Kahuta the two types of centrifuges were housed in "two big halls set slightly at an angle to each other . . . containing about 7000 centrifuges." However, only a thousand or so machines were believed to be operational in 1986. At some stage, probably in the mid 1980s, Pakistan limited its use of P-1 machines, and moved to using P-2 and later possibly more advanced machines. A. Q. Khan subsequently claimed that by 1984 Pakistan had produced enough uranium for a nuclear test, which they were hoping to conduct by 1986. An internal U.S. memo to Henry Kissinger in 1986 claimed that Kahuta had a nominal capability to produce "enough weapons grade material to build several nuclear devices per year." By 1988, it was reported that Pakistan had enough weapon grade uranium for four to six weapons (i.e., 100–150 kg of HEU). A U.S. official claimed in late 1991 that Pakistan had sufficient HEU for as many as six weapons." Zia Mian, et al., "Exploring Uranium Resource Constraints on Fissile Material Production in Pakistan," *Science & Global Security* (London: Routledge, 2009), Vol.17, No. 2, p. 90.
[194] "Plans for Kahuta in the late 1980s called for 2000–3000 centrifuges and a claim by a U.S. official that by 1991 Kahuta had approximately 3000 machines operating. If these 3000 machines were P-1 or P-2 centrifuges, respectively with 3 and 5 kg SWU/year (or SWU) each, this would give a total capacity of 9000 or 15,000 SWU for the full cascade depending on the machine. Taking these reports into account, a

developed the capacity to produce indigenous maraging steel and most likely, other components used in the manufacture of gas-centrifuges. Reportedly, China supplied some 5000 ring-magnets for the Kahuta project in the 1990s, which points to a potential increase in the number of gas-centrifuges. It may also be assumed that KRL began developing more advanced gas-centrifuges, the P-3 and P-4 machines, which are believed to have been based on URENCO's 4-M and TC-20 machines. Yet, it is still not clearly established if any of these more efficient gas-centrifuge machines were ever produced in large quantities or installed. Moreover, it can also be assumed that KRL's annual enrichment capacity grew from 3000 SWU in 1983 to 15,000 SWU in 1990.[195] Thus, the characteristics of various Pakistani gas-centrifuges based on various published sources indicate:[196]

Centrifuge	Rotor Material	Number of Segments	Total Length (m)	Separative Power, kg SWU/year	Peripheral velocity (m/s)
P-1	Aluminium	4	2	1-3	350
P-2	Maraging Steel	2	1	~5	450
P-3	Maraging Steel	4	2	~12	485
P-4	Maraging Steel	6	~3	~20	508

Nevertheless, it appears that KRL may have been confronted with severe technical problems in making sufficient gas-centrifuges that were necessary to produce

plausible scenario for the first phase of Pakistan's enrichment program (until about 1990) may be as follows: 1) Pakistan had no substantial enrichment capacity until approximately 1982; 2) It achieved sufficient capacity to make 20 kg/yr of HEU during 1983–1985. (This calls for a separative power of approximately 3000 SWU, produced by approximately 1000 centrifuges of 3 SWU each), and 3). It increased the capacity linearly to 9000–15,000 SWU by 1990, through a mix of P-1 and the more powerful and less problematic P-2 machines." Ibid.

[195] Ibid, p. 91.

[196] Ibid, p. 92.

weapons-grade enriched uranium, at least till the first half of the 1980s. This was perhaps why A. Q. Khan claimed that he was able to obtain weapon-grade enriched uranium from China. The *Washington Post* recently carried stories based on A. Q. Khan's hand-written letters, which he supposedly passed on to the British press. The story attributes claims to A. Q. Khan and states:

> Mohammed Zia ul-Haq, the nation's military ruler, "was worried," Khan said, and so he and a Pakistani general who helped oversee the nation's nuclear laboratories were dispatched to Beijing with a request in mid-1982 to borrow enough bomb-grade uranium for a few weapons.
>
> After winning Chinese leader Deng Xiaoping's approval, Khan, the general and two others flew aboard a Pakistani C-130 to Urumqi. Khan says they enjoyed barbecued lamb while waiting for the Chinese military to pack the small uranium bricks into lead-lined boxes, 10 single-kilogram ingots to a box, for the flight to Islamabad, Pakistan's capital
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> According to Khan's account, however, Pakistan's nuclear scientists kept the Chinese material in storage until 1985, by which time the Pakistanis had made a few bombs with their own uranium. Khan said he got Zia's approval to ask the Chinese whether they wanted their high-enriched uranium back. After a few days, they responded "that the HEU loaned earlier was now to be considered as a gift . . . in gratitude" for Pakistani help, Khan said.[197]

Interestingly, Munir Ahmad Khan claimed after the Chaghi tests that when PAEC carried out its first test of a working nuclear device in March 1983, "it was long before we had the [fissile] material for the device. We were ahead of others."[198] These claims appear to be consistent those cited above about Pakistani scientists and engineers encountering serious technical challenges in the early 1980s to make the centrifuges function according to plan. It was in January 1984, that A. Q. Khan first publicly announced that Pakistan had acquired the capability to enrich uranium. He told an interviewer, of an Urdu magazine, *Qaumi Digest*, that he considered it his greatest achievement to have achieved in seven years what the West had taken twenty years to

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[197] R. Jeffrey Smith and Joby Warrick, "A Nuclear Power's Act of Proliferation," *Washington Post*, November 13, 2009.

[198] Munir Ahmad Khan, Speech at the Chaghi Medal Award Ceremony, op. cit.

accomplish, i.e., the enriching of uranium to weapons grade. These claims were repeated in two more interviews to Urdu Dailies, *Nawa-i-Waqt* and *Jang* in February 1984.[199]

However, it would be two more years for KRL to produce enough weapon-grade uranium for one nuclear device. A de-classified report on Pakistan's nuclear weapons programme around this time also stated: "We believe KRL will not be able to produce enough material for a nuclear device until late 1985 at the earliest and probably not until 1987 or 1988."[200] It may be recalled that A. Q. Khan had pleaded with Bhutto that the project could never be completed as per the intended deadline of 1980 if it would remain under PAEC. Apparently, delays in producing the fissile material, as per the original plan, were the result of destruction of hundreds of centrifuges in earthquakes. These were caused due to a weak and faulty raft foundation, which ought to have been designed to make the centrifuge cascade beds, earthquake proof. These improvements were eventually made in the project. It is likely that this was again the result of the bureaucratic rivalry in the nuclear establishment, after A. Q. Khan took the reigns of the centrifuge project. He dismissed warnings that the production-scale plant at Kahuta needed a strong raft foundation with the assertion that "there were no earthquakes in the Netherlands," and he knew better on how to proceed with the project.[201]

Thus, the timing of the Chinese supply of 50 kg of weapons-grade enriched uranium appears to be consistent with a major set back in the centrifuge programme due to earthquakes. While the number of operational centrifuges of the P-1 model continued to increase in KRL, hundreds of centrifuges were destroyed in earthquakes, at least on two occasions, one in 1981, another in 1983, and one later.[202] In fact a 6.1 earthquake in September 1981 destoyed all the installed 4000 centrifuges at the Kahuta site. This spelled the end of the centrifuge project and the ability to produce enriched uranium, especially when the project had just started regular operations. It took more than two

[199] A. Q. Khan's interviews with Urdu Magazine *Qaumi Digest,* January 16, 1984; Daily *Nawa-i-Waqt,* (Rawalpindi), February 9, 1984; Daily Jang, February 10, 1984, quoted in Levy & Clark, op. cit., pp. 101-102.

[200] Central Intelligence Agency, "Pakistan's Nuclear Decision Makers: Unanimous Opinion," May 1985. CIA Electronic Reading Room. Available at: http://www.foia.cia.gov (accessed January 15, 2009).

[201] Interview with Mahmood, op. cit.

[202] Levy and Clark, p. 440.

years to build the same number of centrifuge machines, install them and start production. It was in this context that Gen. Zia approached China for weapons-grade enriched uranium in mid-1982, as claimed by A. Q. Khan. The destruction of many gas-centrifuges in earthquakes was confirmed in a letter, purportedly written by Ghulam Ishaq Khan, to A. Q. Khan's biographer, Zahid Malik after the 1998 tests. Ishaq stated:

> On at least three occasions, the elaborated array of hundreds of extremely delicately balanced, fast revolving centrifuges, painstakingly erected, were knocked flat down by severe jolts of unexpected earthquakes (a comparatively rare phenomenon in Kahuta region). These had to be reconstructed and recreated at a great cost of labour and time.[203]

Another 2005 technical report citing the development of gas-centrifuge technology in Pakistan claimed that the project faced tremendous challenges throughout its evolution.[204] Therefore, in the light of the above discussion, it is evident that the manpower, which was recruited and trained by PAEC during the formative years of the enrichment project, proved to be a critical factor in its future success. This team essentially carried out the R&D that led to the breakthrough in developing an indigenous gas-centrifuge design and a working centrifuge machine. Based on this success, pilot and commercial-scale centrifuge plants were eventually built, led by A. Q. Khan and Pakistan was able to master centrifuge technology for producing enriched uranium.

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[203] Ghulam Ishaq Khan, letter to Zahid Malik, August 16, 1999, published in Shahid Nazir Chaudhry, *Dr. Abdul Qadeer Khan Aur Aitami Pakistan* (Lahore: Data Publications, 2004).

[204] "In 1976, Pakistan began construction of facilities for both a pilot and full-scale plant. By 1979, a 54-stage cascade was nearing completion. A decision had been made to concentrate on P-2 style centrifuges but manufacturing difficulties with maraging steel bellows used in the P-2 resulted in having to build 14,000 centrifuges to get 1,000 that functioned. By 1984, it was reported that despite a difficulty in developing proper centrifuge cascade operation, Pakistan had uranium enriched to 3.4% U-235. A demonstration facility was in operation, with a production rate of about 5,000 SWU/yr. It was reported, by 1993, that about 14,000 centrifuges had been installed in Pakistan. However, the reliability of these centrifuges was low. Crashes required replacement of 1,000-2,000 units per year. As new units are constructed and installed, improvements are made, but the basic models remain the same. Pakistan has had a centrifuge-enrichment program for over 25 years. It appears that while improvements are made as new units are constructed, no major design change has occurred. Quality control appeared to have been low in the early stages of the program, with many early units failing, and existing centrifuges being replaced at the rate of one out of fourteen per year. Buying components and assembling them in country allowed Pakistan to develop an enrichment capability in nine years. However, the Pakistani program exhibited significant quality problems in its early years." M. D. Zentner, G. L. Coles, and R. J. Talbert, *Nuclear Proliferation Technology Trends Analysis* (Washington: Pacific Northwest Laboratory, Sept 2005), p. 25. Available at: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-14480.pdf. (accessed May 30, 2010).

7.7. The Italian Connection

In pursuit of gas-centrifuge design information and know-how, various sources were tapped, both open scientific literature, and other European sources, such as URENCO. One such European source was Italy. While the Zippe-type gas-centrifuge machine and URENCO data was related to the gas-centrifuge machine itself, there was no information available on the "process engineering" side of the project. This area dealt with the design information for setting up a complete gas-centrifuge plant for uranium enrichment and its importance was as critical to the success of the entire project as gas-centrifuge itself. This section explains PAEC's pursuit of design information from Italy.

It seems that this link was only made public in 2005 when in September that year, *Nucleonics Week,* a prominent American magazine that deals with nuclear industry and nuclear issues worldwide for the first time revealed that, "Pakistan told the Netherlands in 1976 it had Italian Gas-centrifuge Design." This report was based on declassified Dutch government dossiers related to its investigation of the theft of URENCO's gas-centrifuge design information by A. Q. Khan**.** It stated that Munir Ahmad Khan told Dutch officials in mid-1976 that Pakistan had 'no interest' in developing gas-centrifuges for uranium enrichment, according to Dutch government dossiers related to its investigation of the theft of URENCO's gas-centrifuge design information by Pakistan."[205] Moreover, the report further stated:

> The PAEC head did acknowledge that the Pakistan Institute of Nuclear Science & Technology (PINSTECH) in Rawalpindi had carried out an exploratory gas-centrifuge investigation, and had set up between ten and twenty gas-centrifuges in a laboratory. But according to Munir Khan, PINSTECH's gas-centrifuge effort was based on gas-centrifuge and cascade design information obtained from Italy—not from the URENCO program. [206]

According to this report, in August 2005, unnamed European officials said that it was plausible for Pakistan to have been able to obtain gas-centrifuge and cascade design information from a pilot gas-centrifuge development programme in Italy. This programme was being jointly run by Italian industry and the government sponsored

[205] Mark Hibbs, "Pakistan told the Netherlands it had Italian Centrifuge Design," *Nucleonics Week,* September 22, 2005.
[206] Ibid.

laboratories. Western officials said that Italy began gas-centrifuge research and development in 1969 and by 1973 had done some separation work using a relatively simple, so-called Zippe-type gas-centrifuge. This type was pioneered after World War II by the German engineer Gernot Zippe, and "provided the engineering and physics bases for both Italian and URENCO machines."[207]

The Dutch official mentioned in the above report was A.C.M. Kuys, the sales manager of A. Q. Khan's employer in the Netherlands, FDO or Physical Dynamics Laboratory. He visited Pakistan in September 1976 and met A. Q. Khan and Munir Khan. In an apparent attempt to deflect the impression that Pakistan had been illegally seeking design information on gas-centrifuges, Munir Khan told him: "Pakistan would not have the technological capability to build an industrial-scale gas-centrifuge plant for twenty years."[208] Nevertheless, "unknown to Kuys, Munir Khan's point man in Europe, S. A. Butt continued to seek gas-centrifuge equipment and materials."[209] Furthermore, "Kuys accepted Munir Khan's fabrications and FDO agreed to sell a variety of dual-use equipment to the SWO."[210] Therefore, with respect to the Italian connection, Mahmood claimed:

> When the question arose that in place of eight centrifuge machines at ADW, if we were to install 64 centrifuges or 512 centrifuges at Sihala, how would we connect them in cascades; and how would the feed be injected in the machines; and how would the output be obtained and how would the cooling be maintained, electrical arrangements etc, i.e. the total process engineering for the gas-centrifuge plant. This was a very high vacuum system. These were not the problems of the gas-centrifuge machine but the overall process. We had started working on the design of the process, but we did not have the confidence if our process will work or not. But based on the experience of KANUPP control system, we started process design work in 1975. I mentioned to Munir Ahmad Khan about our work on process engineering, and where we lacked in this area.[211]

[207] Ibid. The report elaborated on Italian efforts in the field of gas-centrifuge technology, and said that had Italy developed and tested a second-generation gas-centrifuge on a laboratory scale by 1975. At about the same time, Italian scientists were doing work on a different, block-mounted gas-centrifuge and had begun to experiment with more advanced rotor tubes made of carbon-fibre. By around 1978, the Italian programme had designed a small uranium enrichment plant. Then, however, Italy dropped its gas-centrifuge programme and shifted its interest toward gaseous diffusion, in parallel with Italy's membership in the EURODIF Consortium.

[208] David Albright, op. cit., p. 32.

[209] Ibid.

[210] Ibid, p. 33.

[211] Interview with Mahmood, op. cit.

Moreover, he added that there was a strong realization that more know-how would be needed to cut short the time, particularly on the process engineering side. This related to specifically how the uranium hexafluoride gas had to be put in and taken out from the gas-centrifuges. Similarly it was also critical to establish how the gas-centrifuge cascades along with the allied facilities were to be designed. All this information was completely non-existent at the time. In short, PAEC only had information about the gas-centrifuge machine and not setting up of the entire gas-centrifuge plant. In this regard, Munir Khan's connections at the IAEA proved useful, who had served with him at the IAEA. During 1975, Prof. Maurizio Zifferero was serving in the Italian Atomic Energy Commission. Mahmood claims that Munir Khan told him that he had spoken to his former colleague, then in Italy and requested him to arrange a visit to a nuclear research centre, outside Rome.[212]

Thus, Mahmood was able to visit to Casaccia, a Nuclear Research Centre run by the Italian Government's Energy Agency, ENEA. The ENEA dealt with nuclear energy and other related high technology areas.[213] He claims: "It was like our PINSTECH. It [Casaccia] had a separate laboratory of gas-centrifuges, similar to that of Almelo plant.[214] Mahmood also claims that on meeting his Italian host, he was told: "Yes Munir has already talked to me, so you come tomorrow morning at nine and I will talk to somebody to show you the facility."[215] The following morning, Mahmood was finally able to visit the facility, with its gas-centrifuge laboratory. After some reluctance, he was able to visit the gas-centrifuge laboratory itself where an experimental centrifuge machine cascade was operating, comprising fifteen to twenty machines. During his visit, he claims to have been able to get hold of the designs of the gas-centrifuges and that of the entire process.[216]

Subsequently, the Italians who had helped Mahmood go around the laboratory visited Pakistan in December 1975, for sightseeing and an air safari of K-2. During their

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[212] Ibid.
[213] For details, please see Italian Government Energy Agency, "Casaccia Research Centre." http://www.enea.it/com/ingl/center/Casaccia_Research_Centre.pdf (accessed May 30, 2010).
[214] Interview with Mahmood, op. cit.
[215] Ibid.
[216] Ibid.

stay here, they helped their hosts to fill the gaps in the information and also in translating information from Italian to English.[217] Mahmood claims that the Italian contact proved to be very useful for them. The real help, in his view was that this source gave them a lot of confidence in what they were doing, and they saw that a number of things that they were doing were being done in the correct way. He also claimed that once he and his colleagues, such as G. D. Alam, found out that the Italians were doing the same things, then improvements were certainly possible. This also helped them in making "confirmed process engineering drawings, which were indigenous. In this endeavor, Dr. G. D. Alam also participated extensively."[218]

Therefore, it is likely that the Italian connection might have been an invaluable source of information and support for the success of the overall gas-centrifuge effort. While technical data and drawings on the gas-centrifuges were available in some form or another in open literature, and from other sources, the designs and drawings of setting up a complete gas-centrifuge plant was very difficult to obtain from any open source. Nevertheless, other than the above-mentioned sources, there is no precise information about the origin of Pakistani centrifuge-enrichment cascade designs. It may well be that more than one source was tapped to obtain the requisite information, which was then modified and indigenously improved to produce Pakistani cascade designs:

> The cascade design plans were described as "the product of original German drawings and descriptions as adapted by Pakistan test results, experience and reference calculations" and show four blocks of cascades totaling 5832 centrifuges. The first block contained two parallel cascades of 1968 machines each and enriched natural uranium to 3.5 percent uranium-235. The second block had 1312 machines and enriched this 3.5 percent material to 20 percent uranium-235. The third block, with 456 machines, further enriched this material to 60 percent uranium-235. The final block, of 128 machines, produced 90 percent enriched material. There are separate feed and withdrawal stages for each of these five cascades. This would allow, in principle, each of these enrichment stages to be carried out in separate facilities.[219]

[217] Ibid.
[218] Ibid.
[219] Zia Mian et al., op. cit., pp. 98-90.

7.8. Concluding Comment

From the above discussion, it is evident that the uranium enrichment programme in Pakistan originated from within the overall plan for nuclear self-reliance of PAEC. Therefore, the adoption of gas-centrifuge technology for uranium enrichment was also an institutional decision rather than based on the suggestions of any single individual. To develop indigenous capability, PAEC launched a multi-pronged strategy, which harnessed all external and internal sources, technical, material, manpower, physical and financial, which ensured its long-term success. Moreover, it was a team effort right from the beginning and was not dependent on the know-how or influence of any one person. Equally important is the fact that PAEC and its leadership had shown that they were capable of planning, organizing and implementing new and challenging projects, while adopting their strategies to according to local conditions.

PAEC also succeeded in keeping the project a secret, without affecting the procurements, since the project only came to the notice of the western press after A. Q. Khan took over and changed the entire strategy for running the project, which is discussed in detail in the following chapter. However, notwithstanding the disputes within the project and its separation from PAEC, the project continued to grow as planned. From 1976 onwards, this was accomplished under the direction of A. Q. Khan, who took it to its logical conclusion, i.e. establishing the main centrifuge plant at Kahuta which bears his name. KRL has been producing highly enriched uranium for Pakistan's nuclear weapons programme since the mid-1980s whose stock is estimated to be more than two tons. This material was used in Pakistan's nuclear tests on May 28, 1998

From a theoretical viewpoint, PAEC's immediate shift to enrichment in the wake of India's nuclear test in 1974 was based on the rational-actor model. It was logical for PAEC to have grasped the impending change in the international nuclear climate and how it would affect Pakistan's nuclear programme. The launch of the enrichment project also signified the continuing effort to implement the original nuclear plan that was to transform the latent nuclear capability to an operational capability. Thus, it also became part of the process of transformation of the Pakistan's nuclear programme from stage one to stage two of nuclear decision-making towards eventual weapons capability. This project also signified the "historical sociology" approach that attempt to explain the proliferation puzzle.

However, the most significant theoretical aspect covered in this chapter is the empirical validation of the domestic and bureaucratic-politics models. The tussling and pulls and hauls among the key players in the project, especially after A. Q. Khan became attached with the project, proves that outcomes and resultants are the product of "politics." Here, the personal interests of some individuals in terms of their prestige or ambitions also played a key role in the way the project progressed. Moreover, A. Q. Khan presented an alternate version of events and how the project should move forward, which clashed with the perceptions of PAEC leadership regarding the best approach to run the project. Therefore, it is necessary to examine the dynamics behind this rivalry that had its genesis in the arrival of A. Q. Khan in Pakistan. These issues are discussed at length in the following chapter.

CHAPTER 8

A. Q. KHAN AND THE URANIUM ENRICHMENT PROJECT

The previous chapter dealt with Pakistan's efforts to set up a uranium enrichment project during the formative years of its inception, prior and subsequent to the arrival of Dr. A. Q. Khan. It primarily focused on the evolution of the project on the technical side. This chapter attempts to explore and analyze the status, politics and controversies of the gas-centrifuge enrichment project after A. Q. Khan's arrival in Pakistan and the circumstances leading up to his eventual take over as Project-Director. These aspects of the uranium enrichment project deserve close scrutiny because A. Q. Khan is widely regarded as founder of Pakistan's uranium enrichment programme. It is also widely believed that he gathered enough information during his stay in the Netherlands during his work with URENCO on uranium enrichment technology. Therefore, it is necessary to investigate how and why A. Q. Khan became part of Pakistan's nuclear programme and how much information he was able to gather during his stay in the Netherlands. A study of these issues provides deeper insight into the reasons behind the controversies within the enrichment project, which would eventually develop into a full-scale rivalry between the PAEC and KRL. In addition, the answer to the intriguing question regarding the genesis of the proliferation network allegedly led by A. Q. Khan can be traced to this rivalry, which led to the separation of the Kahuta project from PAEC and the eventual absence of oversight.[1]

Therefore, the chapter essentially relies on information obtained from the first Project-Director of the Kahuta project, Sultan Bashiruddin Mahmood, and his successor, A. Q. Khan. In addition, information gathered from other scientists, engineers and other relevant sources have also been helpful for this chapter. It comprises three main sections, namely: A. Q. Khan at URENCO; A. Q. Khan and the Uranium Enrichment Project,

[1] Please see Adrian Levy & Catherine Scott Clark, *Deception: Pakistan, The United States and The Global Nuclear Weapons Conspiracy* (London: Penguin Books, 2007); Douglas Frantz and Catherine Collins, *The Nuclear Jihadist* (New York: Hachette Book Group USA, 2007).

1974-76; and A. Q. Khan versus ERL staff. The concluding paragraphs provide a brief analysis of the relevant theoretical approaches, paradigms and models in respect of the empirical evidence presented in the chapter.

8.1. A. Q. Khan at URENCO

This section examines the status, role and position held by A. Q. Khan while working at the URENCO or Uranium Enrichment Corporation's gas-centrifuge enrichment plant at Almelo, the Netherlands. It attempts to ascertain the accuracy or otherwise of the claims that A. Q. Khan had access to URENCO's entire spectrum of the gas-centrifuge enrichment process. Also, the extent to which this information proved to be useful in developing Pakistan own gas-centrifuge project is also discussed. A careful examination of his position, work and activities in the Netherlands, based on investigations of the Dutch government and testimonies of his colleagues will help in finding answers to these questions.

On March 28, 1979, the Second German Television Channel, Zweites Deutsches Fernsehen (ZDF), announced that Pakistan had succeeded in obtaining access to the Ultra-Gas-centrifuge (UC) technology from the URENCO Consortium.[2] According to the channel, the most important individual in this affair was A. Q. Khan, who was employed from 1972-1975 in the Netherlands. He worked with one of the important suppliers and a private sub-contractor to URENCO, namely the Physical Dynamics Laboratory or Fysisch Dynamisch Onderzoek-Technische Adviseurs or FDO. This company was a subsidiary of Ultra-Centrifuge Netherlands (UCN), the Dutch arm of URENCO, and a part of the Dutch firm, United Machine Factories (Verenigde Machine-Fabrieken or VMF-Stork).[3] A. Q. Khan joined FDO in May 1972.

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[2] Frantz & Collins, Ibid, p. 94.

[3] Dutch Ministry of Foreign Affairs, "Report on the Inter-ministerial Working Party Responsible for Investigating the 'Khan Affair," October, 1979, quoted in K. Subrahmanyam, ed., *Nuclear Myths and Realities: India's Dilemma* (New Delhi: ABC Publishing, 1981), also known as *The Investigative Group Report on the Activities of Dr. A.Q. Khan,* Dutch Government Report, 1979.

In the wake of the ZDF report, the Dutch government immediately initiated an investigation into A. Q. Khan's former activities there. This investigation was begun in March 1979, and in June 15, 1979, the Dutch government formed an "Inter-Ministerial Working Group" to investigate the matter. It comprised the Ministries of Foreign Affairs, Interior and Justice, which later included the Ministry of Economic Affairs.[4] This working group was set up after two members of the Dutch Parliament, Jansen and Waltmans, asked questions regarding the A. Q. Khan affair from the Ministries of Foreign and Economic Affairs. Their questions were answered on May 1, 1979 and in view of the status of investigations at the time, it was determined that the knowledge that A. Q. Khan may have acquired during his work at FDO was only an unimportant part of the ultra-gas-centrifuge (UC) technology.[5]

Consequently, in the wake of this debate in the Dutch parliament and concerns shown by the URENCO Consortium member countries, the above-mentioned working group came into being to further probe the matter. Among other things, the Dutch government investigation was mandated "to examine the nature and extent of Dr. Khan's activities in the Netherlands, as well as its possible consequences."[6] Chapter three of this report focused on his activities in the Netherlands. It stated that in the wake of his completion Ph.D in 1971, A. Q. Khan applied for a job throughout the world, including Pakistan, Australia, and elsewhere. He also applied for a job as a metallurgist in FDO and this particular job was not advertised. It had arisen as a result of the re-organization of the FDO's section that dealt with materials testing. The head of the metallurgy division of FDO was a former student fellow of A. Q. Khan at Delft, who played a very important role in getting his application accepted.[7]

Chapter six of the Dutch government report pertained to A. Q. Khan's importance for the development of Pakistan's gas-centrifuge programme. It stated that even though there was no firm evidence, it was possible for Pakistan to have acquired the centrifuge know-how through him. In such an eventuality, a considerable time towards a

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[4] Ibid.
[5] Ibid.
[6] Ibid.
[7] Ibid.

working centrifuge would have been saved. Interestingly, the working group was unable to find any indication that A. Q. Khan had been gathering intelligence on centrifuges during the period 1972 to 1974. The report added that it was worth noting that even after his departure from the Netherlands, he attempted to obtain data on centrifuges from the Netherlands. However, the report conceded the working group was unable to establish that A. Q. Khan's real contribution to the Pakistani centrifuge project, which was most likely related to the acquisition of software.[8]

Additionally the Dutch government's working group concluded that since the beginning of the 1960s, research in the area of uranium enrichment had been classified as secret in the majority, though not all, of the countries. "Until then, the more theoretical knowledge, together with practical knowledge, with the exclusion of sensitive, specific technical knowledge, was freely accessible." In this way, Pakistan would have been able to acquire information on centrifuge technology from unclassified or open sources. In this respect, A. Q. Khan's letter also pointed towards the fact that certain knowledge about gas-centrifuge uranium enrichment was available all over the world. Also, prior to the early 1970s, global concerns regarding proliferation of sensitive technologies were still not widespread. Therefore, the report added that A. Q. Khan's role in the acquisition of hardware for Pakistan could be established more positively.[9] The report concluded:

> Finally, we should note that for the establishment of one's own enrichment process, a profound knowledge is necessary in various fields. Although Khan was able to acquire much knowledge during his university studies, as well as afterwards in areas outside metallurgy, it does not appear likely, because of its complicated nature, that Khan could have played a role in the development of Pakistan's UC process that the international press is attributing to him.[10]

A. Q. Khan officially worked with FDO from May 1, 1972 till March 1976. He was employed in the metallurgy testing division, where he carried out metallurgical tests

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[8] Ibid.
[9] Ibid.
[10] Ibid.

for the Ultra-Centrifuge Project, among other tests.[11] In this respect, the Dutch government report further stated:

> Though A. Q. Khan also worked in the Final Mechanical Division/ Fine Machine Department, also a part of VMF Werkspoor, as was FDO, where certain components of the gas-centrifuges based on Dutch designs were produced and assembled. FMA also produced component parts for the West German gas-centrifuge in Almelo where five of these prototypes were being assembled. However, it could not be proven that A. Q. Khan was able to acquire essential data from FMA. But A. Q. Khan also worked at FDO for three and a half years.[12]

Furthermore the Dutch report also highlighted "A. Q. Khan's activities with Ultra-Centrifuge Netherland (UCN) at Almelo". It stated: "A. Q. Khan visited the gas-centrifuge facility at Almelo, first on May 8 and 9, 1972 and then on October 3, 1974, in connection with a gas-centrifuge blackening operation, on behalf of FDO."[13] Moreover, in the October 1974, UCN began construction of the gas-centrifuges based on the West German design. In this regard, UCN was handed a German report on the gas-centrifuge under construction, consisting of twelve parts. Each part of this report was classified as "secret" and shorter portions or subdivisions of these secret chapters were classified as "service secret." [14] However, UCN requested FDO to assign the work of translating only two out of the twelve-part report, from German to Dutch. These two parts of the report dealt with the construction outline, and as such contained limited information. A. Q. Khan's translation work was not typed in Almelo, even though he was assigned a place in the so-called "brain-box," a temporary hut outside the Almelo facility, where several technicians and engineers working for the UC project were working.[15]

The translations made by A. Q. Khan were typed in the FDO office in Amsterdam, as there was only one typist in the "brain-box." Moreover, while it was generally believed that he was able to frequently visit restricted areas of the UC areas in Almelo, only one employee of FDO could confirm having seen A. Q. Khan with notes in

[11] Ibid.
[12] Ibid.
[13] Ibid.
[14] Ibid.
[15] Ibid.

his hand in the offices of the gas-centrifuge facility itself.[16] Equally important was the time spent by A. Q. Khan in Almelo, which helps in determining his access to the gas-centrifuge plant itself and his ability to obtain secret information. In this respect, the report stated: "the total amount of time spent by A. Q. Khan at Almelo was sixteen working days. While in the 'brain-box' itself, he completed the translation work assigned to him on the two reports within 128 hours, which were more or less identical in nature." Therefore, he could only have had a limited access to information outside his translation.[17] He is also believed to have taken the classified reports given to him for translation home, to be translated by his Dutch wife, and to be typed since there was only one typist available in the "brain-box."[18]

However, in this regard, he also offered his own defence against allegations of theft of gas-centrifuge know-how while working in URENCO. He wrote a letter to Herrn Johannes K. Engel, Chefredaktor, *Der Speigel*, on November 28, 1979, in response to a story published in the German newspaper, written by Walter Cronkite. This story was entitled, "Atombomben fur den Islam?" and was published in its November 12, 1979 issue. In this letter, A. Q. Khan stated:

> I have never indulged in any undesirable activities (in the Netherlands). I did work for two weeks at Almelo in a secluded wooden cabin with one Dutch engineer but never put my foot in the factory. The translation work I did dealt with the heat treatment and cleaning of components. I never got any plant drawings or specifications."[19] If by working for two weeks he could learn and copy all the technology on centrifuge enrichment, then those working there for years must be blockheads and water-heads. The Dutch government is aware of all my activities in the Netherlands and I have not done anything wrong. I am a metallurgist and I only worked on metallurgical problems of no significance to Almelo project. The allegations against me show that all Pakistani students, scientists and engineers working abroad would be dubbed as spies if they were to come back and join any project of national importance. After all, when you learn something, you apply it to problems. Please do check such cheap stories before you publish them…. [20]

He also referred to the above-mentioned Dutch government report to prove that he did not steal any classified information or data on gas-centrifuge technology, or had

[16] Ibid.
[17] Ibid.
[18] Frantz & Collins, op. cit., p. 35.
[19] A. Q. Khan, letter to *Der Speigel,* November 28, 1978.
[20] Ibid.

access to the most sensitive sections of the Almelo facility. He also denied having passed on any such information to Pakistan while working with FDO.[21] Furthermore, the report stated that the James Bond-like attributes, which had been associated with A. Q. Khan by the Western media, did not appear to have been shared by his colleagues and bosses in the Netherlands. None of his associates or friends from his student days or from the time he worked at FDO/URENCO recalled having a big political, cultural or socio-economic conversation on Pakistan with him.

In this regard, the Director of FDO, Engineer A.C.M. Kuys, claimed that he saw A. Q. Khan was a "clumsy scientist, who could look through a microscope for hours, trying to find a piece of fly-dirt." Kuys claimed: "We know Khan, because we worked with him for many years. He had been called James Bond, but this name did not fit Khan's description at all because he was too inept." He asserted that this was the reason why "he was only assigned with completely unimportant parts of the Ultra-Centrifuge project at Ultra Centrifuge Nederland/URENCO?"[22] Similarly, Professor Dr. M. Bogaardt, the senior most official at Ultra-Centrifuge Nederland, further claimed: "Such a great deal has been written that any clever engineer can easily build an enrichment plant. No espionage required."[23] However Prof. Brabers, his Ph.D. supervisor, declared that A. Q. Khan was proud of his country even though he believed that his student was not a patriot or a genius. He thought his student was more internationally oriented who was a genius in making friends.[24] A recent study on Pakistan's gas-centrifuge

[21] Urs Gehriger, "Interview with Abdul Qadeer Khan," *Die Weltwoche,* January 21, 2009. He claimed: "If one reads the Parliamentary Report issued by the Dutch government on this topic, one sees that I was never suspected of any wrong-doing. Certain orders were placed by Pakistan in that period which indicated that an enrichment programme had been initiated, but these were all for non-classified equipment and/or materials, information for which were obtainable from the open market. The case that was initiated against me in the Netherlands was for writing two letters from Pakistan to ex-colleagues requesting specific information, which, according to the Public Prosecutor at that time, were of a secret nature. The case was quashed on procedural matters but the right of appeal was not utilized by the Dutch government because: a) I had obtained seven affidavits from world-renowned professors and scientists confirming that the information in question had been in the public domain for decades and, b) the letters in question had been written nearly ten years earlier and were no longer relevant. It should also be noted that I went to the Netherlands many times after that to visit my parents-in-law, the last time being in July 1992, with the full knowledge and permission of the Dutch authorities. Would that have been possible if I had done anything wrong?"

[22] Veerman and Jacques Ros**,** *Atomic Espionage* (Amsterdam: Centerboek Weesp, 1988). p.113.

[23] Ibid. p.114.

[24] Ibid. p. 45.

programme also shed light on his activities in URENCO.[25] However, some of A. Q. Khan's activities following his return to Pakistan and taking over the enrichment project reveal that his access to information on gas-centrifuges was incomplete and he was still seeking more information.[26] As PAEC was engaging suppliers of valves and other specialized equipment in Switzerland and Germany in 1976, Dutch suppliers of steel and especially hardened tubes were being sought as well. He had worked at FDO for four years before returning to Pakistan in 1976, and he knew some of these and other Dutch suppliers personally. Therefore, in September 1976, he invited one FDO staff member who visited Pakistan.[27]

Subsequently, when two ERL scientists, Dr. G. D. Alam and Dr. Javed Arshad Mirza visited the Netherlands, the same FDO official who had visited Pakistan the previous year accompanied them. The Pakistani guests were carrying a letter from A. Q. Khan to his former colleague and friend at FDO, Fritz Veerman, who was working as a technical photographer at Almelo. Through this letter, A. Q. Khan sought his friend's help regarding certain technical specifications.[28] He wrote: "Very confidently I request you to help us. I urgently need the following information for our research programme." This included queries such as:

1. Etches for pivots:
    a) Tension- How many volts?

25 "Khan's expertise led visits to the Almelo enrichment plant near the Dutch-German border and many other sensitive UCN facilities. URENCO relied on excellent network of high-tech contractors to make gas-centrifuge parts and supply vital equipment and as part of Khan's job he visited several URENCO suppliers, contacts that would later be invaluable when Khan shopped for his own gas-centrifuge programme. Because Khan was fluent in Dutch and German, he was also assigned by FDO in 1974 to help translate the overwhelming number of German documents FDO accumulated. His work took him to the restricted facility known as the "brain-box," a temporary building located next to the factory at Almelo. There, he had access to scores of highly classified gas-centrifuge designs and manufacturing documents and was treated as a fully accredited member of the team. Through his work at FDO, Khan obtained detailed designs of the Dutch SNOR and CNOR gas-centrifuges, and the German G-2 gas-centrifuge. He also gained information about the M-4 gas-centrifuge, and most likely the German G-4 gas-centrifuge. Khan was so confident of how much he had learned that he confided to a colleague he commuted to work with, that he knew all the secrets of the gas-centrifuge project and was himself capable of making a gas-centrifuge." David Albright, *Peddling Peril: How the Secret Nuclear Trade Arms America's Enemies* (New York: Free Press, 2010), pp. 18-19.

26 Ibid, p. 34.

27 Weismann and Krosney, *The Islamic Bomb* (New York: Times Books, 1981), p. 184.

28 Ibid; Shahid-ur-Rahman, *Long Road to Chaghi* (Islamabad: Print Wise Publications, 1999), pp. 57 -58.

b) Electricity- How many amperes?
c) How long is etching to be done?
d) Solution (electrolytic) HCl or something other is added as a solution.

If it is possible, I would be grateful for 3-4 etched pivots. I would be very grateful if you could send me a few negatives for the pattern. You would be having negatives of these."[29]

2. Lower shock absorber. Can you provide a complete absorber for CNOR? Please give my greetings to Frencken, and try to get a piece for me…..Fritz, these are very urgently required, without which the research would come to a standstill. I am sure you can provide me with these. These things are very small, and I hope you will not disappoint me."[30]

He also tried to convince Veerman and through him, another former colleague FDO, to visit Pakistan. In a letter to Veerman, he stated:

> I have a little technical work for him and much photographic work for you. Both of you could take a holiday and at the same time earn something as well. You will have a lot of fun and will not regret it. If you can supply, I shall be very grateful. Pay a visit to Dr. Mirza and Dr. Alam in the hotel and let me know, via them, whether this can be arranged. You may also give the things to Dr. Mirza."[31]

However, this attempt to obtain information was not successful. After reading this letter, Veerman turned to Dr. G. D. Alam and Dr. Mirza, and in a state of agitation said: "Dr. Khan calls me, my dear friend, and has asked me for information that is secret and I cannot provide him. This is the end of our business with Pakistan."[32] The two Pakistanis were able to leave the Netherlands after three days of this incident without getting into trouble. Veerman took the letters to one of his superiors in FDO, who in turn reported the matter to the Dutch intelligence, the BVD.[33] Consequently, this and a few other letters would later be used by the Dutch government to institute a case against A.

[29] Levy & Clark, op. cit, p. 467; Frantz & Collins, op. cit., p. 74.
[30] Ibid.
[31] Frantz & Collins, op. cit.; Veerman and Jacques Ros, op. cit., p. 65.
[32] Shahid-ur-Rahman, op. cit., p. 58.
[33] Frantz & Collins, op. cit., p.74

Q. Khan, even though the information sought by him was not classified and much of it was available in open technical literature.

8.2. A. Q. Khan and Uranium Enrichment Project: 1974-1976

Following his return to Pakistan in December 1975, A. Q. Khan sent a resignation letter to FDO, which would take effect from March 1, 1976.[34] By this time, he had officially joined PAEC's uranium enrichment project in early 1976. In a recent interview, he explained the circumstances that led to his joining Pakistan's nuclear programme. In this regard, he claimed that Pakistan lacked the necessary industrial infrastructure was nonexistent at that time in Pakistan. "Immediately after the Indian nuclear tests in 1974, Zulfikar Ali Bhutto summoned a meeting of scientists in Multan[35] to ask them to make a nuclear bomb." After the debacle of East Pakistan in 1971, Bhutto had an acute sense of Pakistan's insecurity and removed Usmani when the latter failed to go along his plans to make an atomic bomb, as the basic infrastructure was not there. "Usmani was not wrong in his capacity. The Atomic Energy Commission was the only relevant institution at that time, but it lacked the required expertise." He recalled that he was in Belgium in 1971, when the Pakistan Army surrendered in the then East Pakistan and faced utmost humiliation. When India tested its bomb in 1974, he was living in the Netherlands and working in [a] nuclear field. Uranium enrichment by centrifuge method was only being used in the United Kingdom, Germany, and the Netherlands.[36]

He denied that he was contacted from Pakistan. After the Indian test in 1974, he said he thought he felt the urge to approach Bhutto and tell him about "his capability of making the bomb." Though it was a very rare technology, he claimed to have had a firsthand experience of that technology and he knew how it worked. He wrote a letter to Bhutto in September 1974, telling him that he had the required expertise. He claimed that Bhutto's response was very encouraging, who wrote him back after two weeks, asking him to return to Pakistan. "I came to Pakistan in December 1974 to meet Bhutto. I

[34] Weismann and Krosney, op. cit., p. 180.
[35] The Multan meeting was in fact held on January 20, 1972, soon after the fall of East Pakistan.
[36] A. Q. Khan, Interview with Nadeem Malik, *Islamabad Tonight,* AAJ Television, August 31, 2009.

briefed Munir Ahmad Khan and his team about the technology and asked them to start creating the infrastructure before returning to the Netherlands."[37] He claims that when he again visited Pakistan in 1975, Bhutto asked him to inspect the site to check the progress, it was disappointing to see that no progress had been made by that time. However, when he told the Prime Minister that he had to return to the Netherlands, Bhutto insisted that he could not go and asked him to stay and work on the nuclear programme. He said to his wife: "I could claim without exaggeration that no one could do it for Pakistan but me.[38]

In another interview, he recounted his return to Pakistan and how he joined the country's nuclear programme: "Mr. Bhutto was pivotal to our nuclear programme. Without his go-ahead, full support and giving me full freedom of action, nothing would have materialized." He added: "During the course of my work for Physical Dynamics Research Laboratory (FDO) in the Netherlands, I gained the necessary expertise regarding the enrichment of uranium by the gas-centrifuge method. Other necessary information and technical resources were procured from the suppliers. Lots of useful information was already available in published literature. In this kind of programme, the fissile material is the main thing. The rest is not so difficult." [39] While he is widely regarded as a nuclear scientist who built the atomic bomb, A. Q. Khan clarified that his work in the Netherlands was related to uranium enrichment and not the bomb.[40]

8.2.1. Establishing contact with PAEC

This section discusses the circumstances leading up to A. Q. Khan's initial contacts with PAEC and how and why he was informally made privy to its gas-centrifuge-based uranium enrichment project. It also discusses his interaction with PAEC and travels to

[37] Ibid.
[38] Ibid.
[39] Urs Gehriger, "Interview with Abdul Qadeer Khan," op. cit.
[40] "One never has enough knowledge or information on ones own to start a project and bring it to completion. The knowledge I had gained referred to the enrichment of uranium, not to the building of a bomb. From my past experience I knew who the suppliers were and I also knew that, being businessmen, they were willing to sell whatever was required. Later on export laws became much more stringent and embargoes were put in place. The making of the device itself was a totally different field. I had gathered a team of competent engineers and scientists and when Gen. Zia instructed us to do the job, we managed to do so in two years." Ibid.

Pakistan during 1974 and 1975 till his arrival in Pakistan and how the seeds of an intense and bitter rivalry between him and PAEC were sown during this time. In this respect, the then Project-Director of the uranium enrichment project, Sultan Bashiruddin Mahmood, recounted the events leading up to A. Q. Khan's arrival in Pakistan in the spring of 1976. He claimed that in December 1974, Munir Khan showed him a handwritten blue coloured Air Envelope, which stated:

> My name is Dr. Abdul Qadeer Khan, and I am working in a company called FDO, which is a sub-contractor to the Almelo plant. [If] Pakistan has a programme on enrichment, I have information and I can help. [41]

This letter was originally written to Prime Minister Bhutto on September 27, 1974, whose Minister of Information, Maulana Kausar Niazi claimed that Bhutto wrote on the margins of A. Q. Khan's letter: "He seems to be talking sense."[42] Bhutto also showed A. Q. Khan's letter to his Foreign Secretary, Agha Shahi, who recalled that he advised Bhutto to give A. Q. Khan a chance, as they had nothing to lose.[43] With regard to A. Q. Khan's letter, Kausar Niazi also took a similar stance.[44] Therefore, Bhutto passed A. Q. Khan's letter on to the Chairman of PAEC on October 9, 1974, who asked S. A. Butt to check his credentials.[45] Butt recalled: "I checked on A. Q. Khan and reported that he was really engaged in pioneering work in gas-centrifuge technology and can be helpful in Pakistan's nuclear programme."[46] Thereafter PAEC established contact with A. Q. Khan through S. A. Butt on November 6, 1974, while A.Q. Khan responded to PAEC on December 1, 1974.[47] He was subsequently asked to come to Pakistan during winter vacations at the end of 1974. Munir Khan gave a hand written note to his staff officer, S.N. Burney, dated January 2, 1975. The note instructed Burney to visit A. Q.

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[41] Sultan Bashiruddin Mahmood (ex-Project-Director, PAEC Project-706/DIL, 1974-76), interview by authour, tape recording, Islamabad, August 3, 2007.
[42] Levy & Clark, op. cit., p.17.
[43] Ibid, pp. 15-16.
[44] "Khan was keen to offer his services as he had been rejected by other sections of the Pakistani establishment. Khan had written that 'a man of his special talents was being ignored.' Having been awarded a doctorate in metallurgy, he had applied for a job at the People's Steel Mill in Karachi, only to be ignored. This patriotic Pakistani also informed Bhutto that apart from writing innumerable research papers, he had written an internationally known book. In spite of all this, the incompetent officials of the People's Steel Mill were unable to make use of his services." Ibid, p. 16.
[45] David Albright, op. cit., p. 20.
[46] Shahid-ur-Rahman, op. cit., p. 48.
[47] Interview with Mahmood, op. cit.

Khan's sister's house in Karachi and inquire if he had arrived from the Netherlands. [48] The note stated:

> Inquire from Mrs. Hassan if her brother Dr. A. Q. Khan has arrived from the Netherlands. Tell her only that Dr. A. Q. Khan is expected to bring with him a small parcel for you (i.e. Mr. Burney). Do not mention my name or of the PAEC etc. If she or her husband does not know about A. Q. Khan's arrival then leave the matter there. Say you will call in a couple of days again. Inform me of the results on the phone. Do not mention the name of A. Q. Khan on the phone when talking to me but use the name of KARIM. You should be prepared if necessary to show him KANUPP but not under the name of A. Q. Khan but as Karim. Report the results to me on the 4th evening after 7 pm.[49]

The consignment mentioned in this note in all probability contained parts of a gas-centrifuge from a demonstration plant, sent to Munir Ahmad Khan by A. Q. Khan.[50] Mahmood recalls that A. Q. Khan would send such components through the diplomatic bag, which would end up in Munir Khan's residence. During January 1975, Munir Khan and A. Q. Khan would meet for the first time and in all possibility hold discussions on each other's work.[51] During this visit, it is likelt that he was escorted by the Military Secretary to Prime Minister Brig Imtiaz Ali, to see Bhutto[52] and may also have met the Prime Minister in December 1974 in Karachi.[53]

A. Q. Khan claims to have told the Chairman of PAEC and his staff on how to proceed with the gas-centrifuge project.[54] With regard to A. Q. Khan's letter, Mahmood claims that when the Chairman asked for his opinion, he replied that, "we should welcome help from anywhere as this was part of our policy and we did need new people."[55] Therefore, Munir Khan asked Mahmood to visit Brussels and meet S. A. Butt, who was actually posted there as procurement attaché for PAEC, "who would manage things from there."[56] Hence, Mahmood went to Belgium in February 1975, and met Butt.

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48 Shahid-ur-Rahman, op. cit., pp. 4-5.
49 Ibid.
50 Ibid, p. 153.
51 Ibid., p 50.
52 Levy & Clark, p. 29.
53 David Albright, op. cit., p. 21.
54 Ibid.
55 Interview with Mahmood, op. cit.
56 Ibid.

Upon his arrival in Brussels, S. A. Butt told his guest from Pakistan: "We will pick him from the tube station and then meet him in my house."[57] In this regard, Mahmood recalled:

> Therefore as per the programme, we went to the tube station and I saw a gentleman in his forties, a tall man, Abdul Qadeer Khan, who had a habit of speaking quickly. Butt had arranged the attic of his house for both of us and had placed two beds there for the two of us. He then told us that we may talk in the attic and then whatever Bashir sahib says, we shall proceed accordingly. You will only have to tell me what to do and I will do it.[58]

During their conversation A. Q. Khan told him: "I am a metallurgist, working in FDO, and my Ph.D thesis was on crystallography of copper metallurgy."[59] He also stated his background and how he had migrated to Pakistan sometime in 1951. He obtained his B.Sc from Karachi and then joined the Customs Department for a while, then went to West Germany and acquired his M.Sc and then his Ph.D in a specialty of copper alloys from Belgium, under the supervision of Prof. Martin Brabers.[60] In fact his Ph.D thesis, completed at the Faculty of Applied Sciences, University of Leuven, Belgium, in March 1972 was entitled: "The effect of morphology on the strength of copper-based martensites."[61] A. Q. Khan also talked of his fluency in German, Dutch and English languages and that he was working in the metallurgical section of a Dutch firm, known as FDO. He explained that FDO was not directly involved in the design or manufacture of the gas-centrifuges, rather its mandate was fatigue and failure analysis of various parts of machines and equipment being used at UCN's Almelo plant. Mahmood claims that A. Q. Khan showed him drawings of some components that had failed and had come to him for translation and metallurgical and fatigue analysis.[62]

Apparentely, A. Q. Khan stayed in Butt's house for two days along with Mahmood who asked Butt to activate his contact with Khan so as to establish a channel

[57] Ibid.
[58] Ibid.
[59] Ibid.
[60] Ibid.
[61] Bio-data of Dr. A. Q. Khan. www.draqkhan.com.pk (accessed November 9, 2008).
[62] Interview with Mahmood, op. cit. For A. Q. Khan's viewpoint on the nature of his work in FDO, please see his letter to *Der Spiegel,* dated November 28, 1979.

for the flow of information. Therefore, the next day, he and A. Q. Khan traveled to the Netherlands in S. A. Butt's car and saw Khan's house. "We were to develop an arrangement on how to transfer information. He told me that he has a brother in the Netherlands, Abdul Lateef Khan, and introduced him to me."[63] In this respect, Mahmood added:

> So after a while, we started receiving information from A. Q. Khan through S. A. Butt. Some of the information was unique and useful, but generally the information that he passed on to us was similar to the one, which we already had. Then there were some papers that FDO used to publish on failure analysis, stresses and fatigue failures etc. some information regarding the materials used in gas-centrifuges was also passed on to us by A. Q. Khan.[64]
>
> This information was helpful for re-confirmation of what we knew already, and his information only added to our confidence in what we knew and what we were doing. Some other information provided to us included a list of different machine shop equipment, which also confirmed our own lists.[65]

On his return to Pakistan in early 1975, Mahmood told the Chairman of PAEC that A. Q. Khan would be useful and helpful for their gas-centrifuge programme. "At that time, it was our job to construct a working team for the enrichment project, from within and outside Pakistan."[66] Therefore, A. Q. Khan was asked to stay in the Netherlands and send material or information to PAEC. On his way back to Pakistan, Munir Khan had arranged Mahmood's visit to the IAEA's library where he claims to have been able to gather a lot of declassified information and other open source technical literature on uranium enrichment technologies.[67] He also claims that S. A. Butt remarked about A. Q. Khan that he was very ambitious and could pose a threat to PAEC's leadership of the enrichment programme.[68] S. A. Butt would later say: "A. Q. Khan did

[63] Interview with Mahmood, Ibid.
[64] Ibid.
[65] Ibid.
[66] Sultan Bashiruddin Mahmood, Interview with Sabir Shakir, *Waqt News Exclusive,* Waqt News Television, July 23, 2009.
[67] Ibid.
[68] Interview with Mahmood, op. cit.

some daring things, risking his job and imprisonment."[69] He started to supply Butt with information through an intermediary.[70]

8.2.2. The Genesis of the A. Q. Khan-PAEC Rivalry

In the wake of A. Q. Khan's initial contacts with PAEC, he was invited to visit Pakistan in April 1975, during Easter holidays, when he was taken on a tour to KANUPP and most probably met the Chairman of PAEC at Mahmood's residence.[71] Subsequently, A. Q. Khan left for the Netherlands and towards the end of 1975 he expressed his wish to visit Pakistan, during the Christmas holidays in December for fifteen or twenty days. This time, however, his visit would prove to be the harbinger of things to come in the project, especially how the PAEC bosses planned to take the project forward.[72] Following A. Q. Khan's April 1975 visit to Pakistan, it was becoming clear that he and PAEC did not share the same ideas and approach towards the project. In this regard, Mahmood has made claims, which portray A. Q. Khan in a negative light. He asserts that A. Q. Khan's attitude was very negative and disappointing. "My conclusion was that either he doesn't know or he doesn't want to tell us."[73]

He claims to have complained to Munir Khan that A. Q. Khan was finding fault in everything, and there was no positive contribution. In particular, he was making fun of PAEC's indigenization efforts, i.e., they [DIL] were trying to build gas-centrifuges and were talking of industries in Gujranwala. Generally he gave the impression that everything should be procured and talk of local development effort should end. However, Mahmood claims to have told A. Q. Khan that procurement and indigenization would go together.[74] However, years later, A. Q. Khan would continue to defend his stance with regard to giving priority to whole-sale procurements over indigenization.[75]

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[69] Shahid-ur-Rahman, op. cit., p. 50.
[70] Ibid, p. 51.
[71] Interview with Mahmood, op. cit.
[72] Ibid.
[73] Ibid.
[74] Ibid.
[75] "A country which could not make sewing needles or even ordinary durable metalled roads was embarking on one of the latest and most difficult technologies. Only seven countries in the world (USA, UK, France, USSR, China, Germany and the Netherlands) possessed this technology. Of the whole nuclear fuel cycle, enrichment is considered to be the most difficult and most sophisticated technology. It was a

Nevertheless, the young metallurgist did not keep his views to himself. Mahmood explained A. Q. Khan's frustrations with the way PAEC was running the project:

> In fact A. Q. Khan started saying that in this country where not a switch can be manufactured and nothing else can be made, efforts are being made to develop gas-centrifuges locally. Yet we gave him a lot of respect. I took him around to show him local industry. I took him to Lahore and Gujranwala and to Karachi and I also took him to SUPARCO where I made him meet Mr. Salim Mahmud. [76]

Mahmood further claimed that Munir Khan asked him to address A. Q. Khan's reservations, especially with regard to indigenization, however, attempts to satisfy him proved to be unsuccessful. Since work in ADW initially started in a makeshift environment, and the laboratories were not fully air conditioned and work was being done on one side, he also complained that there was no high-tech environment. He was told that a fully furnished and high-tech environment would eventually be created and if they were to wait for it, then it would mean losing precious years of work. Eventually the furnishing would be completed but the work at hand had to take priority.[77] While justifying this approach, Mahmood claimed that Munir Khan was against the philosophy of waiting for elaborate buildings first to begin work. He wanted everything to be done in parallel and building of facilities would also be progressively undertaken.[78] Nevertheless, A. Q. Khan was not convinced, as Mahmood claimed:

> He started saying to our colleagues in the project that Bashir [Mahmood] and Munir don't know what needs to be done and they don't understand the requirements of gas-centrifuge technology and they are building carts where cars should be made. Anyways we told him that you should not criticize like this and you should understand that this philosophy is in the interest of the country and our gas-centrifuge programme cannot survive if it is ever dependent on procurements from abroad.[79]

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real challenge to me and my colleagues. The problem was very clear to us. We were not going to find out new laws of nature but were dealing with a very difficult and sophisticated engineering technology. It was not possible for us to make each and every piece of equipment or component within the country. Attempts to do so would have killed the project in the initial stage. We devised a strategy by which we would go all out to buy everything that we needed in the open market to lay the foundation of a good infrastructure and would then switch over to indigenous production as and when we had to."
A. Q. Khan, "Pakistan's Nuclear Programme: Capabilities and Potentials of The Kahuta Project," Speech delivered at the Pakistan Institute of National Affairs, September 10, 1990 and Dr. A. Q. Khan, "Capabilities and Potentials of The Kahuta Project," *The Frontier Post,* September 10, 1990.

[76] Ibid.

[77] Interview with Mahmood, op.cit.

[78] Ibid.

[79] Ibid.

In fact by 1979, all procurements for the project had virtually come to a halt. In letters to one of his trusted friends, A. Q. Khan acknowledged what Mahmood had predicted.[80] Moreover, from the time of A. Q. Khan's take over till 1979, emphasis was placed on large-scale procurement instead of local development, whereafter ERL was forced to shift its focus back to indigenization.[81]

8.2.3. A. Q. Khan's Arrival in Pakistan and Differences with PAEC

There are two competing narratives, which explain the circumstances surrounding A. Q. Khan's arrival in Pakistan owards the end of 1975. One is based on claims made by A. Q. Khan. The other one derives from claims made by his precedessor who recalls that S. A. Butt, and Munir Khan began receiving hectic phone calls from A. Q. Khan who began complaining that he had been exposed, he might be caught and demanded to be brought back to Pakistan.[82] Consequently, S. A. Butt was asked to confirm A. Q. Khan's claims. According to Mahmood, Butt reported that A. Q. Khan was complaining because probably he really wanted to come to Pakistan while Butt's trip to the Netherlands had shown that everything was normal. However, the flow of information from him had also virtually stopped and things were not the same any more on his part.[83]

It appears that A. Q. Khan had begun to be suspected of espionage in the fall of 1975, partly due to his own indiscretions as he had openly begun making inquiries for gas-centrifuge related materials. He also realized that his access to FDO and UCN related work was coming to an end as he was transferred to a less sensitive section in FDO.[84] Therefore, this paved the way for A. Q. Khan's homecoming and joining Pakistan's nuclear programme. In the wake of his pleas to return to Pakistan, Mahmood claims to have discussed the matter with the Chairman of PAEC. Hence, it was decided

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[80] Frantz & Collins, op. cit., p. 95. A.Q. Khan wrote: "All our material has been stopped; everywhere they are making it delayed. The materials, which we were buying from British and Americans have been stopped. Now we will have to do some work ourselves."

[81] In 1990 A. Q. Khan acknowledged this and wrote: "An enrichment plant needs a lot of precautions or fail-safe systems. We designed them all. We welded thousands of feet of aluminum pipes of the header, and of the feed and collection systems. Once the Western propaganda reached its climax and all efforts were made to stop or block even the most harmless items, we said enough was enough and started indigenous production of all the sophisticated electronic, electrical and vacuum equipment."

[82] Interview with Mahmood, op cit.

[83] Ibid.

[84] David Albright, op. cit. pp. 22-36.

to facilitate his return to Pakistan "as they needed people in their team and in reality if A. Q. Khan was exposed, then the centrifuge programme would also be exposed.[85] Hence, S. A. Butt was asked to arrange A. Q. Khan's travel to Pakistan along with his family.[86] He left for Pakistan on December 15, 1975[87] and according to Munir Khan, "came out of the cold."[88]

By March-April, 1976 he had joined the enrichment project in Pakistan. Initially a house was arranged for him in sector F-8/2. "We gave him very good facilities, but he was very unhappy,"[89] claimed Mahmood. Soon after his arrival in Pakistan, the then Chairman of SUPARCO, Salim Mehmud interviewed A. Q. Khan at the request of the Chairman of PAEC. Salim claims that A. Q. Khan arrived in his office with S. B. Mahmood and was carrying some papers with him. The interview lasted half an hour during which A. Q. Khan stated that he was a copper metallurgist and had acquired his Ph.D in this field from the Netherlands where he had worked at FDO and briefly at Almelo.[90] Following this meeting, Salim informed Munir Khan and the Military Secretary to Bhutto, Brig. Imtiaz Ali that he was not able to form a high opinion of A. Q. Khan. The Military Secretary however told Salim Mahmud: "The Prime Minister has already made up his mind."[91]

However, in this respect, A. Q. Khan would has given a completely different version of events: "I came to Pakistan on vacation in 1976 and stayed on at the personal request of Mr. Bhutto to work on Pakistan's nuclear programme." [92] He also claimed that Bhutto asked him to stay on in order to save the fledgling gas-centrifuge project, which had not moved an inch since his last visit.[93] However, other sources indicate that by late 1975, A. Q. Khan had probably realized that his access to the Dutch gas-centrifuge

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[85] Interview with Mahmood, op. cit.
[86] Ibid.
[87] David Albright, op. cit., p. 26.
[88] Shahid-ur-Rahman, op. cit., p.51.
[89] Interview with Mahmood, op. cit.
[90] Salim Mahmood (ex-Chairman of SUPARCO), interview by authour, written notes, Islamabad, May 21, 2007.
[91] Ibid.
[92] A. Q. Khan, "Bhutto, GIK and Kahuta," *The News* (Islamabad), July 29, 2009.
[93] Shahid-ur-Rahman, op. cit., p. 51.

programme had virtually ended and had no future career prospects there. Moreover, he had become increasingly aware of becoming exposed on charges of espionage. Therefore, he could not opt for any other option but to stay on in Pakistan, albeit not without securing a promising and important place for himself in the gas-centrifuge project.[94]

One of the main areas of dispute between A. Q. Khan and the PAEC leadership was procurements with the former strongly advocating wholesale procurements for the gas-centrifuge project. As stated above, he had objected to PAEC's dual track approach of indigenization involving local industries and procuring essential materials and equipment in parallel. In this regard, he would later claim: "With years of experience working on similar projects in Europe, my contacts there with the various manufacturing firms were an invaluable asset for me."[95] He also maintained that Pakistan did not have the technological infrastructure to build the components needed for a gas-centrifuge plant. This approach would have "cost an enormous amount of time" and he was sure "that the gas-centrifuge project would have been aborted at the very early stages because of this."[96] In this regard, Mahmood gave different views:

> In fact due to the change in the leadership of the project, the project was delayed and its indigenous direction came to an end. A lot of emphasis was placed on foreign procurement. Local development, which was the spirit of the project that "we must do it here in Pakistan" ended. The cost of the project also increased substantially. These people would then import things from abroad according to their whims and wishes.[97]

Moreover, soon after taking over the reigns of the project, A. Q. Khan himself turned up in Europe to make orders for procurements. In one such instance, he went to the Netherlands in August 1976.[98]

8.2.4. The Road to PAEC-ERL Separation

The seeds of the rivalry between PAEC and A. Q. Khan were being nourished with each passing week. When A. Q. Khan joined ADW/DIL, he was given the job of Director

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[94] David Albright, op. cit., p. 29.
[95] Ibid, p.22.
[96] Ibid.
[97] Interview with Mahmood, op. cit.
[98] Ibid, p. 35.

(Research & Development) at a salary of Rs. 3000[99] per month, while Mahmood was the overall Project-Director.[100] A. Q. Khan would repeatedly complain that he was being treated shabbily by PAEC and had left behind a lucrative career and job, and therefore expected to be appointed to an important position.[101] However, Mahmood claims that the average salary of a Grade-20 officer in the government at that time was much less than what A. Q. Khan was being offered, and he was being given the highest possible salary in the entire project.[102] He alleged that soon after A. Q. Khan joined the project, he would make people sit around tea and engaged them in gossip. He would compare the comfortable working environment back in the Netherlands with the basic furnishings at ADW. In addition, A. Q. Khan continued his criticism regarding the way the project was being managed, especially the indigenous efforts being planned and worked out.[103]

This, Mahmood claimed, had the effect of demoralizing the staff and it slowed down the pace of the work. During a discussion, he told A. Q. Khan that they had expected the project to progress further with his arrival. On the contrary, "work has stopped and the team has become demoralized."[104] A. Q. Khan replied that he was not happy and wanted to leave. [105] Therefore, during a meeting at the former's residence the same evening, Munir Khan handed a copy of a handwritten letter to A. Q. Khan, which he had written to Bhutto. In this letter the Chairman of PAEC had apprised the Prime

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[99] Shahid-ur-Rahman, op. cit., p. 51.
[100] Interview with Mahmood, op. cit.
[101] "Upon Mr. Bhutto's insistence, I decided to remain in Pakistan while my wife returned to the Netherlands to pack up all our belongings. In doing this I gave up a highly respectable and lucrative job, good a salary and attractive perks, and my wife left her elderly parents behind to follow me. We did all this so that I could serve my beloved country. I only received my first salary of Rs 3,000 per month after six months.[101] We were given a house in what were, at that time, the outer limits of Islamabad – F-8/1. There were only three houses on the whole road and no streetlights. We did not complain or bargain for more. We never asked for any favours from the government and never received any." A. Q. Khan, "The Past and the Present," *The News* (Islamabad), November 12, 2008.
[102] Interview with Mahmood, op. cit; In fact, Munir Ahmad Khan as Chairman of PAEC was also getting a take-home salary of less than Rs. 4000/- per month when he joined PAEC in 1972, while he was previously earning equivalent to more than Rs. 20,000/- per month at the IAEA. Bio-data of Munir Ahmad Khan.
[103] Interview with Mahmood, Ibid.
[104] Ibid.
[105] Ibid.

Minister on the progress being made in the centrifuge project and had expressed the hope that with the arrival of A. Q. Khan, they hoped to re-double their efforts.[106]

The host of the meeting asserts that Munir Khan gave a copy of this letter to A. Q. Khan with the words: "You don't seem to be happy with us, but look this is what I have written to the Prime Minister about you."[107] Following this episode, A. Q. Khan and Mahmood saw Munir Khan off. Mahmood claims that as they saw the Chairman's car drive away, A. Q. Khan threatened to teach him a lesson,[108] who shrugged it off when he was told about it the next morning. Ostensibly, A. Q. Khan took a copy of this handwritten letter to Agha Shahi and Ghulam Ishaq Khan, and Brig. Imtiaz Ali. According to Mahmood, he told them: "Look this is what the Chairman of PAEC, has said about me; I am the expert at building gas-centrifuges. The others working in the project are incompetent and I should be made in-charge of the project."[109]

Soon, an emboldened A. Q. Khan wrote to Munir Khan on April 19, 1976, wherein he showed his displeasure at the state of affairs in the enrichment project and expressed his inclination to leave.[110] Nevertheless, he continued to push for the removal

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[106] Ibid.

[107] Ibid.

[108] Ibid.

[109] Ibid.

[110] He claims to have written: "Dear Mr. Chairman, it has been about two weeks since I asked Bashir to convey to you my request to spare a few moments for me. Whether he forgot to do so or you could not accommodate it in your busy programme is not clear. I am, therefore, compelled to convey to you this message in writing. I have been here for more than four months and have been able to get a pretty good idea of the position of the project. I have tried to contribute as much as I could under the circumstances but, frankly speaking, I am not at all satisfied with it and could do at least ten times of what I have been able to do. Lately, a number of 'very experienced' and 'able' engineers have joined or are about to join the project and they should be able to see the project through under their 'able' and 'intelligent' Director and your guidance. I think my presence here will now in no way be of much help to the project. Of late I cannot help having the feeling that I am no more than just a subordinate. Before things get out of hand and lead to an unpleasant breakup, I would like to stop my association with this project. It was a well-thought decision to come over here and help the country and both my wife and I had also considered all eventualities. I think it is advisable for us now to take necessary steps to proceed abroad at our earliest convenience. Since there has been nothing in writing so far, we can leave the things as they stand. Should you so desire, I am willing to contribute to the project as long as we are here. One thing, which I would like to mention, is that the target given to the Prime Minister can never be met. Activities undertaken so far have put the target back by at least two years and if things go as they are going now I don't think the project will be completed (if at all completed) by 1980. Each week passing is putting the project behind by at least two to three months. I am thankful to the Prime Minister and to you for the confidence in me and for undertaking this project so vital to this country. Thank you very much." A. Q. Khan, letter to Munir

of the incumbent Project-Director, Sultan Bashiruddin Mahmood. Meanwhile, at about the same time Dr. A. Q. Khan joined the project, Dr. G. D. Alam was made in-charge of the "B-2" laboratory in ADW in January 1976 and was assigned work related to vacuum technology and process engineering for the project. [111] Alam recalled that the Director-General of the uranium enrichment project was Mahmood and A. Q. Khan was given the post of Director, Research and Development, while all administrative powers were with Mahmood. This was unacceptable for A. Q. Khan.[112] In this regard, Alam claimed that A. Q. Khan was suffering from frustration by working under Mahmood and had clearly stated that he would not work as a subordinate to the Project-Director but would rather go back to the Netherlands. Therefore, Munir Khan set up a Board of Governors. This set up included Dr. A. Q. Khan, Dr. G. D. Alam and Bashiruddin Mahmood and it was agreed with respect to this Board that a Director (Finance) would later on be added to the Board and till then administrative powers would remain with Mahmood.[113]

However, Alam claims that this Board was also unacceptable to A. Q. Khan "who wanted everything to be under his control." That is what he conveyed to Prime Minister Zulfikar Ali Bhutto and declared that he would not work under these circumstances. Therefore, Bhutto told him that he would be given autonomy. In this regard, Bhutto set up a high-level Board comprising the then Finance Secretary, Ghulam Ishaq Khan, Foreign Secretary, Agha Shahi, and A.G.N. Kazi. This Board was assigned the task of coordinating the project and as a result of this set up Mahmood became a subordinate of A. Q. Khan and therefore left the project. [114] Nevertheless, it would still be a few more months before the project would have a new leader. A. Q. Khan, for his part, continued to exert pressure and convince Munir Khan to remove Mahmood and create the conditions that would eventually enable him to take over the project.

Moreover, it seems that A. Q. Khan had serious reservations with regard to two important areas of the project. One was organization, and the other was procurement.

Ahmad Khan, Chairman of PAEC, April 19, 1976, published in Shahid Nazir Chaudhry, *Dr. Abdul Qadeer Khan Aur Aitami Pakistan* (Lahore: Data Publications, 2004).
[111] Interview with Mahmood, op. cit.
[112] G. D. Alam, Interview with Urdu Daily, *Assas-o-Lashkar* (Rawalpindi), June 12, 1998.
[113] Ibid.
[114] Ibid.

Linked with this was the issue of recruitment and selection of staff, coupled with the implementation, or alternatively, the elimination of all normal rules, procedures and regulations governing the PAEC.

8.2.5. Complaints against PAEC

It is likely that A. Q. Khan was able to arrange his meetings and convey his complaints to Prime Minister Bhutto through Imtiaz Ali and a few other cabinet ministers. These efforts were indeed successful in gaining the attention of Bhutto and Mahmood's departure from the project was now a matter of time. [115] As the power struggle between PAEC and A. Q. Khan for control of the project was continuing, he purportedly wrote a letter to Bhutto on July 25, 1976, in which he demanded his appointment as Project-Director and challenged the credentials of Munir Khan.[116] He also accused the Chairman of PAEC of misleading Bhutto about the enrichment project and claims to have told the Prime Minister in a meeting:

> Munir Khan has been pressing me to tell you lies that he would be able to explode a plutonium device by the end of 1976.[117] Where there is no fuel fabrication plant, no un-safeguarded reactor, no fuel cutting/shredding facility and no reprocessing plant, how he can claim that. He is a liar and is taking you for a ride. Moreover, the target given to you about the enrichment plant of 1980 is totally wrong. The way he is handling the project we will never be able to have an enrichment plant.[118]

He asserts that these remarks were conveyed to Bhutto in the presence of Agha Shahi and Imtiaz Ali, which prompted the Prime Minister to ask him to stay on in

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[115] Ibid.

[116] A. Q. Khan's letter to Prime Minister Zulfikar Ali Bhutto, July 25, 1976, printed in Shahid Nazir Chaudhry, op. cit. He wrote: "I have been here now for almost seven months and have done my best to be useful for the project. However, I am constrained to write to you that I am a totally disappointed and dejected person and have come to the conclusion that either things should change or I should leave. I have written a letter to Mr. Munir Ahmad, Chairman, PAEC, about the state of affairs. Bashiruddin Mahmood, in-charge of the project is a stupid person. He lacks vision, comprehension, and even the required qualifications to lead such a project. His boss, Munir Khan is the biggest fraud I have ever met. He projects himself as a nuclear expert and a doctor. As a matter of fact he just holds a B.Sc Engineering from a third-rate Lahore University and a nine month diploma of a third-rate North Carolina State Polytechnic in Power (Electrical) Engineering. His job at the IAEA was somewhat similar to an account clerk keeping a record of nuclear plants etc. He has no practical experience."

[117] This was denied by Munir Ahmad Khan in an interview with Daily *Ausaf* in June, 1998 and by Dr. Samar Mubarakmand in post-Chaghi test interviews.

[118] Ibid.

Pakistan and take over the enrichment project.[119] In the above-mentioned letter, he also threatened to go back to the Netherlands if he was not made Project-Director.[120] However, in this respect, a recent study on the centrifuge project has offered a different viewpoint. It states that prior to the arrival of A. Q. Khan to Pakistan, PAEC already had a workable design for a centrifuge machine and had ordered several items from Germany and Switzerland for the project. It added that A. Q. Khan's complaints against Munir Khan and S. B. Mahmood were aimed at making up for his loss of time, information and employment in Holland and designed to seize control of the project.[121]

In this regard, Mahmood alleged that A. Q. Khan wanted everything in his control, and "wanted that to be known as the super-genius. All this was aimed at defaming Munir Ahmad Khan and PAEC.[122] It is, however, unlikely that A. Q. Khan wrote this letter to Bhutto, because, by July 25, he had already succeeded in having Mahmood removed as Project-Director on July 17, 1976. It may have been that he wrote a less aggressive letter to Bhutto on an earlier date. In an apparent reference to his rival, A. Q. Khan claimed: "The big bosses said they had full confidence in me despite the objection from a few people."[123] In this regard, A. Q. Khan recalled that he instantly became the victim of professional jealousy as his rivals tried to convince Bhutto and Ghulam Ishaq Khan that he "was a sharp young man trying to deceive them, who would flee after making money and taking them for a ride." His rivals also pointed out that centrifuge technology was a difficult process, which was mastered by only a handful of advanced countries. He affirmed that since Bhutto and Ghulam Ishaq Khan were men of wisdom and foresight, since they believed in his sincerity and reposed faith in his

[119] A. Q. Khan, Interview with Nadeem Malik, op. cit.

[120] A. Q. Khan's letter to Prime Minister Zulfikar Ali Bhutto, July 25, 1976, op. cit. He wrote: "Mr. Prime Minister, I came to Pakistan, leaving respected, lucrative position, to serve my country and to make it a nuclear power. I have been handed over to a most incompetent, ignorant person to play his Puch. I won't do it. I am extremely grateful to you for calling me and associating with this programme, but I am of no use to you any more. Coincidentally, I am the only person in Pakistan who can set up this facility. As a matter of fact, I am the one of the dozen or so in the world who can do this job. I would earnestly request you to please let me go back abroad. I am really sorry."

[121] Ibid, pp. 29-30.

[122] Interview with Mahmood, op, cit.

[123] Levy & Clark, op. cit., p. 53.

abilities. However, he asserted that while some people advised him to lie to Bhutto that the bomb would be ready in three years, he never paid heed to their advice.[124]

According to him, there were others who advised him to make a device containing about 2,000 tons of explosives laced with some radioactive material. This would give the impression that it was a nuclear explosion. "The claim that Pakistan was ready to explode a nuclear device in December 1976 was based on this presumption."[125] He argued that technocrats should stick to the truth and not mislead the government by making untenable and false claims.[126] In this regard, it is not clear whether Munir Khan was present in any such meeting or not where Bhutto did reprimand him as per A. Q. Khan's claims. Agha Shahi, however, claims that following his interaction with A. Q. Khan, Bhutto was annoyed with Munir Khan.[127] A. Q. Khan also asserts that when Bhutto wanted to replace Munir Khan, Agha Shahi tried to persuade Dr. Bagi Beg, at the Rockefeller Institute in New York, to return to Pakistan and become Chairman of PAEC, but he politely declined.[128] However, Agha Shahi argued that the uncertainty with regard to the success of the enrichment route went in favour of Munir Khan who was allowed to continue as head of PAEC.[129]

With regard to A. Q. Khan and Agha Shahi's above-mentioned claims, Bhutto's Finance Minister, Dr. Mubashir Hasan offered a unique explanation of Bhutto's

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[124] A. Q. Khan, "The Past and the Present," *The News* (Islamabad), November 12, 2008.

[125] Ibid. As stated above, Munir Ahmad Khan and Dr. Samar Mubarakmand denied this claim. In response to A. Q. Khan's claims of PAEC misleading Bhutto regarding carrying out dummy nuclear tests, Samar Mubarakmand asserted after the 1998 nuclear tests that this was not true and "PAEC's tradition was not one of carrying out dummy explosions." Munir Ahmad Khan also explained his positon with regard to A. Q. Khan's claims that PAEC had misled Bhutto about the date of the nuclear test. In an interview after the 1998 tests, Munir Khan claimed that the notion that he had told Bhutto that PAEC could carry out a nuclear test in 1976 was not true and was the figment of A. Q. Khan's own imagination. "How can you carry out a nuclear test in three years with 250 people. If this were possible, why couldn't A. Q. Khan carry out a nuclear explosion within four years of his arrival in Pakistan?" Please see Samar Mubarakmand, Interview with Waheed Murad and Mazhar Iqbal, *Daily Asas* (Rawalpindi), June 2, 1999; and Munir Ahmad Khan, Interview with Hamid Mir and Saeed Qazi, *Daily Ausaf* (Islamabad), June 18, 1998. However, because PAEC had begun work on selecting and preparing the nuclear test sites at Chaghi and Kharan around this time, an impression of preparing for a nuclear test may have been generated, though it does not imply that PAEC was ready with a nuclear device at the time.

[126] A.Q. Khan, "The Past and the Present," Ibid.

[127] Shahid-ur-Rahman, op. cit., p. 52.

[128] A.Q. Khan, "Tales and Anecdotes," *The News* (Islamabad), January 28, 2009.

[129] Shahid-ur-Rahman, op. cit., p. 53.

decision-making. He argued that Bhutto was a master politician who was adept in the art of dealing with people. He was a politician after all and would give the impression to someone whom he did not want to discourage or get rid of, that he believed in him and he could count of his full support. He would also say things that would please his interlocutor and not reveal any signs of negativity.[130] He added that it was a mistake on Munir Ahmad Khan's part that "he was honest and incorruptible while his rival coalition was making money through wrong means and he would report on them." While his rivals were quickly making influential coalitions while "he did not know that when a combination of power and money, all in the name of national security comes into being, then breaking it becomes very difficult."[131]

On reports that he had lost the confidence of his friend and boss, Hasan emphasized: "Zulfikar Ali Bhutto needed the services of Munir Ahmad Khan until his death. If A. Q. Khan's case was so strong against Munir, then why did Bhutto and Zia-ul-Haq retain him as Chairman of PAEC and continued to use his services in the developing the atomic bomb and the nuclear programme?"[132] Nonetheless, Bhutto as Chief Executive of Pakistan was also directly in-charge of PAEC whose Chairman reported only to him, and was therefore intimately aware of the progress of its various projects. As Prime Minister and head of the PAEC Council, he would preside over the annual meetings of the Council wherein progress on various projects would be discussed.

In another twist to the ongoing controversy in DIL, while it is generally believed that a bio-technologist, Dr. Amir Muhammad Khan was being tipped as a possible replacement for the Chairman of PAEC, he was in fact being considered as a replacement for Mahmood.[133] Apparently, Imtiaz Ali and Agha Shahi had suggested Amir Muhammad Khan's name to the Prime Minister for Mahmood's replacement at DIL and/or PAEC. Agha Shahi had his own reasons to go against Munir Khan. Over the years, he saw the latter as an independent player in influencing foreign policy decision-

[130] Mubashir Hasan, Former Finance Minister of Pakistan, 1972-1974, interview by authour, tape recording, Lahore, March 17, 2007.
[131] Ibid.
[132] Ibid.
[133] Interview with Mahmood, op.cit.

making, especially on nuclear issues, which undermined his position. Nevertheless, Bhutto did not install a bio-technologist as director of the enrichment project, nor did he replace the Chairman of PAEC. The latter continued to visit Bhutto throughout his detention following the coup by Gen. Zia. The deposed Prime Minister would also send Munir Khan messages from jail, inquiring about the status of various projects and giving instructions to complete on-going projects as per schedule.[134]

Thus, inspite of the autonomous status granted to the centrifuge project, PAEC remained in-charge of all other aspects of the nuclear fuel cycle, the plutonium programme and the development of the nuclear weapon itself.[135] In fact, a few days before Bhutto's overthrow, Munir Ahmad Khan submitted a comprehensive status report to the Prime Minister on April 4, 1977. This report pertained on the development of the nuclear programme and various fuel cycle projects, including centrifuge, and stated that within a year, PAEC would be completing over ten separate nuclear plants and facilities.[136] Based on this report, Bhutto would write from his jail cell, that when he was ousted from power, Pakistan was on the verge of nuclear capability.

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[134] Farhatullah Babar, "Bhutto's Footprints on Nuclear Pakistan," *The News* (Islamabad), April 4, 2006; Haris N. Khan, op. cit; Benazir Bhutto quoted in Levy and Clark, op. cit, p. 50.

[135] David Albright, op. cit., p.30.

[136] In this respect, Gen. Arif, ex-Vice Chief of Army Staff, Pakistan Army, recalled: "Pakistan is self-sufficient in nuclear raw materials. PAEC was tasked for mining, milling and refining the materials and converting them into yellow cake and uranium hexafluoride. It was also tasked to design and manufacture the highly complicated trigger mechanism, make the implosion device and dig tunnels for conducting the tests. The added responsibilities of this body included use of nuclear sciences for medical purposes. Mr. Munir Ahmad Khan was the Chairman PAEC during the period 1972-1991. Munir was a soft-spoken person for whom reticence was a virtue. He was a good planner, skilful negotiator and a convincing orator who spoke with ease, conviction and authority. While explaining his viewpoint he would speak in low tone and at times appeared to be whispering. Shy of media he worked in silence and led a happy team. ERL was later renamed A. Q. Khan Research Laboratory. It received uranium hexafluoride gas from PAEC and fed it into the cascades of ultra-centrifuges located in its enrichment plant where it was enriched to weapon-grade level. The enriched uranium hexafluoride gas, when converted into metal, forms the core in the weapon. An outstanding metallurgist, Dr. A. Q. Khan's professional excellence was matched by his passion and enthusiasm. He enjoyed wide fiscal autonomy in his work and hated bureaucratic hurdles and technological barriers in his way. A go-getter and a pleasant conversationalist with soft demeanour, Dr. A. Q. Khan loved publicity, had an insatiable urge to meet the Press and enjoyed open and frank discussion on security-related issues. His penchant for media coverage was surpassed by the eagerness of the media to exploit his weakness for publicity and fame. At times his keenness for self-projection created serious difficulties for him and for the country." K. M. Arif, *Estranged Neighbours—India Pakistan: 1947-2010* (Islamabad: Dost Publications, 2010), pp. 287-288.

8.2.6. Change of Guard at Project-706/DIL

On July 17, 1976, [137] while Mahmood was busy in the commissioning of the Electron-Beam Welding Machine at ADW, he was informed that Agha Shahi along with Munir Khan and A. Q. Khan were sitting in his office. Agha Shahi was sitting in the chair of the Project-Director, facing him was Munir Khan and A. Q. Khan was sitting on the side.[138] Shahi opened the conversation: "The Government has decided that Dr. A. Q. Khan will be the new Project-Director. Please hand over all the keys and papers to A. Q. Khan." [139] Agha Shahi also asked him for the keys of the secret stores adjacent to his office. Munir Khan witnessed this entire episode in total silence, which must have taken five minutes. When Mahmood asked A. Q. Khan as to what all this was about, the latter replied it was none of his concern, and he asked him to hand over the office to him as he was the Project-Director now.[140]

Therefore, as Agha Shahi and A. Q. Khan left, Munir Khan asked Mahmood to come along with him to his office. They met the same evening in the office of the Chairman of PAEC, where Munir Khan apparently told him that A. Q. Khan had complained to the Prime Minister on four counts. First that [S. B. Mahmood] had procured sub-standard maraging steel, which was in fact ordinary steel. This had caused a loss of fifty million rupees to the national exchequer. Secondly, that Mahmood had only recruited people from Lahore and therefore had indulged in nepotism. Thirdly, that Mahmood had relations in India and lastly that the Chairman, and Member (Technical), of PAEC were allegedly Qadianis.[141]

Munir Khan told Mahmood that he had responded to these allegations and informed Bhutto that, "all these allegations were completely false and baseless."[142] The Chairman of PAEC also told the Prime Minister in a meeting, that, "since he had intimately known him and his family, how could he allow anyone to level such baseless

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[137] David Albright, op. cit., p. 30.
[138] Ibid.
[139] Ibid; Shahid-ur-Rahman, op. cit., p. 53.
[140] Interview with Mahmood, Ibid.
[141] Ibid.
[142] Ibid.

allegations against him."[143] He would later state that such allegations were unsubstantiated and were designed to malign his reputation and automatically cause defamation in the eyes of the people.[144] However, Bhutto told Munir Khan that while he trusted him, but the charges regarding maraging steel leveled against Mahmood were serious in nature and he did not want the religious parties and others to use it as an issue against him, who were actively agitating against his government. Therefore it was necessary to investigate this matter and clear it up.[145] Mahmood, however, pleaded innocent:

> Every year, a security analysis was connected for everyone in PAEC. When I was appointed head of the enrichment project, a lot of scrutiny was conducted. When such false allegations were leveled, there were religious and political disturbances in the country, and some people, due to personal ambitions or reasons, or due to some conspiracy, accused me being Qadiani because they were non-Muslims under the 1974 law passed by the Parliament, and therefore could not hold any sensitive position in government.[146]

Therefore, a high-level inquiry committee was constituted to investigate allegations of purchase of sub-standard maraging steel. It was headed by the then Foreign Minister, Aziz Ahmad and included the Director-General, Inter Services Intelligence (ISI), Lt. Gen. Ghulam Jillani Khan. Mahmood was suspended pending the finalization of the inquiry committee's findings and was summoned to Aziz Ahmad's office where Munir Khan and A. Q. Khan were also present. Ahmad told Mahmood that the charges against him comprised his procurement of ordinary steel instead of maraging steel and that too worth Rs. fifty million. "By doing this you have committed a huge misuse of government funds." [147] Mahmood claims to have replied that in his capacity as the Project-Director, he had to keep the present and future requirements in mind. He clarified that he bought maraging steel in such a large quantity because whenever the project's existence was leaked, any more maraging steel further procurements would

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[143] Ibid.
[144] Munir Ahmad Khan, Letter to Dr. Maliha Lodhi Editor, *The News*, Islamabad (Pakistan). October 19, 1992.
[145] Interview with Mahmood, op. cit.
[146] Sultan Bashiruddin Mahmood's interview with Sabir Shakir, *Waqt News Exclusive*, Waqt TV, July 23, 2009. Transcript available at: http://www.pakdef.info/forum/showthread.php?10571-SBM-Interview-on-Pakistan-s-nuclear-program&p=158942#post158942. (accessed, December 15, 2009).
[147] Interview with Mahmood, op. cit.

end. This was the idea behind this purchase and the money had not been blocked or wasted but it had been spent well.[148]

As far as the contention that the steel bought by was not maraging steel but ordinary steel, this was a pure technical problem and he offered that samples of the steel may be sent to laboratories for testing: “The specifications for the purchase given by me were made to the best of my judgment and I checked it and I believe that it is maraging steel. You may ask A. Q. Khan to select any three labs for testing, and if it is found that my judgment in this case is wrong, then you may punish me.”[149] Therefore, this idea was well received by Aziz Ahmad who suggested that A. Q. Khan should recommend the laboratories for testing the maraging steel samples. These samples would be sent to S. A. Butt who would then pass them on for testing.[150]

Consequently, inquiry proceedings were immediately initiated against Mahmood, while A. Q. Khan became the new Project-Director of ADW/DIL, which was renamed Engineering Research Laboratories on July 31, 1976. Another accused scientist of PAEC was the then Member (Technical), Dr. Riazuddin. He was also heading up the theoretical physics group tasked with developing the design of the atomic bomb, who declared that the allegations leveled against him were baseless: “When one cannot find any substance against somebody else, it is very easy to discredit him by labeling him a Qadiani.”[151] He explained that he had been very close to Prof. Salam throughout his career. Both were theoretical physicists and Salam, was Ahmedi/Qadiani, who were non-Muslims by law and could not hold any sensitive position in the nuclear programme or the government. Anyone suspected or known to belong to this sect was either shifted to a less sensistive position in the nuclear programme, or effective sidelined to insignificant positions after 1974. This became the general rule with regard to all classified projects.[152]

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[148] Ibid.
[149] Ibid.
[150] Ibid; Shahid-ur-Rahman, op. cit., p. 53.
[151] Dr. Riazuddin (Director General National Centre for Physics, ex Member, Technical, PAEC), interview by authour, tape recording, Islamabad, February 15, 2007.
[152] Ibid.

Prof. Salam, therefore, had to resign as adviser to the President of Pakistan for Science & Technology in 1974. He was Riazuddin's teacher in Government College, Lahore, and his mentor during his Ph.D at Cambridge University. Before joining PAEC, Riazuddin had been working at the Internatioanl Centre for Theoretical Physics, Trieste, in Italy and Salam was equally close to Munir Ahmad Khan from their college days in the 1940s at Government College, Lahore. He said that even though they were devout Muslims, their close association with and respect for Prof. Salam as a scientist, made them an easy target of such allegations.[153] Nevertheless, these allegations would prove to be false in due course of time. In early September 1976, S. A. Butt sent a telegram to Mahmood with the words, "Congratulations," followed by a letter on September 14, 1976.[154]

The same day, he apprised the Chairman of PAEC of S. A. Butt's findings regarding maraging steel, which exonerated Mahmood of any wrongdoing. Following this finding, he recalled that the I.S.I. in January 1977 also gave its report regarding the allegations made against the PAEC leadership. It cleared them of all charges and established that none of the accused had anything to do with the Ahmadi/ Qadiani sect. Thereafter when the Chairman of PAEC suggested that he would now speak to Aziz Ahmad and ask him to restore him as Project-Director, Mahmood demurred. He claims to have said that doing so had the potential of harming the centrifuge project. This he believed in view of the events and controversies in the past few months and the fact that A. Q. Khan had developed his own support base and had instigated his ouster.[155]

Subsequently, Mahmood was re-instated in PAEC and transferred to the uranium-refining project at Baghalchur in Dera Ghazi Khan. He was given the task of expanding its capacity three times to prepare for the future uranium feed requirements of the Kahuta project.[156] Following A. Q. Khan's assumption of the office of the Project-Director in July 1976, a high-level coordination Board was set up by the government to supervise the project. This Board comprised A.G.N. Kazi, Secretary-General Finance

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[153] Ibid.
[154] Ibid.
[155] Ibid.
[156] Ibid.

and Economic Affairs, Ghulam Ishaq Khan, Secretary General-in-Chief, Agha Shahi, Secretary-General Foreign Affairs, and Munir Ahmad Khan, Chairman of PAEC, as members of the Board.[157] ERL had been made autonomous under the supervision of this Board by August, 1976, while the project itself continued to function under the auspices of the PAEC till the end of 1977 by which time Gen. Zia had overthrown Bhutto's government in a coup. After 1977, ERL was administratively separated from PAEC but it continued to function under the Project-Board. [158] Munir Khan would later state: "General Zia believed that I was Bhutto's protégé, even though I did not have any political affiliation with anyone. Therefore, when Gen. Zia came into power, A. Q. Khan managed to manipulate the situation and had the enrichment project separated from PAEC."[159]

Nevertheless, Gen. Zia further enhanced ERL's autonomy following his takeover in 1977. This may have been done for political or other reasons. One reason was certainly Zia's caution regarding Munir Khan, whose friendship and association with Bhutto was well known. Afew years after Gen. Zia's coup, the authours of *The Islamic Bomb* wrote: "Munir made little secret or his disdain for many of his nominal military superiors. Yet he has somehow retained their confidence and is still the man in-charge of the bomb project."[160] Secondly, making ERL separate and independent from PAEC would eventually generate fierce competition, which was seen as a means of accelerating the nuclear programme. This was equally likely to have been a way of obtaining information from A. Q. Khan and Munir Ahmad Khan on each other, who were encouraged to do the same. It is also argued that giving ERL independence from PAEC was a means to overcome the perceived bureaucratic constraints and controls in PAEC. In addition, it was also possible that A. Q. Khan was deliberately propped up as the public face of the nuclear programme, so as to serve as a 'decoy,' for PAEC where most of the work on the programme was being done.[161] While Bhutto had made the centrifuge

[157] Ibid.
[158] Munir Ahmad Khan, Interview with Daily *Ausaf*, op. cit.
[159] Ibid.
[160] Weismann and Krosney, op. cit, p. 47.
[161] Mark Fitzpatrick, ed. *Nuclear Black Market: Pakistan, A.Q. Khan and the Rise of Proliferation Networks- A Net Assessment* (London: International Institute of Strategic Studies, 2007), p. 65.

project autonomous, Gen. Zia effectively separated it and thereby instituted a policy of divide and rule in the nuclear programme.

However, throughout the next decades, PAEC continued to meet its mandated goals in several nuclear fuel cycle, civil and military reactor and nuclear weapon related projects, within the framework of its existing bureaucratic controls. On the other hand, with the benefit if hindsight and with the emergence of the private proliferation of centrifuge technology involving A. Q. Khan network in 2004, it may be presumed that this could have been avoided had the gas-centrifuge enrichment project remained under PAEC's control.

8.3. A. Q. Khan vs. ERL staff: The first proliferation controversy

It appears that the bureaucratic rivalry between A. Q. Khan and PAEC scientists and engineers working under him in ERL did not end with his appointment as Project-Director and the projects' separation from PAEC. As a result, their first major disagreement emerged in 1980 when two of the most important members of the ERL technical staff, G. D. Alam and Anwar Ali clashed with A. Q. Khan. In this respect, G. D. Alam claimed:

> While working with Dr. A. Q. Khan, I reached a point where it became impossible for me to continue to work with him. A foreign (Arab) country established contact with A. Q. Khan and told him, 'you give us nuclear technology and we will offer you great rewards in return.' Following this contact, A. Q. Khan tried to act secretly from the government and in this respect, A. Q. Khan took six scientists into confidence including myself. At this, I told him 'at this point we are performing a national duty of serving the nation. If we were to accept the offer of a foreign government, and if our government finds out about it, which it will do eventually, then it will have two negative consequences. One, that while doing good work, we will at the same time be branded as traitors instantly. Second if the foreign government were to acquire technology from us and then transfer it on to India, then what would happen? [162]

However, despite these reservations and objections, A. Q. Khan said that we would go to this foreign country. Alam alleged that A. Q. Khan took them into confidence to help Arab country, as he was not in any position to do anything on his own

[162] G. D. Alam, Interview, op. cit.

with regard to technology. It was also confirmed years later that A. Q. Khan had taken at least three of his fellow scientists into confidence in this respect. [163] Moreover, none of the scientists consulted by A. Q. Khan in this matter agreed with him, which included Anwar Ali. Nevertheless, despite everyone's objections, Alam claimed that A. Q. Khan proceeded with his plan on his own and went on to visit the foreign country in question.[164]

Following this episode, Anwar Ali sought an appointment with Gen. Zia and informed him of the whole episode. Subsequently, Gen. Zia summoned A. Q. Khan and demanded an explanation of the whole affair. When confronted, Alam claimed that A. Q. Khan swore on the Holy Quran and declared: "I have not done anything wrong."[165] However, Zia was not prepared to accept allegations of one scientist working in the enrichment project against A. Q. Khan. It is obvious that the President must have asked for further confirmation and evidence. Alam claims that Lt. Gen. Anis Ali Syed, who was tasked to keep an eye on A. Q. Khan, had already been won over by him.[166]

In addition to Gen. Anis, Maj. Gen. Syed Ali Zamin Naqvi, Advisor (Security) to both PAEC and ERL also gave his verdict which absolved A. Q. Khan of any wrong doing. G. D. Alam claims to have complained directly to him about A. Q. Khan's unauthorized contacts with a foreign country in connection of sale of nuclear technology, but Naqvi chose to ignore the complaints and instead informed A. Q. Khan.[167] This incident had been a serious lapse on his part in performing his duties of nuclear oversight and vigilance. [168] Interestingly, Naqvi was also a candidate for the post of Deputy Chairman of PAEC soon after Gen. Zia's coup in 1977.[169] However, since could not secure this position, he was appointed Advisor (Security) to PAEC and ERL, he began

[163] Ibid.
[164] Ibid.
[165] Ibid.
[166] Ibid.
[167] Ibid.
[168] Interview with Mahmood, op. cit; G. D. Alam, Interview, op. cit; Interview with Anwar Ali, op. cit.
[169] K. Subrahmanyam, ed., *Nuclear Myths and Realities: India's Dilemma* (New Delhi: ABC Publishing, 1981), p. 155.

putting his weight against Munir Ahmad Khan in the bureaucratic tussling with ERL.[170] Hence, while a treason case was being considered against Dr. G. D. Alam and Anwar Ali, Munir Khan interceded with President Zia and called them back to PAEC, and no further punitive action was taken against the two. Anwar Ali returned to PAEC in early 1981. He would go on to play a key role in the Directorate of Technical Development of PAEC, which was responsible for the development of Pakistan's nuclear weapons' design, development and testing. He would also play an important role in the Shaheen missile programme and served as Chairman of PAEC from 2006-2009. [171]

Nevertheless, by this time, Kahuta had been completed and the plant had become operational. President Zia visited the plant on May 1, 1981. He was so pleased to see the facility that he re-named the gas-centrifuge plant, known as Engineering Research Laboratories (ERL) as Dr. A. Q. Khan Research Laboratories or KRL. This visit, coming only months after A. Q. Khan's encounter with Zia over alleged attempts to sell technology to a foreign country without the sanction of the government, may have been Zia's way of re-assuring A. Q. Khan of his trust in him. Nevertheless, the change from ERL to KRL became public through an interview, which A. Q. Khan gave to the Urdu daily, Nawa-i-Waqt on January 3, 1984. [172] It was the only such example in the world where an institution was named after a living person.

General Khalid Mehmud Arif served as Gen. Zia's Chief of Staff from 1977-1984 and Vice Chief of Army Staff from 1984-1987. The President had assigned him the task of supervising the nuclear programme on his behalf. He thus summed up the divergent management styles of the two nuclear rivals in Pakistan's nuclear programme:

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[170] Munir Khan would later complian to Lt. Gen, Ghulam Jillani Khan, former Director-General, I.S.I: "You (General Jillani) have been privy to our nuclear programme both during the days of Mr. Bhutto and General Zia and we have had occasions to work together very closely. Had there been any serious misgivings about the PAEC or its former Chairman in the minds of our Chief Executives, you would have known that. General Naqvi and Colonel Farooqi were feeding all kinds of stories to ISI and every three years, they tried their best to have one of their boys made Chairman of PAEC but they failed. The story that General Arif asked Zia to reverse a decision to replace me is contradicted by Arif who told me this was untrue. After we had done our job (which was more than 12 years ago) I asked General Zia to let me go but he said, "We will go together." Munir Ahmad Khan, personal letter to Lt. Gen. (retd) Ghulam Jillani Khan, July 12, 1995.

[171] Interview with Mahmood, op. cit; G. D. Alam, Interview, op. cit; Interview with Anwar Ali, op. cit.

[172] A. Q. Khan, Interview to Nawa-i-Waqt, January 1, 1984.

> Dr. A .Q. Khan and Munir were professional rivals who were seldom on friendly terms with each other. Nuclear success in Pakistan was achieved by the dedicated efforts of all scientists, technologists and technicians in PAEC and ERL under the guidance of the government. There was no single hero of this success story. Munir and A. Q. Khan were two different personalities. They were working for the same cause and for the same country. And yet both were poles apart in their conduct and mannerism in professional and personal lives. Despite their close proximity in official work, both led different lives and were not the best of friends with each other. Munir was a sober, quiet and unassuming person dedicated to his work. A. Q. Khan was a glib-tongued flamboyant individual always in search of publicity and glory. He had created a group of admirers around himself who convinced him that he was taller than his height.[173]

8.4. Concluding Comment

This phase of Pakistan's nuclear history is replete with claims and counter-claims, with the truth shrouded in the fog of controversy, professional rivalries and intense bureaucratic politics. Yet, it is evident that Pakistan's success in uranium enrichment through the gas-centrifuge technology, like other projects of its kind, was essentially the outcome of indigenous team effort. This endeavour was initially founded on PAEC's technical, manpower, physical, financial, and procurement infrastructure, especially during the formative years of the project. During this time, S. A. Butt succeeded in acquiring the critical materials, machines and equipment to jump-start the project, while the manpower selected by PAEC provided the nucleus for the successful development of the prototype centrifuge at ADW, the first cascade at Sihala and the early years of Kahuta. However, from July 1976, onwards, A. Q. Khan led the project for the next twenty-five years, during which time the production-scale Kahuta centrifuge plant was developed and put into operation. He continued to expand the project, recruit more people and obtain more autonomy.

Although the project began producing enriched uranium for Pakistan's nuclear weapons by the mid-1980s, this journey was littered with formidable technological challenges and A. Q. Khan undoubtedly deserves credit for successfully taking the project forward to its logical end as its administrator. This will be remembered as his

[173] K. M. Arif, *Estranged Neighbours,* op. cit., pp. 288-289.

seminal contribution to the nuclear programme of Pakistan. Nevertheless, the seeds of the institutional rivalry between PAEC and A. Q. Khan and the private proliferation network emerged from KRL's procurement chain. This became an import-export procurement enterprise in the 1980s and 1990s and had its roots in the projects' separation from PAEC in the fall of 1977. Nevertheless, over the years, A. Q. Khan succeeded in taking credit for not only the uranium enrichment project, but the entire programme itself.

From a theoretical perspective, the above discussion essentially validates Allison's bureaucratic-politics model. This project, especially following A. Q. Khan's arrival in Pakistan became the symbol of "pulling and hauling" amongst key players in important positions. One group of players was able to establish ascendency over the other when the project was separated from PAEC. The outcomes were indeed a compromise and a mixture of the alternative solutions being presented by PAEC and A. Q. Khan. Here the personal ambitions of one individual who wanted to secure as much autonomy, freedom from checks and balances and resources became a key element in the bureaucratic rivalry. The analysis presented in this chapter also validates the "historical sociology" approach. Since A. Q. Khan had a vested interest in the growth of the project under his control, PAEC also started competing for prestige, resources and influence with him. Equally significant, the "nuclear myth-maker" approach can be clearly seen to be validated in the way A. Q. Khan succeeded in developing and then perpetuating his indispensability for the success of the enrichment project. Producing enriched uranium is just one aspect of nuclear capability. To make the bomb, several challenges had to be overcome and the design, manufacture and testing infrastructure put in place. This was again the responsibility of PAEC while bureaucratic politics and mythmaking re-appear in the next chapter, which explains the most crucial component of Pakistan's nuclear capability, i.e. its atomic bomb.

CHAPTER 9

NUCLEAR WEAPONS DEVELOPMENT AND TESTING

The previous chapters discussed Pakistan's efforts to develop and master the nuclear fuel cycle, which provided the fissile material for the nuclear device. The other non-nuclear components of the device, such as the design, trigger mechanism, etc, had to be built in parallel. This was the challenge, which Zulfikar Ali Bhutto had put before the scientists and engineers of PAEC at the Multan Conference. In this context, after the 1998 nuclear tests, the Chairman of PAEC recalled the mandate given to him:

> While we were building capabilities in the nuclear fuel cycle, we started in parallel the design of a nuclear device, with its trigger mechanism, physics calculations, production of metal, making precision mechanical components, high-speed electronics, diagnostics, and testing facilities. For each one of them, we established different plants, facilities and laboratories.[1]

Therefore, the basic theme of this chapter is Pakistan's journey towards nuclear weapons capability and its development of the atomic bomb. The chapter comprises eight sections, namely: Designing the Bomb; India's Smiling Buddha and Defence Committee of the Cabinet; Making the Bomb: The Wah Group and Directorate of Technical Development; Chaghi, Kharan and Kirana Hills; Making the Deliverable Weapon; KRL and Cold Tests; and the Chaghi and Kharan Tests. The concluding paragraphs analyze the relevant theoretical approaches, paradigms and models in respect of the empirical evidence presented in the chapter.

9.1. Designing the Bomb

Pakistan began conceptual work on the atomic bomb within a year of the Multan meeting of January 1972. It may be recalled that this meeting had re-oreinted Pakistan's nuclear

[1] Munir Ahmad Khan, Speech delivered at the Chaghi Medal Award Ceremony, Pakistan Nuclear Society, PINSTECH Auditorium, Islamabad. March 20, 1999.

programme towards acquiring nuclear capability. It is interesting to note that Pakistan started work on designing the bomb before it launched its fuel cycle programme for producing fissile material. However, the only theoretical physicst of international repute who seemed promising to help with this project was Prof. Abdul Salam, the then Science Advisor to the President of Pakistan. He was also the director of the International Center for Theoretical Physics (ICTP), Trieste, Italy and the two best Pakistani theoretical physicists were working with him—Dr. Riazuddin and Dr. Masud. Salam had attended the Multan meeting where he was seated on stage with Dr. Usmani and Zulfikar Ali Bhutto. He was well aware of the proliferation decision taken by the new political leadership.

Therefore, he along with the newly appointed Chairman of PAEC, Munir Ahmad Khan met President Bhutto, most likely to discuss the future course of the nuclear programme. Then in October 1972, Prof. Salam informed the two Pakistani scientists—Dr. Riazuddin and Dr. Masud Ahmad—who were working with him at the International Centre for Theoretical Physics, Trieste, of the decision to acquire nuclear capability and directed them to report to the Chairman of PAEC on their return to Pakistan. This was the beginning of the Theoretical Physics Group,[2] whose first leader, Dr. Riazuddin recalled:

> The Theoretical Physics Group was formed on the suggestion of Dr. Salam, and Munir Ahmad Khan had great respect for him. Otherwise there were people who said that there is no need for theoreticians, but historically every country working on nuclear weapons, starting from Oppenheimer onwards, started with the theoretical physics group because these are the people who design the device, calculate various parameters. So even in Russia, these theoretical physicists started the work on the bomb, even in China; it was the theoretical physicists who started the work on the bomb. [3]

The Theoretical Group was formed on the pattern of the Manhattan Project, which was the first step towards nuclear weapons capability. On his arrival in Pakistan, Riazuddin received a briefing from Munir Ahmad Khan. He was directed to join Quaid-i-Azam University, (QAU), Islamabad's Physics Department, where he began theoretical

[2] Shahid-ur-Rahman, *Long Road to Chaghi* (Islamabad: Print Wise Publications, 1999), p. 38.
[3] Dr. Riazuddin (Director General National Centre for Physics, ex Member Technical, PAEC), interview by authour, tape recording, Islamabad, February 15, 2007.

Research & Development (R & D) on the atomic bomb.[4] As no mainframe computers were available in Pakistan, other than at the QAU, Riazuddin and Masud Ahmad began their theoretical work using the mainframe computer at the University.[5] Masud Ahmad was the second theoretical physicist who had initially planned to proceed to West Germany on completion of his fellowship at ICTP, but was instructed by Salam to return to Pakistan. Equipped with literature on the Manhattan Project, which was provided to him by Salam, he joined PAEC and became part of the core team comprising the Theoretical Group.[6]

Riazuddin worked closely but informally with PAEC from October 1972 to December 1973, while he continued to work at the Physics Department of QAU, Islamabad. It was in December 1973, that he was appointed Member (Technical), PAEC, on his return from the National Technical Information Centre, Maryland, USA. He continued to serve PAEC in this capacity till 1976 when Dr. Ishfaq Ahmad succeeded him as Member (Technical). However, Riazuddin continued his association with PAEC for another three years till 1979 as an Advisor at the request of the Chairman.[7] The Theoretical Group completed the conceptual and theoretical design of the implosion-based atomic bomb by 1978.[8] However, prior to handing over charge of Member (Technical) to his successor in 1976, Riazuddin submitted a handwritten report about a simple implosion design to Munir Ahmad Khan in October 1976.[9]

When Dr. Ishfaq Ahmad took over from Dr. Riazuddin as Member (Technical), he expanded the Theoretical Group, himself being a theoretical physicist. He also began work on miniaturization of the nuclear device along with developing numerical simulation techniques. Hence, the Theoretical Group acquired the capability to not only design advanced weapon designs, but also the analyses of complicated designs, accurate measurements, and predictions of various parameters of the design. This included analyses of detonation of the explosive lenses and initiation of the chain reaction. The

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[4] Shahid-ur-Rahman, op. cit., p. 38.
[5] Ibid.
[6] Ibid.
[7] Interview with Riazuddin, op. cit.
[8] Ibid.
[9] Ibid; Shahid-ur-Rahman, op. cit., p. 75.

miniaturized nuclear weapon design tested on May 30, 1998, was claimed to be in complete conformity with the design parameters developed by the Theoretical Group.[10]

Riazuddin was perhaps the best scientist who was appointed the head of this group in PAEC. He had been a student of Prof. Salam in Government College, Lahore, and then at Imperial College London. He was a holder of two masters, one in Mathematics and other in Physics, in addition to a Ph.D in Theoretical Particle Physics, which he received in 1959 from Cambridge University. He was also Principal Research Associate, Daresbury Nuclear Physics Laboratory, U.K, 1972 and during this time he also served as a Visiting Professor, University of Maryland, College Park, Maryland, USA.[11]

This rich academic background was immensely helpful, given the mathematical calculations needed in the theoretical work involved in a fission explosive device and was one of the factors in his selection as head of the Theoretical Group. Another important factor that led to his selection was his unsuspecting personality, which gave him a purely academic outlook and he could not be suspected of working on nuclear weapons. This perfectly harmonized with secretive culture in PAEC, which was introduced by Munir Ahmad Khan and began to be implemented in all classified projects of PAEC, given the sensitive and secretive nature of the work involved. In this regard, Riazuddin emphasized:

> Munir Khan took some very good steps in the PAEC. He was very secretive and he said to me that you are the best man I have got, because you are very quiet and talk less. He used to tell me and everyone else in the PAEC that we must never share anything regarding our work with anyone else, not even with our wives, since one tends to divulge things to wives. He had immense respect for Dr. Salam and me. He used to call me Professor Sahib.[12]

Thus, the first practical which Riazuddin and Masud Ahmad took was the collection of scientific and technical information available on the subject. Much of it had been available from de-classified reports and literature from the Manhattan Project,

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[10] Shahid-ur-Rahman, op. cit., p. 75.
[11] Ibid, p. 38.
[12] Interview with Riazuddin, op. cit.

which also used the implosion method for the plutonium bomb, "Fat Man" which was dropped on Nagasaki. In this respect Dr. Riazuddin claimed:

> The first thing I did was to get all the open literature, the unclassified or de-classified. I brought many reports from USA and I traveled in December of 1973 for my summer research to Alberta and on the way I was able to get whatever one could get from the National Technical Information Service in Maryland. Now that one has to do, every scientist has to do that, to do the literature survey and then try to get whatever is available, so I got very good reports which were available openly and were not secret and some of them were declassified.[13]

Therefore, equipped with the requisite information and literature, Riazuddin and his team began work on their mandate which was to develop a design of a bomb, akin to a tailor who stiches a suit.[14]

> The conceptual design we had to develop included various parameters on which the yield would depend, like critical mass, radius, how much explosive is to be used, how many lenses are to be used, how it is to be detonated, what will be the yield of the weapon and how much compression one has to achieve.[15]

Another important challenge facing the Theoretical Group was whether to opt for implosion or gun-type method for the atomic bomb. India's nuclear test of May 18, 1974, however, also affected the direction of the work being carried out by PAEC. In this regard, he argued:

> In the wake of the Indian test, the urgency for Pakistan to get the bomb became more acute. Therefore an important decision taken was that the implosion method would be used in view of the economy of fissile material as opposed to the gun method, which required much more material. However, the implosion method is also technologically more challenging to master than the gun method. In addition, the critical mass of uranium device is three times that of plutonium device, so the implosion would have to be for a bigger core, and the implosion would be quite complicated. So both technological complications were combined in implosion method, i.e. triggering and compression of a large mass of highly enriched uranium.[16]

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[13] Ibid.

[14] "We were the designers of the bomb, like the tailor who tells you how much of material is required to stitch a suit. We had to identify the fissile material, whether to use plutonium or enriched uranium, which method of detonation, which explosive, what type of tampers and lenses to use, how the material will be compressed, how shock waves will be created, what would be the yield." Shahid-ur-Rahman, op. cit., p. 39.

[15] Ibid.

[16] Interview with Riazuddin, op. cit.

This also explains why PAEC began work on exploring the various technologies and methods to enrich uranium in the immediate wake of India's 1974 nuclear test. However, the decision to adopt the implosion method was taken as early as December 1973, when Prof. Salam visited Pakistan. He brought copies of an article entitled: "The Curves of Binding Energy," by Theodore Taylor, which was written for common understanding of the general public.[17] This was also the same time when Dr. Riazuddin was appointed as Member (Technical) PAEC. The Theoretical Group was also involved in calculations to obtain maximum yield with the minimum possible use of fissile material and what other materials could be used to achieve this. One such material is beryllium, which is used as tamper/ reflector, as it is a good neutron reflector, which helps in initiating and accelerating the chain reaction in a nuclear device. However, beryllium reflectors are difficult to manufacture and handle, given their brittle and toxic nature. Therefore, the first design that was prepared by the Theoretical Group used a reflector made from natural uranium (U-238) metal. [18]

Following the May 1998 nuclear tests, the head of the test team and then Member (Technical), PAEC, Dr. Samar Mubarakmand recalled that contribution of the Theoretical Physics Group produced indigenous designs of different nuclear weapons Pakistan.[19] Thus, the Theoretical Group became the focal point for an institutionalized research programme in nuclear weapons design in Pakistan, which proved its utility and worth during the cold tests and the hot tests of May 1998.

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[17] Shahid-ur-Rahman, op. cit., p. 40.

[18] Ibid.

[19] "The critical thrust was to set up a theoretical physics group that could work on the design of the bomb. At that time, the responsibility was entrusted to Dr. Riazuddin, who was in the Physics Department of the Quaid-i-Azam University. He was Member (Technical) of PAEC in those days and was a theoretical physicist and he set up the group. Dr. Masud Ahmad was a student of Dr. Riazuddin and now Dr. Masud heads the team that is the design team. But I must say that our design was a pure indigenous process. Nobody in the world would come and help you to design nuclear weapons, or to fabricate them or even test them. It had to be a purely Pakistani effort and our scientists on the theoretical side were so capable, they studied the literature that was available and they worked so hard, developed computer codes, acquired powerful computers to design this system and came up with the design that was to be manufactured." Dr. Samar Mubarakmand, "A Science Odyssey: Pakistan's Nuclear Emergence," Speech delivered at the Khwarzimic Science Society, Centre of Excellence in Solid State Physics, Punjab University, Lahore, November 30, 1998.

9.2. India's Nuclear Explosion and the Defence Committee of the Cabinet

The above discussion indicates that in anticipation of India's nuclear test of 1974, the "bomb" option was already actively present in the minds of the Prime Minister and Chairman of PAEC, although they did not yet know when India would carry out the test. However, when India did test, it did not come as a complete surprise because Indian technical and political leaders had already pointed towards such a possibility. Therefore, India's intentions of carrying out a nuclear test were not hidden from Pakistan, however the actual preparations could not be detected, even by the United States.[20] In July 1970, the Chairman of the Indian Atomic Energy Commission, Dr. Vikram Sarabhai stated: "India is capable of conducting underground nuclear explosives and is internationally entitled to do so as a non-party to the NPT." [21]

He went on to make a public announcement to this effect at the Fourth United Nations International Geneva Conference on the Peaceful Uses of Atomic Energy, in Vienna, in September 1971. One of the Scientific Secretaries of the Conference was Munir Ahmad Khan. He and the world saw Sarabhai state: "Indian scientists were developing nuclear explosive engineering, i.e. peaceful nuclear explosives as a top priority."[22] At 8.05 a.m. on the morning of May 18, 1974, India carried out its first ever test of a nuclear (plutonium) device at the Pokhran test site in the Rajasthan desert, only about fifty miles from the Pakistani border. Soon after the test, the Chairman of the India Atomic Energy Commission, Homi Sethna called up Prime Minister Indira Gandhi's office and informed her principal secretary, P.N. Dhar: "The Buddha is Smiling."[23] Soon afterwards, the All-India Radio interrupted its regular transmission and aired a special

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[20] Earlier in the year, the PAEC Chairman, Dr. I.H. Usmani invited the Canadian Prime Minister Pierre Trudeau over a family lunch while he was on his way back from a Commonwealth Conference in Singapore in January 1971. The Canadian Prime Minister had specially diverted his route to visit the Canadian supplied Karachi Nuclear Power Plant (KANUPP). The Canadian Prime Minister however was not convinced of Pakistani concerns about the possible use of the Canadian supplied CIRUS reactor by India for its weapons program and assured Dr. Usmani that there was nothing to worry about. In fact when the Canadians had asked the Indian government to give assurances that it would not use the plutonium from the CIRUS reactor for the manufacture of any nuclear explosive, both peaceful and military, the Indian Prime Minister refused to give any such assurances. Please see Weismann and Krosney, op. cit., p. 133.

[21] George Perkovich, *India's Nuclear Bomb: The Impact on Global Proliferation* (Berkeley, CA: University of California Press, 1999), p. 155.

[22] Ibid. p. 159.

[23] Jeffrey T. Richelson, *Spying on the Bomb* (New York: W.W. Norton & Company Inc. 2006). p. 232.

announcement: "At 8.05 a.m. this morning, India successfully conducted an underground nuclear explosion for peaceful purposes at a carefully chosen site in Western India."[24]

India had gone nuclear by exploding a device with a yield of about 10 kilotons.[25] Therefore, in the weeks following the Indian 1974 nuclear test and these developments, Bhutto called a meeting of the Defence Committee of the Cabinet (DCC), which was held on June 15, 1974. He had earlier denounced India's nuclear test by calling it "a fateful development, and a grave and serious event has not taken place in the history of Pakistan." He proclaimed that, "Pakistan will not succumb to nuclear blackmail.[26] During the DCC meeting, Bhutto gave the formal go-ahead to PAEC to begin work on the atomic bomb. Prior to this meeting, he held detailed brainstorming sessions with the chiefs of the Pakistani armed forces regarding the options before Pakistan to respond to India's test and its implications for Pakistan's security.[27] It was agreed that developing a nuclear deterrent capability was the only viable option for Pakistan. The DCC meeting aimed at finding ways on "how Pakistan should expedite its programme in response to the Indian explosion." [28]

During the meeting, the participants gave presentations on the subject, including the Foreign Minister Aziz Ahmad, the Foreign Secretary, Agha Shahi, Finance Secretary A.G.N. Kazi, Secretary Defence, Lt. Gen. (Retd) Fazal-e-Muqeem Khan, the three Chiefs of Staff of the Armed Forces, Pakistan Peoples Party Secretary General J. A. Rahim and Information Minister Kausar Niazi. [29] Since the Chairman of PAEC was on an official visit abroad, representing Pakistan at the IAEA Board meeting, the then Member (Technical), Dr. Riazuddin represented the PAEC. He gave the participants of the DCC an outline of PAEC's programme, and the progress made on the nuclear fuel cycle. In addition, he also briefed the meeting on the simultaneous work being carried out on the design and the triggering mechanism of the nuclear device using implosion

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[24] Ibid.
[25] Ibid. pp. 233-234. The steps taken by Pakistan in response to India's 1974 nuclear test are discussed in detail in Chapter 4.
[26] Shahid-ur-Rahman, op. cit., p. 43.
[27] Ibid, pp. 43-44.
[28] Interview with Riazuddin, op. cit.
[29] Shahid-ur-Rahman, op. cit., pp 44-45.

method by the Theoretical Group and the Wah Group respectively. Production of fissile material also came under discussion and how the material could be obtained since the KANUPP reactor was under safeguards.[30]

The question of whether first to go for the fissile material and then the triggering mechanism was also discussed. On this issue, Riazuddin while representing PAEC's position stated that if Pakistan would first opt to develop the fissile material and then the nuclear device or vice versa, it would delay the programme. Therefore, owing to the urgency to develop the bomb in view of India's test, it was necessary to go simultaneously for the fissile material and the device. The participants of the meeting re-affirmed their full support to PAEC for the development of the nuclear programme.[31]

During the meeting, Bhutto was his usual self, and in a flamboyant and confident mood in his remarks stated that India's test had posed a serious threat to Pakistan's security, as it has just dismembered Pakistan. He stated that India's nuclear capability added a much greater threat for Pakistan in addition to its conventional superiority. He claimed that he had tried to implore upon Ayub Khan to begin work on the nuclear option as Minister of Foreign Affairs and as Minister-in charge of PAEC affairs. He also mimicked the former President who he said believed that there was no need for Pakistan to develop the nuclear option, since it could be bought off the shelf, should the need arise.[32]

Aziz Ahmad and Agha Shahi briefed the meeting that none of the four nuclear powers, namely, China, United States, United Kingdom and France had given any positive signal for providing any negative security assurances to Pakistan in the wake of India's test. They had also not supported Pakistan's proposal for a nuclear-free South Asia. Therefore, in view of these developments, the only option before Pakistan was to develop its own nuclear deterrent capability. [33]

9.3. Making the Bomb: The Wah Group and the Directorate of Technical Development

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[30] Ibid.
[31] Interview with Riazuddin, op. cit.
[32] Shahid-ur-Rahman,, op. cit., p. 44.
[33] Ibid, p. 45.

Once the decision to go for the bomb had been taken in 1974, a separate Directorate was established in PAEC to coordinate the activities of all the specialized groups working on the atomic bomb. This was the beginning of the Directorate of Technical Development or DTD. It reported to the Chairman of PAEC through the Member (Technical), and was perhaps the best kept secret of Pakistan's nuclear programme, which was only made public at the time of the the 1998 tests. Thus, the DTD controlled and handled all aspects of the design, fabrication, manufacturing and testing of the atomic bomb. It was tasked to coordinate the different groups working in PAEC on each of the constituent elements of a nuclear device. In this regard, a 1983 de-classified U.S. State Department report on Pakistan's nuclear programme stated:

> We believe that a nuclear weapons design programme was started under Prime Minister Bhutto and that this programme has continued. We have information that nuclear explosive design and development work began in Pakistan soon after the 1974 Indian nuclear test. The work was given to an organization within the Pakistan Atomic Energy Commission, which handled such topics as implosion hydrodynamics, neutronics, high explosives testing, and metallurgy, including packaging of high explosives.
>
> Subsequently, work was done on an electronic triggering circuit for nuclear device detonation, as well as experiments on conventional as well as shaped charges. This work complemented the acquisition of reprocessing and enrichment capability. We believe that Pakistan has already undertaken a substantial amount of the necessary design and high explosives testing of the explosive triggering package for a nuclear explosive device and we believe Pakistan is now capable of producing a workable package of this kind. The nuclear explosive development programme has attempted to purchase cameras and camera equipment specifically for nuclear-related explosives work.[34]

In March 1974, Munir Ahmad Khan summoned a meeting to start actual work on the atomic bomb. The meeting was a milestone in Pakistan's nuclear endeavour as it formally launched work on the nuclear weapons programme. It was attended by Prof. Salam, then Science Advisor to the President of Pakistan, Dr. Riazuddin, and Mr. Muhammad Hafeez Qureshi, a mechanical engineer and head of Radioisotope and Applications Division (RIAD) in PINSTECH. The Chairman of PAEC did not use the word "bomb" in the meeting, but informed Hafeez Qureshi that he had been selected to begin work on "a project of national importance."[35] He "referred to Indian designs to go

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[34] U.S. Department of State, *The Pakistani Nuclear Programme,* June 23, 1983.
[35] Shahid-ur-Rahman, op. cit., pp. 3-4.

nuclear and its implications for Pakistan's security." Hafeez Qureshi was asked to join hands with another expert, Dr. Zaman Sheikh, who was working in Defence Science and Technology Organization (DESTO). The Chairman told him that their office was to be located close to the Pakistan Ordnance Factories (POF), Wah, "since you would evidently need a lot of explosives."[36] Hafeez Qureshi thus recalled: "talk about Pakistani plans for the nuclear option was in the air for a long time and I fully understood what I was being told."[37]

On March 25, 1974, a PAEC team led by the Chairman visited the Pakistan Ordnance Factories, P.O.F, Wah, near Islamabad. This team included Prof. Salam, Dr. Riazuddin, and Hafeez Qureshi. They held discussions with the then Chairman of P.O.F, Lt. Gen. Qamar Ali Mirza for collaboration in the establishment of a high explosive factory, and a big project of national importance. The project was deceptively code named "Research" and one of POF's senior officials, Muhammad Afzal was deputed to cooperate with the PAEC team. The first two members of "Research" were Zaman Sheikh and Hafeez Qureshi and their project owing to its location, came to be known as the "Wah Group".[38] Its initial work focused on Research and Development on explosives for use in the nuclear device, also known as explosive lenses, but it expanded over the years to include mechanical, chemical, precision and high explosive engineers and experts. The Wah Group procured equipment for various R&D projects being developed under its wings, and simultaneously developed indigenous capabilities as foreign procurements became tougher by the day.[39] The Wah Group also dealt with developing the triggering mechanism for the atomic bomb, used in detonation of the device, implosion hydrodynamics, high explosive testing, and neutron source or initiator.[40]

The DTD and the Wah Group was headed by its long term Director-General, Muhammad Hafeez Qureshi. He also led the teams that carried out Pakistan's first cold tests in 1983 and subsequent cold tests till the early 1990s. Thus, he laid the foundation

[36] Ibid, p 4.
[37] Ibid., p 5.
[38] Ibid, p. 41.
[39] Ibid, p. 4.
[40] Ibid, p. 41.

of Pakistan's nuclear weapon development and testing programme.[41] P.O.F. Wah, included a facility to produce the powerful explosive RDX. But PAEC's requirement was an explosive that was several times more powerful known as the HMX or His Majesty's Explosive.[42] Such specialized chemical explosives have high detonation velocities, usually in excess of 6000 m/s.[43] Pakistan had to develop indigenous facilities for producing specialized explosives used in nuclear weapons as such items could not be procured from any outside source. In addition, chemical and explosive experts had to be trained to produce such explosives and operate such laboratories.[44]

Zaman Sheikh would develop the explosive lenses for the bomb. Despite the fact that hundreds of scientists and engineers of PAEC had been trained in various disciplines during the 1960s, apparently not a single one was trained in high explosives.[45] This was obvious due to the completely peaceful orientation of Pakistan's nuclear programme at the time. Zaman Sheikh was thus the only high-explosive expert available for developing the explosive lenses used in triggering the implosion-based nuclear device. In this respect, Riazuddin recalled that, "Zaman Sheikh was the only person who knew explosives. None of us knew explosives. He was recommended to us by Tariq Mustafa, from the Ministry of Defence, and we did not know him otherwise." [46]

As stated above, when Prof. Abdus Salam visited Pakistan in December 1973, he brought with him copies of an article entitled: "The Curve of Binding Energy." Written by Theodore Taylor, the article was essentially a piece of writing about the atomic bomb for the man on the street. Taylor had compared the explosive lenses used in triggering the implosion in the bomb with the 'breasts of women.' Therefore, when Salam asked Zaman Sheikh, the explosives expert, if he could design and develop "Explosive Breasts" for the nuclear device, he blushed. By that time, it was clear that Pakistan would

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[41] Ibid, p. 4.
[42] Ibid.
[43] Nuclear Non-Proliferation Institute, Morris Plains, N.J. 07950 USA: Ara Barsamian, "Nuclear Weapons Glossary," NNPI, 2005. Available at http://www.nuclearnonproliferation.org/Nuclear%20Weapons%20Glossary.pdf. (accessed May 8, 2010).
[44] Samar Mubarakmand's Speech, op. cit.
[45] Shahid-ur-Rahman, op. cit., p 38.
[46] Interview with Riazuddin, op. cit.

go for the implosion device and explosive lenses were a critical component of such a weapon. [47]

In an implosion-type nuclear weapon, the implosion is achieved by an assortment of explosive lenses, or highly specialized explosive charges, and detonating them symmetrically in such a way that several spherically diverging detonations or shock waves are transformed into a single spherical converging wave. This wave then collapses the tamper or reflector inwards, which surrounds the fissile metallic core of the device. Subsequently, this transforms the core or pit of the device consisting of fissile material (U-235 or Pu-239) into a super critical mass and the chain reaction takes place, resulting in the fissioning of the fissile material. The explosive lenses, are both hexagonal and pentagonal, and have to be homogenous, shaped accurately and with high precision, and free of impurities in order to achieve precise control over the speed of the detonations taking place. They have to be assembled with tolerances of a less than a millimeter. The designing of these lenses and their casting and shaping with high precision was a formidable challenge in the Manhattan Project that produced the world's first atomic bombs. It wasn't until the spring of 1945 that this challenge was overcome. Without mastery over the designing and developing high precision explosive lenses, the implosion device would simply not work.[48]

Within the Wah Group, an ultra-high precision manufacturing facility was established. It's job was to put together the various components that make up the nuclear device, such as high explosives, electronics, the metallic uranium, the tampers and reflectors etc, in one working package. The metallic core for the bomb was produced in a laboratory led by Dr. Khalil Qureshi whose mandate also included coating and machining of the core, while the explosives and electronics had to be manfuctured as one whole in a facility led by Dr. Mansoor Beg. [49]

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[47] Shahid-ur-Rahman, op. cit., p. 40.

[48] Jeremy Bernstein, *Nuclear Weapons: What You Need To Know* (New York: Cambridge University Press, 2008), pp. 150-151.

[49] "When you are making a bomb, you put the electronics in it, the bomb has got explosives, it has metallic uranium which comes from Dr. Khalil Qureshi, out top metallurgist and he converts the gas from Kahuta into metal and then he does the coating and machining. Then you have to have a holding system that holds everything, the bits and pieces in such a way that we get a very rugged device. The device has to be rugged

The Wah Group used Computerized Numerically Controlled or CNC machines for ultra-high precision manufacturing of the various components of the atomic bomb.[50] It was here that atomic bombs of various shapes, sizes, dimensions and configurations were manufactured. Parvez Butt played a key role in the precision engineering involved in the making of the bomb. He recalled that Hafeez Qureshi and his Group began work in close proximity of P.O.F. Wah, but only with very basic equipment and facilities. Following a visit to the Qureshi's laboratories, he expressed his reservations to Munir Ahmad Khan about the Wah Group's prospects in accomplishing its task, in the absence of state of the art facilities and Computer Numerically Controlled (CNC) machines. Munir Khan asked Butt: "If the Americans could do without CNC machines in the 1940s, why can't we do the same now?" Butt replied: "The American had Old Joe!" Old Joe referred to the highly skilled technician and foreman who helped in the manufacture and machining of the different components that made up the first bombs.

Nevertheless, in due course of time, CNC machines were acquired for the said purpose. The Wah Group was also equipped with other relevant state of the art facilities to ensure quality control during the engineering and manufacture of the atomic bombs.[51] Another important group was tasked to develop the neutron source/initiator for triggering a chain reaction in a nuclear weapon that worked with the Wah Group. Known as the Fast Neutron Physics Group, it was established in PINSTECH parallel with other specialized groups sometime around 1980.[52] Led by an experimental physicist, Dr. Samar Mubarakmand, this group constituted a fundamental element of the trigger mechanism for Pakistan's nuclear weapons programme.[53] He was personally handpicked by the Chairman of PAEC for this task, given his expertise in the field of fast neutron spectrometry. Earlier, he had obtained a Ph.D. in experimental nuclear physics in 1966

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so that if you want to have deliverable weapons, you do not have problems. You can put them on an aircraft or missile. All the facilities for explosives and chemical manufacture, explosive machining and electronics transfer their products to the manufacturing facility and Dr. Mansoor Beg was the Director of that facility." Dr. Samar Mubarakmand's Speech, op. cit.

[50] Parvez Butt (ex-chairman, PAEC), interview with author, written notes, Islamabad, August 13, 2007.

[51] Parvez Butt. Speech delivered at the Munir Khan Memorial Reference, Pakistan Agricultural Research Council Auditorium, April 29, 2007, Islamabad.

[52] Samar Mubarakmand, (ex-Member Technical, PAEC/ Chairman NESCOM), Interview by authour, written notes, Islamabad, June 26, 2008.

[53] Ibid.

from the University of Oxford, whose supervisor was Prof. D. H. Wilkinson—the world-renowned experimental nuclear physicist.[54]

A neutron initiator[55] or source is necessary for initiating a fission chain reaction at the precise moment in the core of a nuclear device. In order to obtain a significant yield from the nuclear explosion, sufficient neutrons must be present within the supercritical core of weapon-grade highly enriched uranium or plutonium, just at the right time. If the chain reaction begins too soon, the result will be a fizzle yield, much less than the desired specification of the weapon design. If, however, the chain reaction occurs too late, there will be no yield at all. Pakistan may have used Polonium-210[56] mixed with beryllium as the neutron source in its first generation weapons. Subsequent weapon designs may have used tritium as a neutron source, which has a half-life of twelve years compared to polonium which has a half life of 138 days.[57]

To supply the initiation pulse of neutrons at the right time, the polonium and the beryllium need to be kept apart until the appropriate moment and then thoroughly and rapidly mixed by the implosion of the weapon. A tamper/reflector is an optional layer of dense material (typically natural or depleted uranium or tungsten) surrounding the fissile material. It reduces the critical mass and increases the efficiency by its inertia, which delays the expansion of the reacting material. The tamper prolongs the short time the material holds together under the extreme pressures of the explosion, thereby increasing the efficiency of the weapon, i.e. increases the fraction of the fissile material that actually fissions. The tamper also acts as a neutron reflector.[58] While beryllium metal is the best

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[54] The Proceedings of the Pakistan Academy of Sciences, "Citation of New Fellows," Vol. 41, No.1, June 2004. http://www.paspk.org/41-1.htm (accessed on September 5, 2007).

[55] Early neutron triggers in almost all countries developing nuclear weapons consisted of a highly radioactive isotope of polonium, Po-210, which is a strong alpha emitter, and when combined with beryllium, it absorbs alphas and emits neutrons. Due to the short half-life, a neutron initiator using this material needs to be replenished frequently. Polonium is scattered in the earth's crust in very small quantities, and although it can be obtained by the chemical processing of uranium ores, Po-210 is only available at the rate of 0.1 mg per ton of uranium ore. Therefore, due to its extreme scarcity, polonium-210 is produced in appreciable quantities a nuclear reactor by bombarding bismuth-209 with neutrons. Please see Argonne National Laboratory, EVS. "Human Health Fact Sheet, 2005." www.ead.anl.gov/pub/doc/polonium.pdf (accessed on September 5, 2007).

[56] Interview with Riazuddin, op. cit.

[57] Shahid-ur-Rahman, op. cit, p. 82.

[58] Jeremy Bernstein, op. cit., p. 132.

reflector material, it is very difficult to manufacture, therefore, the first weapon design developed by the Theoretical Physics Group used U-238 as reflector. [59]

PAEC also established a beryllium metal plant as part of its nuclear weapons infrastructure where beryllium compounds are indigenously produced. This project was designed to produce reflectors or tampers for the nuclear devices.[60] In addition, to produce different types of neutron sources, a dedicated laboratory reflector was set up in PAEC.[61] Subsequent modern designs of nuclear weapons developed by PAEC may have discarded the use of tampers as most modern weapons that use fusion (tritium) boosting, tremendously increase the fission rate, thereby precluding the need for tamper material. This also helps in the miniaturization of nuclear weapons. The weapons tested by Pakistan in the May 1998 tests were boosted fission devices.[62]

9.3.1. R-Labs/Block

The triggering mechanism and the diagnostic facilities for the nuclear device had to be designed and developed indigenously in parallel with the theoretical group and the neutron lab. For this purpose, a dedicated laboratory was established in PINSTECH, which came to be known as R Labs or R Block. This was a challenge for the electronics engineers who had to develop high-speed electronics for simultaneous detonation of the explosive lenses.[63] [64]

To achieve this goal, R Labs developed special high-speed electronic switches or Krytrons, used to trigger the explosives in the bomb. These switches are used to

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[59] Shahid-ur-Rahman, op. cit., p. 40.
[60] Ibid, p. 97.
[61] Interview with Samar Mubarakmand, op. cit.
[62] Munir Ahmad Khan quoted in Federation of American Scientists (FAS). "Pakistan's Nuclear Weapons Programme-1998: The Year of Testing". http://nuclearweaponarchive.org/Pakistan/PakTests.html (accessed on September 25, 2008).
[63] Please see Jeremy Bernstein, op. cit., p. 150 for the importance of achieving simulatenous detonation of the lenses to achieve an implosion chain reaction.
[64] "When a bomb is made, it has to be detonated, and the detonation is not from one point alone. It is from several points on the surface of the bomb and the trick lies in this that you should be able to detonate the bomb from several points at the same time. This is called simultaneity and the simultaneity has to be of the order of 50 ns (nanoseconds). A nano-second is 1/1000 of a microsecond. Therefore it can be imagined that in 50 ns, you have to detonate the bomb at several points so that the implosion takes place in a simultaneous fashion." Dr. Samar Mubarakmand's Speech, op.cit.

simultaneously trigger all the thirty-two or more high explosive lenses or the "Detonation Wave Generators" that produce the shock waves for compression of the implosion device and obtaining super criticality of the fissile material with the precision of 50 nano-seconds. Pakistani scientists were able to develop solid-state Krytrons for triggering the implosion devices.[65] In 1983, PAEC had also reportedly attempted to acquire high-speed electronic switches, or krytrons, from an American firm EG & G Electro-Optics, used as triggers in nuclear bombs. This special type of trigger was known as KN-22 and S.A. Butt and Nazir Ahmad Vaid were involved in an attempt to procure these items. However, their procurement effort was not successful.[66]

9.3.2. K- Labs/Block or the Uranium Metal Laboratory (UML)

Enriched uranium hexafluoride or highly enriched uranium has to be converted into metallic form and given the right shape to be used in the core of the nuclear device. Therefore, the "production of metal"[67] was one of the technologies leading up to nuclear weapons capability for which PAEC established an independent laboratory, sometime around 1977. It came to be known as the Uranium Metal Laboratory (UML), also known as K-Labs/Block, PINSTECH.[68] Dr. Khalil Qureshi, as head of UML was responsible for converting the enriched uranium hexafluoride gas from Kahuta into metal in addition to the coating and machining of highly enriched uranium metal that forms the metallic core of fissile material at the centre of a nuclear device.[69] UML also developed the natural uranium ingots for metallic natural uranium fuel for the Khushab plutonium production reactor. This fuel was produced at the Kundian Nuclear Fuel Complex. [70]

UML has also been performing various R & D activities for all projects of PAEC, whether classified or unclassified, which involved extensive metallurgical applications.

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[65] Ibid.
[66] Please see David Armstrong and Joseph Trento, *America and the Islamic Bomb* (New Hampshire, USA: SteerForth Press, 2007), pp. 129-139.
[67] Munir Ahmad Khan's Speech, op. cit.
[68] Samar Mubarakmand's Speech, op. cit.
[69] Ibid.
[70] Sultan Bashiruddin Mahmood (ex-Director-General, Nuclear Power, PAEC), interview by authour, written notes, Islamabad, August 3, 2007.

Since UML specializes in production of metal for nuclear weapon cores, the plutonium cores for devices using Pu-239 in new generations of Pakistani nuclear weapons may also have been produced at UML.[71] While UML was being developed, uranium metal was first made at the Chemical Plants Complex (CPC),[72] at Dera Ghazi Khan, where PAEC produces the uranium hexafluoride gas from yellow cake. A 1985 CIA Research Paper on Pakistan's nuclear programme stated:

> UML fabricates and machines parts for a nuclear device implosion system. UML is located at the New Labs complex at PINSTECH, and, although it is organizationally part of the Directorate of Nuclear Fuels and Materials, personnel associated with UML respond to the directions of officers within the Directorate of Technical Development and use DTD funds and channels to procure materials. [73]

9.4. Chaghi, Kharan and Kirana Hills

On May 28, 1998, PAEC carried out five successful hot tests of nuclear devices in Ras Koh Range, in Chaghi district of Baluchistan province. This was followed by another test on May 30th, which was conducted a few hundred kilometers away, in the Kharan desert. The PAEC in 1976 also began work on the selection and preparation of nuclear test sites. This was being done in parallel with other projects relating to the nuclear fuel cycle and the theoretical and practical aspects of the nuclear device itself. Munir Ahmad Khan may have initiated work on the selection and development of the nuclear test sites in 1976 because PAEC was told, "whenever you would be ready, you would detonate the bomb."[74] Therefore in 1976, Brig. Muhammad Sarfaraz, Chief of Staff at 5 Corps Headquarters, Quetta, Baluchistan, received a directive from the Pakistan Army General Headquarters (GHQ), Rawalpindi The message directed the Corps Commander to make

[71] Ibid.
[72] Dr. Muhammad Shabbir (ex- Director CPC Project) quoted in Shahid-ur-Rahman, op. cit., p.67.
[73] Central Intelligence Agency, "Pakistan's Nuclear Programme: Personnel and Organization," November 1985. CIA Electronic Reading Room. pp. 24-25, http://www.foia.cia.gov (accessed January 15, 2009).
[74] Samar Mubarakmand's Speech, op. cit.

available an Army helicopter to a forthcoming team of scientists from PAEC for operational reconnaissance of some areas in Baluchistan. [75]

The PAEC team comprising Dr. Ishfaq Ahmed and Dr. Ahsan Mubarak, a geophysicist, landed at Quetta and were provided the helicopter as per the GHQ instructions. Over a span of three days, they reconnoitered the area between Turbat, Awaran and Khuzdar to the south, Naukundi to the east and Kharan to the west. Their objective was to find a suitable location for an underground nuclear test, preferably a mountain. Because Pakistan had signed the Partial Test Ban Treaty (PTBT) in 1963, therefore carrying out a nuclear test in the atmosphere was not an option. Hence, it was necessary to find a suitable underground nuclear test site.[76] After a hectic and careful search, they found a mountain, which matched their specifications. This was a 185-metre base-to-summit high-granite mountain in the Ras Koh Hills in the Chaghi Division of Baluchistan, which, at their highest point, rose to a height of 9,367 feet (3,009 metres) above sea level. The Ras Koh Hills are independent of and should not be confused with the Chaghi Hills further north on the Pak-Afghan border, in which, to date, no nuclear test activity has taken place.[77]

The PAEC requirement was that the mountain should be "bone dry" and capable of withstanding a twenty kiloton nuclear explosion from the inside. Tests were conducted to measure the water content of the mountains and the surrounding area and to measure the capability of the mountain's rock to withstand a nuclear test. Once this was confirmed, Dr. Ishfaq Ahmad commenced work on a three-dimensional survey of the area with the help of the Geological Survey of Pakistan (GSP). This survey took one year to conduct and in 1977 it was decided that the proposed tunnel needed to be bored in the mountain with an overburden of a 700 metres over it, thus sufficient to withstand twenty to forty kilotons nuclear explosive.[78]

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[75] Rai Muhammad Saleh Azam, "When Mountains Move- The Story of Chagai," *Defence Journal* (Karachi), Vol 3, No. 11, (June 2000). http://www.defencejournal.com/2000/june/chagai.htm (accessed on December 15, 2008).
[76] Ibid.
[77] Ibid.
[78] Dr. Ishfaq Ahmad (Chairman of PAEC 1991-2001) quoted in, Shahid-ur-Rahman, op. cit., 77.

During the same year, Brig. Sarfaraz, who, in the interim, had been posted to GHQ Rawalpindi, was summoned by the President and Chief of Army Staff, Gen. Zia-ul-Haq and was told that the PAEC wanted to lease him from the Army to carry out work related to the Pakistan nuclear programme. This resulted in the creation of an organization called the Inspectorate General, Special Development Works (SDW), a subsidiary of the PAEC but directly reporting to the Chief of the Army Staff and entrusted with the task of preparing Pakistan's nuclear test sites. [79] Sarfaraz, for all practical purposes, was selected to head the SDW, a nuclear variant of the Pakistan Army's famous Frontier Works Organization (FWO), which, along with the Chinese, built the Karakorum Highway during 1966-1978. His name had been suggested to the Chairman of PAEC because of his background in science and his experience in R & D work. He was also directed to meet Munir Khan who informed Sarfaraz of the basic parameters of the assistance that was to be provided to, and the work to be done for PAEC by SDW. These included:[80]

1) The primary task of SDW was to prepare underground test sites (both horizontal and vertical shaft tunnels) for twenty-kiloton nuclear devices, along with all the allied infrastructure and facilities. The sites had to be designed in such a way that they could be utilized at short notice (in less than a week) and were to be completed by December 31, 1979 at the latest. [81]
2) The second important task of SDW was to provide PAEC with all possible assistance and infrastructure for carrying out cold and laboratory tests.
3) SDW was to liaise with various government departments and organizations for any possible assistance, which included the Ministry of Defence, Ministry of Foreign Affairs and Finance, Frontier Works Organization (FWO), Intelligence Agencies etc.

After a series of meetings between SDW, PAEC officials and the President of Pakistan, it was decided that SDW should prepare two to three separate test sites.

[79] Ibid.
[80] Muhammad Aslam Lodhi, "Dr. Samar Mubarakmand," *Qaumi Heroes,* (Lahore: Ilm-o-Irfan Publishers, April, 2005), pp. 47-75.
[81] Shahid-ur-Rahman, op. cit., pp. 77-78.

Therefore, a second site for a vertical shaft tunnel was prepared in the Kharan Desert, at a barren location approximately 150 kilometers west of the Ras Koh test site, situated in a rolling sandy desert valley lined with sand ridges between the Ras Koh Hills to the north and the Siahan Range to the south.[82] After scrutiny of different options, the final selection of the sites was done on the recommendation of a geological expert attached with the Pakistan Army, Muhammad Hussain Chughtai. He had had experience and expertise in building tunnels and had also built the tunnels for the Tarbela Dam project. In 1976, he was selected by PAEC to assist in the selection and construction of the tunnels for nuclear tests. Prior to the selection of the Chaghi test site, he had declared the mountains near Turbat unsuitable due to their low density, as they could not withstand a nuclear test explosion.[83]

Subsequently, the Chaghi-Ras Koh-Kharan areas became restricted entry zones and were closed to the public, prompting rumours that Pakistan had given airbases to the United States. The fact that United States Agency for International Development (USAID) had set up an office in Turbat, Baluchistan, only added fuel to such rumours.[84] Eventually a 3,325 feet long horizontal shaft tunnel was bored in the Ras Koh Hills, which was eight to nine feet in diameter and was shaped like a fishhook for it to be self-sealing. "The overburden available was about 400 feet. That was the height of the mountain available for containment."[85]

The vertical shaft tunnel at Kharan was 300 feet by 200 feet and was L-shaped. Both test sites had an array of extensive cables, sensors and monitoring stations. The preparation of the test sites was yet another challenge for PAEC.[86] Both the nuclear test

[82] Ibid, p. 9.
[83] Muhammad Aslam Lodhi, op. cit.
[84] Shahid-ur-Rahman, op. cit., p. 78.
[85] Samar Mubarakmand's Speech, op. cit.
[86] "The designing of the tunnels was also a very intricate thing. It was not just blasting a hole into a mountain. Again there is a lot of science. If you have a straight tunnel and you put the bomb at the end of the tunnel, you plug the tunnel with concrete and explode the bomb, the concrete is really going to blow out and so all the radioactivity is going to leak out through the mouth of the tunnel. We did not want this to happen. The tunnel is not designed safe but is designed in the form a double-S shape and when we detonate the bomb, the pressures are very great. They move the mountain outward and you use the force of the bomb to seal the tunnel. When the rock expands under the explosion, the rock moves in the direction so that it seals the tunnel. So the tunnel collapses inward by the force of the tunnel. This is how you seal the

sites at Ras Koh and Kharan took two to three years to prepare and were completed by 1980,[87] before Pakistan had completed work on the nuclear weapon. However, the actual work on the construction of the Chaghi site began in earnest in early 1978. By the end of the year, Chughtai along with fifty of his men had encamped at the site while Brig. Sarfaraz and SDW took over all construction work of the site. In addition to SWO, some locals were also hired by PAEC to assist in the timely completion of the site, and at the same time adequate measures were taken to camouflage the construction activity.[88]

During the construction of the test sites, Dr. Ishfaq Ahmad and Dr. Ahsan Mubarak visited the site a few times to oversee and supervise progress. Munir Ahmad Khan also visited the Chaghi site once while it was under construction. Dr. Samar Mubarakmand first visited the site in 1981 and began installing diagnostic cables and equipment as per PAEC requirement.[89] As the tunnels and the shafts for the test were being prepared, Dr. Ahsan Mubarak established a Telemetric Seismic Recording Station in the area. This was aimed at understanding and recording the environment and climate of the area. This helped PAEC when it had to conduct the hot tests in 1998 as a twenty-year record of the direction of the wind and air pressure was available. [90]

9.4.1. The Cold/Hydrodynamic Tests and The Diagnostics Group

Around 1980, PAEC was nearing completion of the nuclear test sites and the device itself. The next milestone towards nuclear capability was to test the nuclear device in cold tests. Thus the DTD was expanded with the addition of the Diagnostics Directorate, which was also led by Dr. Samar Mubarakmand. The measurement of cold or hydrodynamic and hot tests is necessary for validation of various design parameters of a nuclear device, such as expected yield, trigger mechanism, explosive lenses etc. This requires the development and application of advanced diagnostics techniques. State of the art Computerized Numerically Controlled (CNC) machines and high speed

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tunnel through the force of the bomb. Dr. Mansoor Beg is an expert in this. Apart from the manufacturing things, he is the one who does all the calculations and gives it to the geologists who do this work." Ibid.

[87] Shahid-ur-Rahman, op. cit., p. 78.

[88] Muhammad Aslam Lodhi,, op. cit.

[89] Ibid.

[90] Ibid.

computers were used by the Diagnostics Group, which were developed by PAEC at R Labs. [91][92]

To conduct the cold tests, the SDW built twenty additional sites for cold tests, forty-six short tunnels, thirty-five underground accommodations for troops and other associated facilities.[93] Therefore, the cold test programme became an important consideration in PAEC's nuclear weapon development plans. When Pakistan's first cold test was carried out in the Kirana Hills, it became a milestone in the country's nuclear history. The DTD, and all the specialized groups that worked under its ambit DTD were involved in the cold tests. Prior to the first cold test, an advance team was sent to open the cold test tunnel and to clear the area of any possible wild boars or hogs, which inhabited the site. This was followed by the Diagnostics Directorate headed by Dr. Samar Mubarakmand, who arrived at the site with trailers equipped with diagnostic equipment and computers. The next to follow was the Wah Group, headed by Hafeez Qureshi, which brought the nuclear device in sub-assembled form. They were

[91] Shahid-ur-Rahman, op. cit., pp. 75-76; Interview with Dr. Samar Mubarakmand, op. cit.

[92] "Suppose you had a bomb, what to do with it? You have to have a facility, a site where you can test the bomb and you would also like that when the bomb is detonated, you can do the diagnostics or the measurement on it. There can be two approaches; either to detonate a bomb and sit back and clap or to treat it as a scientific experiment – try to get the maximum scientific data from the nuclear detonation. We chose to do the latter and for that we had established another Directorate – the Diagnostics Directorate. They are really smart people. They are trained very thoroughly in capturing the yield of the device. They measure the number of neutrons produced in the device, the efficiency of the nuclear bomb: how much uranium produces how much power – this is the efficiency. One must remember that the phenomenon is a single shot phenomenon. It is a very fast process. You press the button and everything is finished within a nano-second. The bomb goes to maximum power, stays there for some time and comes down to zero power in less than a nanosecond. So in this time, one must do all the measurements and if you miss the data, it is the end of it; it is finished and would not repeat. So it is a single shot event and our Diagnostics Directorate has the capability of measuring the yield of the device. They not only measure the yield of the devices that they themselves detonate but also of the devices that are exploded across our border. The diagnostic people are not only responsible for diagnostics of the device but also for detonating the device. The detonation of a device is not done by sitting close to it. It is a very sophisticated process. This expertise was established over the years by a dedicated team of people and when we did the experiments, the detonation at Chaghi, we were able to detonate the first five devices from a distance of about fifteen kilometers and the last detonation on the May 20; we were able to do from a distance of forty-five km. This was not the first time we were doing these experiments. We had performed so many cold tests before. We had practiced the remote control detonations of the cold test over the years. So we knew what we were doing. We were very professional and very well trained. We had a team of 300-400 people who were responsible for developing the detonation procedure. So this is a massive programme." Dr.Samar Mubarakmand's Speech, op. cit.

[93] Shahid-ur-Rahman, op. cit., p. 79.

accompanied by the high-speed electronics and HMX explosive experts who had developed the explosive lenses for the device.[94]

Asking the scientists and engineers involved in the exercise to learn to drive the trailers and big trucks that would take all the equipment to the site ensured the extent of the secrecy of the cold test programme. The team also acquired heavy driving licenses and drove the trucks for hundreds of kilometers, without drivers.[95] Once the site had been prepared for the test, the team members of the Wah Group assembled all the components of the nuclear device and placed it in the tunnel. Nearly twenty cables, linking the oscillators to vehicles carrying diagnostic equipment were connected to the device to monitor various technical parameters and performance of the device during the test.[96]

A cold test essentially is the actual detonation of a complete nuclear bomb, except that instead of the highly enriched uranium or plutonium in the core of the bomb, only natural or depleted uranium is used. Therefore, no fission reaction takes place once the bomb is detonated but otherwise, it is a complete nuclear device in all respects.[97] When a nuclear device is detonated with or without the fissile material, it produces a high neutron flux, or a dense stream of neutrons. If fissile material in the form of either highly enriched uranium or plutonium-239 is used in place of natural uranium, the high neutron flux acts as the neutron initiator that triggers the fission chain reaction in the bomb. In the first cold test, one of the primary objectives of testing the implosion package of the nuclear device was to see if the neutron initiator, developed by the Fast Neutron Physics Group, performed according to the technical parameters. If it did, it would provide confidence that the bomb would work, and that the neutron initiator had indeed generated a high neutron flux. The Diagnostics Group needed to have the capability to monitor and accurately record the neutron flux in the device. The cold test also validated the performance of the explosive lenses and the trigger mechanism

[94] Ibid.

[95] Samar Mubarakmand, Interview with Hamid Mir. *Capital Talk.* Geo Television. March 05, 2004.
[96] Shahid-ur-Rahman, op. cit, p. 79.
[97] Samar Mubarakmand's Speech, op. cit.

developed by the Wah Group, in addition to the design parameters developed by the Theoretical Physics Group.[98]

The first indigenous bomb tested by PAEC in its first cold test was a bulky device and was quite big in size. It was "such a fat bomb."[99] With regard to the first cold test, the Chairman of PAEC would later claim:

> It is well known that India tried to test in 1981 and then again in mid-1980s when the Pokhran site was re-equipped and expanded. Pakistan knew this. On our side, we were getting ready to respond. Pakistan had carried out its first cold test, which confirmed the dependability of its design, in 1983. This implosion device was less than half the size of the one, which India tested in 1974. We got ready with it even before we had enough enriched uranium. If India had tested in the mid-1980s, Pakistan could have responded.[100]

The device tested on March 11, 1983, was detonated by a push button method unlike the radio link via computer method used in the May 1998 Chaghi tests. When the detonation took place, most of the wires were severed that were supposed to transfer the data to the oscillators. At first, the test team had blank faces when they first looked at the computers, giving the thumbs down signal, indicating that nothing had happened. However, a closer examination of the oscillators indicated that in fact two of them had worked which showed that the neutrons had been generated and the chain reaction had indeed taken place. This had the effect of changing the mood of the test team from disappointment to immense joy, with many shedding tears of joy.[101] The cold test had indeed been a success and it was a "red letter day in Pakistan's nuclear history."[102]

The first successful cold test was conducted under the supervision of Dr. Ishfaq Ahmad. A second cold test was conducted soon afterwards,[103] which was witnessed by Ghulam Ishaq Khan, Vice Chief of Army Staff, Gen. Khalid Mahmud Arif, and the Chairman of PAEC, Munir Ahmad Khan.[104] Dr. Samar Mubarakmand termed the first

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[98] Ibid.
[99] Shahid-ur-Rahman, op. cit., p. 79
[100] Munir Ahmad Khan, "Things To Do After Testing," *The News* (Islamabad), June 14, 1998, Islamabad.
[101] Brig. Sarfaraz quoted in Shahid-ur-Rahman, op. cit., p. 79.
[102] Rai Muhammad Saleh Azam, op. cit.
[103] Samar Mubarakmand, Interview with Hamid Mir, op. cit.
[104] Rai Muhammad Saleh Azam, op. cit.

cold test as a lifetime achievement for everyone involved in the classified projects.[105] He also claimed that despite this success, it was kept a secret and was not publicly declared. Due to the threat of international sanctions and cut off of aid.[106] Gen. K. M. Arif, the then Vice Chief of Army Staff also recalled the first cold tests:

> It was a red-letter day. I can tell you we were all very excited. The tests went perfectly. Pakistan to all intents and purposes now had its bomb. The work of our scientists was nothing short of heroic. From now on there were twenty-four more cold tests to straighten out the triggering mechanism until we got the hang of it exactly.[107]

Within a year of the 1998 nuclear tests, Munir Ahmad Khan recalled the day when Pakistan successfully carried out the first cold test of a nuclear device:

> On March 11, 1983, we successfully conducted our first cold test of a working nuclear device. Dr Ishfaq, Dr Samar Mubarakmand, and many others were there. I remember that the Chairman of the Senate, Ghulam Ishaq Khan wanted to be present, but just like today, bad weather intervened and he could not reach there. That evening, I went to General Zia with the news that Pakistan was now ready to make a nuclear device. The team that conducted that test was basically the same that carried out the Chaghi test last year. I also want to put this on record that we conducted this cold test long before the [fissile] material was available for the real test. We were ahead of others. [108]

9.5. Making The Deliverable Weapon

With the success of the first two cold tests, two options were available to PAEC with regard to the future course of action to be taken in the development of nuclear weapons. One was that as soon as the fissile material was available, a hot test should be carried out, like the one in May 1998 at Chaghi, and then based on that experience, to move forward. The second one was that since the cold tests had validated the weapon designs

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[105] "When we first went for a cold test, we were very apprehensive. It was the first biggest event of our lifetime and it was conducted. The Diagnostics Directorate had the capability to measure the high flux of neutrons in a cold test and they measured the neutrons from this cold test very successfully. When we saw these neutrons on our recorders, we were very happy. We thought that we had achieved the objective of our lifetime. I remember that people were very happy for several days. If you have a cold test and you detect neutrons you can be more tan 100 % sure that if you put enriched uranium in the same bomb, it is bound to give you fission. So the test was successful and we were very happy." Dr. Samar Mubarakmand's Speech, op. cit.

[106] "Pakistan Became Nuclear State in 1983- Dr. Samar," *The Nation* (Islamabad), May 2, 2003.

[107] Adrian Levy and Catherine Scott Clark, *Deception: Pakistan, the United States and the Global Nuclear Weapons Conspiracy* (New Delhi: Penguin Books, 2007), p. 96.

[108] Munir Ahmad Khan's Speech, op. cit.

developed by the Theoretical Group, more modern designs should be developed which would be smaller, rugged and deliverable by aircraft or missiles. For every country that develops nuclear weapons, the first bomb is always very large in size and is not suited for delivery by aircraft or missiles.

Therefore, new and miniaturized designs had to be developed. However, the question facing PAEC was whether to move towards miniaturization of the bomb design or wait for it until after a hot test was conducted. It told the government that it was ready for a hot test and sought permission to carry out a hot test, which was declined by President Zia on the grounds that the time was not appropriate for carrying out a hot test.[109] Moreover, PAEC had to continue improving its bomb designs through cold tests. Therefore, between 1983, till 1992, PAEC carried out twenty-four cold tests in Kirana Hills in two-dozen 100-150 foot long tunnels, wherein different bomb designs were tested. During this period, the Theoretical Physics Group led by Dr. Masud Ahmad, after every eighteen months or two years or so, developed a new bomb design, which would then be tested in a cold test.[110]

Moreover, PAEC cold tested at least four to five new bomb designs. The success rate of these cold tests was claimed to be almost 100 percent. Sometimes, doubts about the accuracy of the diagnostics team were raised and it was suspected that they were always giving positive results and at least there should be some failure some time. It was also suspected that the electronics may have become faulty but since the cold tests were so successful, it sometimes brought an element of doubt for the diagnostics team.[111] Nevertheless, as new designs were being developed, new versions of bombs were also being manufactured and tested in cold tests. The real breakthrough, however, in developing a deliverable bomb design was achieved in the second half of the 1980s when PAEC scientists were successful in developing a design, with a reported yield of 10-20

[109] Samar Mubarakmand's Speech, op. cit.
[110] Ibid.
[111] Ibid.

kilotons, which could be carried by all Pakistan Air Force (PAF) aircraft, primarily the F-16.[112]

Dr. Samar Mubarakmand claims that PAEC began work on a developing a complete "nuclear weapon system," capable of being deliverable by missiles in 1988. This programme was completed by 1995.[113] Thus, the SDW Directorate in PAEC was succeeded by the National Development Complex (NDC), which was founded in 1990-1991. Dr. Samar Mubarakmand was appointed director of this new project by Munir Ahmad Khan with the mandate to develop a deliverable nuclear weapon system, including the delivery system or the missiles.[114] The latest and most sophisticated bomb design which PAEC could claim to be state of the art, and which made them very proud was one that was very small, compact and high-yield with tremendous efficiency. This was a truly miniaturized design, which was successfully cold tested in 1992.[115] This was the design, which was tested in the May 30, 1998 test at Kharan and was sufficiently sophisticated to be carried by missiles.[116] During the 1980s, the Wah Group developed different bomb designs for the Pakistan Air Force, for tactical weapons and for missiles.[117]

When PAEC had initiated a programme to develop a miniaturized, deliverable nuclear weapon system in 1988, [118] the only means of delivery available to Pakistan were the fighter-bombers of the PAF. Therefore, PAEC began an eight month long exercise with the PAF for perfecting delivery of a nuclear weapon by PAF aircraft. At 0600 hours, on July 27, 1990, a PAF F-16 aircraft carried out a simulated bombing exercise in which an atomic bomb was dropped 500 meters above the ground, but without a core of any fissile material. This marked the culmination of the eight-month joint PAEC-PAF exercise. This airdrop was simultaneously photographed by a PAF aircraft in the air and

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[112] "Offensive Weapons, Pakistan- The Nuclear Bomb," *Janes Strategic Weapon Systems,* July 10, 1006.
[113] Interview with Samar Mubarakmand, op. cit.
[114] Ibid.
[115] Samar Mubarakmand's Speech, op. cit; Samar Mubarakmand, Interview with Hamid Mir, op. cit.
[116] Ibid.
[117] Samar Mubarakmand, Speech delivered at the Munir Ahmad Khan Memorial Reference, Pakistan Agricultural Research Council Auditorium, April 29, 2007, Islamabad.
[118] Interview with Samar Mubarakmand, op. cit.

by a team on the ground. [119] These bomb delivery exercises began when the Chairman of PAEC gave a briefing to the Air Staff at PAF headquarters in Chaklala, Rawalpindi. Among those who attended the briefing included Chief of the Air Staff, Air Chief Marshal Hakim-ullah, Air Vice-Marshal Najeeb Akhtar and Air Commodore Shahid Hamid, who was then commanding PAF F-16s at the Sargodha Air Base. The Chairman was assisted by Dr. Ishfaq Ahmad, Parvez Butt, Dr. Samar Mubarakmand, and Hafeez Qureshi. [120]

Munir Ahmad Khan briefed the assembled Air Marshals that PAEC had carried out several cold tests including one of a device that could be carried by aircraft. Therefore, PAEC was now ready to test the device deliverable by aircraft. [121] PAEC had to develop a device specifically designed for PAF that could be carried and dropped by F-16 aircraft. This meant that the nuclear device, which was to be dropped by aircraft, had to be fitted with extra electro-mechanical components and added safeguards so as pre-empt any possibility of its detonation in case of an accidental drop inside Pakistani territory. This included radar, a timer, and a programme for self-destruction. When the bomb was first fitted on the F-16, it did fit the weapon carrying station of the aircraft. However, the size of the design seemed to be too big for landing in case the aircraft had to abort its mission without dropping the bomb. Therefore, it had to be miniaturized as per the aircraft's requirements and specifications by the Wah Group. In the first test by an F-16, the size, shape and outer casing of the bomb was identical to an original one, except that it was a dummy otherwise. Further tests exposed the requirement to add more sophisticated features and safeguards, which was done. [122]

According to Hafeez Qureshi, the bomb was always brought in the dead of the night in a covered vehicle. The lights of the Sargodha air base would also be turned off while only two F-16s would be parked on the tarmac, one for carrying the device, and the other for photographing its drop. The PAEC team was under instructions to carry out these exercises in a manner that they would not be revealed to surveillance satellites and

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[119] Shahid-ur-Rahman, op. cit., pp 82-83.
[120] Ibid p. 83.
[121] Ibid.
[122] Ibid .p 84.

special measures were taken to keep them safe from any possible spies on the ground.[123][124]

During these exercises, PAEC joined hands with PAF in evolving and perfecting various bombing techniques for delivering a nuclear bomb by air. This included 'conventional free-fall,' 'loft bombing,' and 'toss bombing' and' low-level lay down attack' techniques. In the years following these exercises, PAF F-16 and Mirage-V aircraft had been adequately prepared for delivery of nuclear weapons on enemy territory.[125] Therefore, with the conclusion of these exercises, Pakistan had perfected its nuclear weapon design and delivery capability to the extent that its deterrent could now be considered as "quasi-operational."

9.7. KRL and Cold Tests: A Parallel Nuclear Weapons Programme?

This section discusses the origins and outcome of a parallel nuclear weapons development programme in KRL, which originated due to the bureaucratic rivalry and intense institutional competition between PAEC and KRL. The book, *Long Road to Chaghi,* has described KRL's involvement in the nuclear weapons programme. It quotes A. Q. Khan who claims that he was directed by Gen. Zia to initiate work on making a bomb in 1982, which included all aspects of the nuclear device. He also adds that Zia instructed him not to mention it to anyone else.

> According to Dr. A. Q. Khan, sometimes in 1982, President Zia invited him to the Presidency and directed in the presence of Lt. Gen. Syed Ali Zamin Naqvi, Advisor to the President on Nuclear Affairs, to start work "all the way," on the manufacture of a nuclear device. This meant that KRL had been commissioned, in addition to uranium enrichment, to design the bomb, develop [the] trigger mechanism, convert enriched uranium into metal, work on the nitty-gritty of the device, and assemble it.
>
> Dr. Khan claimed that he was instructed by President Zia not to mention his new responsibilities to any body, "not even to Finance Minister Ghulam Ishaq Khan, Foreign Minister Sahibzada Yakub Khan, and his Chief of Staff, Lt. Gen. K. M. Arif". As regards funds, he was asked to make use of his own budget or write directly to Gen. Zia. PAEC scientists have questioned the veracity of Dr Khan's claim. However, it explained

[123] Ibid, pp.84-85.
[124] "The device that was tested successfully on July 27, 1990, had the entire characteristics and safeguards of a weapon produced by any of the five nuclear weapon states. The device would activate only in the enemy territory when the pilot enters the code, and once he safely leaves Pakistani territory. If for any reason there is an accidental drop on Pakistani territory, the device would drop like dead weight." Ibid.
[125] Rai Muhammad Saleh Azam, op. cit.

> a host of unanswered questions relating to Pakistan's nuclear programme, e.g. the PAEC complaint that Lt. Gen. Zamin Naqvi passed on PAEC design of the device to KRL and a similar complaint by KRL against Lt. Gen. K. M. Arif.[126]

A. Q. Khan claims that Gen. Zia was "angry and frustrated" with the slow pace of work being carried out by PAEC. He further claimed that Zia used harsh words against Munir Khan and told him: "Dr. Sahib, I have no doubt that he is a C.I.A. agent and is deliberately dragging his feet on the work assigned to him." The fact that the only other witness to this meeting was Gen. Naqvi, PAEC officials maintain that the accuracy and veracity of A. Q. Khan's claims is doubtful.[127] However, a 1988 de-classified CIA assessment of Pakistan's nuclear programme stated:

> Munir Ahmad Khan, who has been chairman of the PAEC for nearly 15 years, is probably Zia's most important scientific advisor. He had direct access to the President and has more influence over decisions on nuclear research and applications than any other advisor. We believe that Munir Khan's longevity as PAEC chairman is based on performance, not favouritism. He is neither a supporter, nor an admirer of Zia, but his unstinting support for Pakistan's nuclear objectives has preserved his position. [128]

Earlier, President Zia had visited PINSTECH in November 1986 and noted in the visitor's book:

> It has been a matter of great pride and satisfaction to see what all is going on in PAEC. It was heartening to see the progress that has taken place. I congratulate Mr. Munir and his associates for all that they have done. We are proud of their achievements and pray for their success in the future.[129]

With regard to A. Q. Khan's claims Munir Ahmad Khan wrote to Lt. Gen. (Retd) Ghulam Jilani Khan. He stated that since Gen. Jilani had been privy to the nuclear

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[126] "According to Dr. A. Q. Khan, sometimes in 1982, President Zia invited him to the Presidency and directed in the presence of Lt. Gen. Syed Ali Zamin Naqvi, Advisor to the President on Nuclear Affairs, to start work "all the way," on the manufacture of a nuclear device. This meant that KRL had been commissioned, in addition to uranium enrichment, to design the bomb, develop [the] trigger mechanism, convert enriched uranium into metal, work on the nitty-gritty of the device, and assemble it. Dr. Khan claimed that he was instructed by President Zia not to mention his new responsibilities to any body, "not even to Finance Minister Ghulam Ishaq Khan, Foreign Minister Sahibzada Yakub Khan, and his Chief of Staff, Lt. Gen. K. M. Arif". As regards funds, he was asked to make use of his own budget or write directly to Gen. Zia. PAEC scientists have questioned the veracity of Dr Khan's claim. However, it explained a host of unanswered questions relating to Pakistan's nuclear programme, e.g. the PAEC complaint that Lt. Gen. Zamin Naqvi passed on PAEC design of the device to KRL and a similar complaint by KRL against Lt. Gen. K. M. Arif." Shahid-ur-Rahman, op. cit. p. 104.

[127] Ibid.

[128] Central Intelligence Agency, "Middle East—South Asia: Nuclear Handbook," May 1988, p. 56, op. cit.

[129] PINSTECH Silver Jubilee Technical Report- 1965-1990.

programme, both during the days of Mr. Bhutto and General Zia, he would have known any doubts in their minds about PAEC or himself. He added: "The story that General Arif asked Zia to reverse a decision to replace me is contradicted by Arif who told me this was untrue. After we had done our job (which was more than 12 years ago) I asked General Zia to let me go but he said, 'we will go together."[130] Therefore, it is likely that if President Zia asked A. Q. Khan to start a parallel bomb development programme, it would have been designed to further fuel the ongoing rivalry between PAEC and KRL.

Nevertheless, A. Q. Khan may also have found a "short-cut" to building an atomic bomb, or something that looked like one during this time. In addition A. Q. Khan claims that KRL had carried out its own independent cold test of a nuclear device in March 1984, at a site adjacent to the centrifuge plant. Following this test, A. Q. Khan also claims to have written to President Zia on December 10. 1984 and stated that, "everything was in place at Kahuta to detonate a real nuclear bomb."[131] In this respect, Ghulam Ishaq Khan, wrote to the official biographer of A. Q. Khan, Zahid Malik, in August 1999:

> The nation owes a debt of gratitude to its scientists. Using weapons grade enriched uranium, a product of KRL, they had developed by 1984, a nuclear explosive device which could be detonated at short notice.[132]

Gen. Khalid Mahmud Arif served as Chief of Staff to President Zia-ul-Haq from 1977 to 1984 and later as Vice Chief of Army Staff till 1987. He was tasked to supervise the nuclear programme by President Zia.[133] He recalled that he was not aware when or where did KRL carry out cold tests of a nuclear device and if they did so, they were not mandated or mandated or allowed to do so. Morever, following A. Q. Khan's publicized interview with Kuldip Nayar, he was asked to stop all further work on the device, with PAEC having the sole mandate to design, develop and test the bomb.[134] Hence the question arises, that if KRL did in fact carry out at least one cold test of a nuclear device,

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[130] Munir Ahmad Khan, personal letter to Lt. Gen. (Retd), Ghulam Jilani Khan, former Director-General, Inter-Services-Intelligence (ISI), July 12, 1995.
[131] Levy & Clark, op. cit., p. 112.
[132] Ibid.
[133] General K.M. Arif, (ex- Vice Chief of Army Staff, Pakistan Army), interview by authour, written notes, Rawalpindi, April 15, 2008.
[134] Ibid.

how it manage to do so given the lack of specialized teams that were only working at PAEC. In this regard, Dr. Riazuddin expressed the view that it is unlikely that KRL could have developed its own nuclear device given the lack of a Theoretical Physics Group or a dedicated specialized high-explosive group. Another controversy surrounding this affair is the production of a suitable neutron source for the nuclear device. KRL officials have claimed that they had an independent neutron source.[135]

PAEC is thought to have used Polonium-210 as a neutron source in its design, and this, like all other neutron sources such as tritium or plutonium are only produced in a nuclear reactor.[136] Therefore, given the lack of a neutron source generating mechanism such as a nuclear reactor, it is unlikely that such a source could easily have been produced by KRL. However, such a source may have been procured from some outside source for a one-time test. Also, these neutron sources, such as Po-210, have a half-life of 138 days, which require it to be constantly replenished and therefore have a permanent supply of the neutron source. The other neutron source is tritium, which is also known as an “external neutron trigger.”[137] Its half-life is twelve years, but it is much more difficult to develop than Po-210, and can only be produced by irradiating lithium-6 targets in a reactor or through a tritium recovery facility that extracts this material from heavy water moderated nuclear reactors.[138]

PAEC had set up exactly such a facility in 1987 and both a tritium recovery plant and an irradiation facility, such as a reactor was only available with PAEC. Therefore, it is unlikely that KRL was able to produce a neutron source for a nuclear device, even though it is claimed that it started work on a neutron source in 1983. However, it may have been plausible that A. Q. Khan was able to obtain a nuclear weapons design, and a neutron source, such as uranium deuteride from outside Pakistan or elsewhere and initiated work on his own parallel programme to build a device. In this respect, it was rumored and reported that China may have passed on a design of a nuclear device from

[135] Shahid-ur-Rahman, op. cit., p. 82.
[136] Interview with Riazuddin, op. cit.
[137] Ibid.
[138] Ibid.

its fourth nuclear test of 1966 to A. Q. Khan.[139] This design, known as CHIC-4, was subsequently sold to Libya by A. Q. Khan and had his comments on the margins including the remark: "Munir's bomb will be bigger."[140]

It may also have been that the Chinese helped A. Q. Khan with bomb design information in exchange of help in centrifuge technology. In this regard, the Dr. Shafiq-ur-Rahman, who served in KRL and is the son of A. Q. Khan's close and long-time associate at KRL, Brig. Sajawal Khan Malik claimed that the Chinese were assisting A. Q. Khan in making triggering mechanisms and high explosives for the bomb.[141] Apparently, A. Q. Khan was determined to beat PAEC and in addition to enriching uranium, he wanted to be the first with the nuclear weapons design too. "He wanted to be the racing car driver, not the petrol pump attendant."[142] Reportedly, A. Q. Khan told one of his colleagues at KRL: "You may have a Rolls-Royce, but if you don't have the gas to put in it, it isn't going to run. We can enrich uranium, but without a bomb and a delivery system, it isn't going anywhere."[143]

During the early 1980s, the British Intelligence Service MI-6 broke into the hotel room where A. Q. Khan was staying during one of his foreign trips. It is believed that they were able to photograph the documents in his suitcase, which were identified as designs of a nuclear device from China's fourth nuclear test of 1966. Subsequently, Vernon Walters, a former CIA deputy director was sent to meet President Zia and confront him on this issue. When he spread the copies of the drawings across the table, Gen. Zia in the presence of Munir Khan said: "What is this thing that looks like anyone could have drawn?" Munir Khan also seemed surprised and Walters told Zia that this was the design of a nuclear warhead which they had obtained from A. Q. Khan's briefcase and warned him not to do anything that would embarrass President Reagan.[144]

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[139] Please see Levy & Clark, op. cit.
[140] Gordon Corera, *Shopping for Bombs* (London: Hurst & Company, 2006), p. 222.
[141] Levy & Clark, op. cit., pp. 100-101.
[142] Ibid, p. 97.
[143] Douglas Frantz and Catherine Collins, *The Nuclear Jihadist* (New York: Twelve Books, 2007), p. 150.
[144] Ibid, p. 111.

Therefore, were there any other sources of the atomic bomb design for KRL? It may have been that PAEC's design was passed on to KRL through Gen. Naqvi, while A. Q. Khan claims that his design had been passed on to PAEC through Gen. Arif. In this respect, Hafeez Qureshi claims to have been directed sometime in 1982-83 by the Chairman of PAEC that all the work done by the Wah Group and DTD on the design and trigger mechanism of the bomb should be delivered to Gen. Naqvi. This he claimed was necessary because Gen. Zia had asked all the design and technical information on the bomb project to be kept in safe custody of the G.H.Q. Hafeez Qureshi then asked Munir Khan whether doing so would be wise and appropriate and whether the Chairman had confirmed the authenticity of the directives from the President himself. He was told that the orders had come directly from the President and therefore had to be complied with.[145]

Qureshi also claimed that only a fortnight after he had delivered the designs and data on the bomb to Gen. Naqvi, a representative of KRL had turned up at the Wah Group's special high-explosive factory. This person produced "the exact specifications of the explosive lenses developed by the Trigger Group," which had developed the lenses for the nuclear device under Zaman Sheikh. This implied that the PAEC bomb designs submitted with Gen. Naqvi had been passed on to KRL. However, A. Q. Khan claimed the whole story to have been the other way around, i.e. KRL's designs had been passed on to PAEC.[146] Furthermore, A. Q. Khan claims that sometime in the summer of 1983, Gen. Zia had undergone a gall-bladder operation, when he met Gen. K.M. Arif and showed him pictures of the cold tests and the nuclear devices, which KRL had developed. He further claimed that Arif on seeing the pictures "turned blue" and asked about the design of the bomb, along with the designs of the Kahuta enrichment plant. A. Q. Khan told him that these had been placed with the GHQ on Gen. Zia's orders, and later claimed that Gen. Arif had made their copies and passed them on to PAEC, which Arif denies.[147] A. Q. Khan claims that PAEC then duplicated his bomb designs.[148]

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[145] Shahid-ur-Rahman, op. cit., p. 105.
[146] Ibid.
[147] Interview with Gen. K. M. Arif, op.cit.
[148] Shahid-ur-Rehman, Ibid, p. 80.

It is however likely that after the Chinese bomb designs, which A. Q. Khan was carrying in his suitcase were produced before Gen. Zia and Munir Khan, and the President may have directed A. Q. Khan to submit them with GHQ for safekeeping. However, recently *The Washington Post* published a story supposedly based on an eleven-page handwritten letter of A. Q. Khan to his friend and British journalist Simon Henderson. The story attributing A.Q. Khan stated that he had obtained 50 kg of weapon-grade enriched uranium and a bomb design from China in 1982.[149] A. Q. Khan also appears to have confirmed the presence of the Chinese design in 1998 when he claimed: "there was no technical need to proceed with hot tests, since Pakistan had a design of proven reliability."[150] Thus, the origin of KRL's nuclear weapons design and development programme can be determined with a greater degree of certainty. Equipeed with a tested design available, A. Q. Khan's procurement agents attempted to buy equipment and materials such as neutron generators, flash x-ray equipment used in nuclear tests, metal hemispheres and dished plates, high-speed cameras and detonators.[151] These items were specifically useful in a nuclear weapons programme.

With regard to converting the enriched uranium to metal, it appears that KRL also began a parallel programme in this area in completion with PAEC. A. Q. Khan claimed at the time of the 1998 tests that KRL was the first one to have converted enriched uranium into metal.[152] It was also claimed that "for reasons of security and some other considerations, enriched uranium is now converted into metal by KRL itself,"[153] and "at Kahuta, uranium gas is enriched to weapons grade level and at a nearby facility converted into metallic cores for uranium devices."[154] A. Q. Khan also reportedly obtained know-how to establish facilities in KRL to covert enriched uranium into metallic cores for a nuclear device from the German subsidiary of URENCO, known as

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149 R. Jeffrey Smith and Joby Warrick, "A nuclear power's act of proliferation," *The Washington Post,* November 13, 2009. Available at: http://www.washingtonpost.com/wp-dyn/content/article/2009/11/12/AR2009111211060.html?sid=ST2009111300578 (accessed May 30, 2010).
150 Mark Fitzpatrick, *Nuclear Black Markets: Pakistan, A. Q. Khan and the Rise of Proliferation Networks* (London: International Institute of Strategic Studies, May 2007), p. 32.
151 David Albright, op. cit., p. 48.
152 Rai Muhammad Saleh Azam, op. cit.
153 Shahid-ur-Rahman, op. cit., p. 67.
154 Ibid. p.94.

URANIT.[155] This was reportedly later passed on to China by A. Q. Khan, which then passed it on to Iran.[156] With regard to the source of KRL's bomb design, some sources claim that PAEC may have been the original recipient of a Chinese design, which was then passed on to A. Q. Khan by Gen. Zia.[157]

Nevertheless, it is likely that KRL was unable to continue any cold tests after 1984 and the mandate to develop the nuclear weapons programme continued to rest with PAEC. It is also likely that the one cold test carried out by KRL in 1984 was not successful and might also have been a test of a crude nuclear device. It may also have been that Gen. Zia prohibited KRL from putting any more resources in this effort when its basic mandate was still far from complete.[158] In addition, it can be presumed that KRL did not have the manpower, expertise and resources to sustain an indigenous and comprehensive nuclear weapons design, development and testing programme. It lacked a dedicated theoretical physics design team, a special expolsives plant, and specialized diagnostic equipment. It may be recalled that PAEC had initiated basic design work on the nuclear device as early as 1972 and was only successful in carrying out its first cold test some eleven years later.

However, it managed to rapidly improve and expand its design, development and testing infrastructure and accumulated sufficient know-how and the working nuclear devices themselves, which enabled it to carry out the 1998 tests. PAEC also carried out twenty-four cold tests following its first test of 1983 whereas KRL was only able to conduct one in 1984. Given that all nuclear weapon states have carried out several cold and hot tests to prove the dependability of their weapon designs, it is evident that an on-going cold test programme was needed for the survival and growth of any such programme. In Pakistan's case, this however, was only true for PAEC, which was possible only because dedicated manpower, laboratories and knowhow was continuously

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[155] Mark Hibbs, "Agencies Trace Some Iraqi Urenco Know-How to Pakistan Re-Export," *Nucleonics Week,* November 28, 1991, p.1.
[156] Ibid.
[157] Mark Fitzpatrick, ed. *Nuclear Black Market: Pakistan, A.Q. Khan and the Rise of Proliferation Networks- A Net Assessment* (London: International Institute of Strategic Studies, 2007), p. 32; and David Albright, op. cit., p. 259n.
[158] For details, please see Chapters 7 and 8.

developed in all areas of nuclear design, development and testing for over a decade, and no short-cut was attempted or planned.[159]

Hence, it was PAEC which continued to carry out cold tests of different nuclear weapon designs and was responsible for the 1998 nuclear tests. This implies that the Chinese bomb design, obtained by A. Q. Khan and passed on to Libya, was not used by Pakistan's nuclear weapons programme. In this regard, Dr. Samar Mubarakmand thus claimed that Pakistan's nuclear weapons technology was indigenous and not borrowed from outside.[160]

9.8. The Chaghi and Kharan Tests

In the wake of India's nuclear tests on May 11th and 13th, 1998, the balance of power in South Asia was qualitatively changed forever. India had gone overtly nuclear and it presented an open challenge to the international community, but Pakistan was directly faced with a nuclear challenge. India's nuclear test now provided Pakistan with the choice to demonstrate its nuclear capability and restore the balance of power in the region. It was also a chance for PAEC to do what it had been denied since the early 1980s, i.e. to carry out a hot test. Soon after India's May 11th test, when a senior Pakistani military officer called up Dr. Samar Mubarakmand, then Member (Technical) PAEC, and asked him if he had heard the news regarding India's test in Pokhran, he replied, "Congratulations!" Hearing this, he got a bit of a shock and asked: "You are congratulating us on India's tests?" to which Samar replied: "Yes, because now we would get a chance to do our own tests." [161]

Dr. Ishfaq Ahmad, who succeeded Munir Ahmad Khan as Chairman of PAEC, in 1991, also expressed similar views. After the 1998 tests, he claimed that, "we were ready for a nuclear detonation as early as early 1980s and the opportunity was only provided to

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[159] Haris N. Khan, "Pakistan's Nuclear Programme: Setting the Record Straight," *Defence Journal* (Karachi) Vol. 13, No. 13 (August, 2010).
[160] Samar Mubarakmand's Punjab University Speech, op. cit.
[161] Ibid.

us by Mr. Vajpayee.” [162] In the wake of the Indian tests, a meeting of the DCC was called on the morning of May 13, 1998, at the Prime Minister’s Secretariat, Islamabad, to assess the geo-strategic situation.[163] This meeting was, in addition to the Prime Minister, attended by the Chairman Joint Chiefs of Staff Committee and Chief of the Army Staff, General Jehangir Karamat, Chief of the Air Staff, Air Chief Marshal Perviaz Mehdi Qureshi, Chief of the Naval Staff, Admiral Fasih Bokhari, Minister for Finance, Sartaj Aziz, Minister for Foreign Affairs, Gohar Ayub Khan and the Foreign Secretary, Shamshad Ahmad.[164] As Dr. Ishfaq Ahmad was abroad on a visit to the United States, he was represented by Member (Technical) PAEC, Dr. Samar Mubarakmand. He gave a technical assessment of India’s tests and Pakistan’s preparedness to respond in kind. Also in attendance was Dr. A. Q. Khan, Director of the Khan Research Laboratories.[165]

There were two main points on the DCC’s agenda that day. Firstly, should Pakistan respond to India by its own tests and which organization from within the country’s nuclear establishment ought to be assigned this gigantic assignment? Dr. Samar Mubarakmand gave a technical assessment on behalf of PAEC, and claimed that India’s some of India’s tests were failures. He asserted that PAEC could carry out the tests for Pakistan within ten days of a decision.[166] A. Q. Khan on behalf of KRL made similar claims.[167]

However, Dr. Samar Mubarakmand who was present in the meeting and would head the nuclear test team claimed that when the Prime Minister asked the participants “what was their point of no return, in case he decided to cancel the decision to test at the last moment,” there were two replies. According to him, A. Q. Khan replied that his point of no return was two minutes, while the Samar stated it to be seventy-two hours. Mubarakmand claims that this was the moment when the Prime Minister realized that A. Q. Khan “did not know what he was talking about.” Hence, attention was diverted to

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[162] Dr. Ishfaq Ahmad, Speech delivered at the Chaghi Medal Award Ceremony, Pakistan Nuclear Society, PINSTECH Auditorium, Islamabad. March 20, 1999.
[163] “All Aspects of N-Test Evaluated,” *Dawn,* May 14, 1998.
[164] Rai Muhammad Saleh Azam, op. cit.
[165] Ibid.
[166] Ibid.
[167] Ibid.

PAEC whose scientists briefed the meeting that nuclear testing was their job and mandate. [168]

While the DCC remained indecisive about these two agenda points, Dr. Ishfaq Ahmad, Chairman, PAEC returned from the United States on May 16, 1998. The following morning, he was summoned by the Prime Minister along with Dr. Samar Mubarakmand, and asked for his opinion on the two undecided agenda points of the May 13 DCC meeting. The Chairman of PAEC, informed the Prime Minister that the decision to test or not rested with the Government, but the PAEC was ready to do its duty as and when required to do so. The Prime Minister told Dr. Ishfaq Ahmad that in case of any failure in conducting the tests, India would be poised to embark on any misadventure against Pakistan, and it would cast serious doubts on Pakistan's nuclear capability. The Chairman of PAEC, while assuring the Prime Minister said: "Mr. Prime Minister, take a decision and, God willing, I give you the guarantee of success." [169]

The May 13 meeting of the DCC, however, had remained inconclusive about the two agenda points that would determine Pakistan's future course of action in response to India's test. Therefore, an exclusive meeting of DCC was held again on May 17 or 18, 1998, chaired by the Prime Minister and attended by the three Service Chiefs. This meeting finally decided that Pakistan will give a matching response to India's tests and that PAEC would carry out the tests, as it was the best suited and most experienced organization to carry out this Herculean task successfully.[170] Dr. Samar Mubarakmand maintains that PAEC was given the task of carrying out the nuclear tests at Chaghi and Kharan since the weapons were produced by PAEC, as were the testing infrastructure and capability and the team for carrying out this task was also working on it for several years.[171]

Consequently, the then Member (Technical) PAEC, Dr. Samar Mubarakmand went to Chaghi with 140 scientists, engineers and technicians and conducted these tests. Prior to their being dispatched to Chaghi, the Prime Minister again summoned Dr. Ishfaq

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[168] Interview with Samar Mubarakmand, op. cit.
[169] Rai Muhammad Saleh Azam, op. cit.
[170] Ibid.
[171] Samar Mubarakmand, Interview with Hamid Mir. op.cit.

Ahmad, on May 18, 1998, and communicated the DCC's decision to carry out the tests. The Prime Minister's exclaimed in Urdu: "Dhamaka Kar Dein," meaning "Conduct the explosion". [172] A. Q. Khan for his part lodged a protest with the Chief of the Army Staff, Gen. Jehangir Karamat.[173] He also wrote a letter to Lt. Gen. Zulfiqar, the then head of the Combat Division Directorate in the G.H.Q on May 20, 1998. Mubarakmand claims that A. Q. Khan stated in his letter: "Samar and his team at PAEC are a bunch of blacksmiths and carpenters. Their device is inferior to mine and won't work. Therefore, I should be allowed to carry out the test."[174] Samar also claims that soon after India's tests of May 11 and 13, 1998, A. Q. Khan sent a senior KRL scientist to PAEC on May 14, who put forward a request to Samar to "lend KRL some nuclear devices in case the Government assigned the task of carrying out the test to KRL."[175] In addition, Dr. Samar claims that when he asked the visiting KRL scientist, "why don't you test all those nuclear devices which you have been claiming to have built all these years in KRL," the scientist disdainfully replied that none of them were working devices.[176]

The visitor was then told that PAEC was running the nuclear weapons programme since 1974 and should not be expected to hand over any thing to someone who had no experience, expertise or know-how in the field.[177] However, as a result of A. Q. Khan's letter to Gen. Zulfiqar, it was decided that a team of KRL scientists would be allowed to witness the tests as guests and observers, but would not participate in the testing itself. [178] Nevertheless, Dr. Ishfaq Ahmad went back to his office and gave orders to his staff to prepare for the tests and called for an urgent extraordinary meeting of the top PAEC executives, scientists and engineers. Thereafter, the Pakistani armed forces and other relevant institutions were ordered to assit the testing team in providing all

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[172] Rai Muhammad Saleh Azam, op. cit.
[173] Ibid.
[174] Interview with Samar Mubarakmand, op. cit.
[175] Ibid.
[176] Ibid.
[177] Ibid.
[178] Ibid.

round logistic support in transporting the teams, the weapons, components and other necessary equipment to the test site in addition to providing physical security.[179]

Moreover, in the wake of the decision to carry out the tests, a high level meeting was urgently called in PAEC Headquarters, chaired by Dr. Ishfaq Ahmad, and attended by Dr. Samar Mubarakmand. During the meeting, it was decided to derive maximum benefit from the hot tests since only cold tests had been performed earlier. Therefore, multiple tests would be carried out of bombs with different designs and yields. As the Ras Koh Hills in Chaghi housed five horizontal shaft tunnels and the Kharan site had one vertical shaft, it was decided to conduct six nuclear tests in all, in which different bomb designs and yields would be tested. All these designs had been successfully tested in cold tests earlier.[180]

The test preparations began with quality control checks on the various components of the nuclear devices to be tested and the diagnostics equipment. A massive logistical operation with the help of the Pakistan Army and Air Force also began in earnest to transport the men, equipment, and the devices themselves to the Chaghi test site. On May 19, 1998, two teams comprising 140 PAEC scientists, engineers and technicians left for Chaghi, Baluchistan. They included members of various specialized teams from the DTD.[181] All the installations including the tunnel portals and the instrumentation and fire control cables leading into the tunnel shafts were effectively camouflaged.[182]

The nuclear devices were themselves airlifted in semi-assembled form via flown PAF C-130 transport aircraft from PAF Chaklala, Rawalpindi to Dalbandin Airfield.[183]

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[179] Rai Muhammad Saleh Azam, op. cit.

[180] Ibid.

[181] Ibid.

[182] "The facilities were made to look like a small hamlet using adobe huts so as to deceive satellite surveillance. The tunnel portal itself was located inside an adobe hut. Barbed wire was placed around all the facilities so as to minimize the number of tracks and to keep pedestrian and vehicular movement on designated tracks. A team of soldiers assigned to the task continuously erased vehicle tracks caused by incoming and outgoing trucks and jeeps. Support camps were established a few hundred yards away from Ground Zero at both the sites. These included lodging, food and water, restroom, shelter and communications facilities. These too were camouflaged. At Ras Koh, these support facilities were located directly south of the mountain in which the shafts had been bored." Rai Muhammad Saleh Azam, Ibid.

[183] Ibid.

Once at the Dalbandin airfield, the sub-assembled parts of the nuclear devices were separately taken in sub-assembled form to the test sites at Ras Koh Hills and Kharan on Pakistan Army Aviation Mil Mi-17 helicopters. At Ras Koh Hills in Chaghi, these devices were placed in five separate 'Zero Rooms' situated latterly of the kilometer long horizontal tunnels.[184] Reportedly, Dr. Samar Mubarakmand personally supervised the complete assembly of all the components of the five nuclear devices. Subsequently, the diagnostic cables were laid from the tunnel to the telemetry. These connected all the five nuclear devices with a command observation post ten kilometers away. All this took five days to complete. On May 25, 1998, soldiers of the Pakistan Army's 12 Corps arrived to seal the tunnel.[185]

By the evening of May 26, 1998, the tunnels were sealed and plugged. The following day the cement had entirely solidified owing to the extreme heat. When the engineers declared that the concrete had toughened and the site was set for performing the tests, the same was communicated to the Prime Minister of Pakistan. It was thus decided that the date and time for Pakistan's first nuclear hot tests would be for 3:00 p.m. on May 28, 1998.[186]

9.8.1. Pakistan's Finest Hour [187]

Prior to the tests on May 28, 1998, all civil and military personnel were evacuated from 'Ground Zero' except for members of the Diagnostics Group and the firing team. They were involved in clearing the site of some paraphernalia from 1978.[188] At 1.30 pm, on May, 28, ten members of the team reached the Observation Post (OP) which was located

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[184] Ibid.

[185] "Engineers and technicians from the Pakistan Army Engineering Corps, the Frontier Works Organisation (FWO) and the Special Development Works (SDW) supervised them. Dr. Samar Mubarakmand himself walked a total of 5 kilometers back and forth in the hot tunnels checking and re-checking the devices and the cables, which would be buried forever under the concrete, despite the fact that it was suffocating inside the tunnel. This was due to cement that was being mixed with the sand inside the tunnels. Finally, the cables were plugged into the nuclear devices. The process of the sealing the tunnels thereafter began with the mixing of the cement and the sand and their pouring into the tunnels. It took a total of 6,000 cement bags to seal the tunnel and twice the amount of sand." Please see Rai Muhammad Saleh Azam, Ibid.

[186] Ibid.

[187] Ibid.

[188] Ibid.

ten kilometres away from Ground Zero, who checked the firing equipment one last time. An hour later, an Mi-17 helicopter arrived at the site, carrying a team of observers and guests, including Dr. Ishfaq Ahmed, Dr. A. Q. Khan, and four other scientists from KRL including Dr. Fakhr Hashmi, Dr. Javed Ashraf Mirza, Dr. M. Nasim Khan and S. Mansoor Ahmed. A Pakistan Army team headed by Lt. Gen. Zulfiqar Ali Khan accompanied them.[189] When Dr. A. Q. Khan arrived at the site, he went into the Command Post and according to Dr. Samar Mubarakmand, asked: “which button is to be pushed?”[190]

Dr. Samar Mubarakmand claims to have replied to A. Q. Khan that the man who would push the button had already been selected and the relevant persons involved had been assigned their respective tasks.[191] Therefore, when the all-clear signal was given, a young Chief Scientific Officer of DTD, Muhammad Arshad, who had designed the triggering mechanism, pushed the button. At exactly 3:16 p.m. Pakistan Standard Time (P.S.T.) he pushed the button and the computerized control system was activated which produced the signal to the devices for detonation.[192] After thirty seconds of pushing the button, the earth in and around the Ras Koh Hills trembled, and the mountain shook and changed colour to white. Dr. Samar Mubarakmand said that the five devices that were tested at Chaghi on May 28 and the one at Kharan on May 30 were all based on PAEC designs.[193] He also insisted that the nuclear tests at Chaghi had been performed entirely by the nuclear test team of PAEC scientists, engineers and technicians. According to him A. Q. Khan was invited at the time of first explosions and was accompanied by Ishfaq Ahmad. “They reached there ten to fifteen minutes before the tests and joined the prayers. We performed for the success of the explosions. They stayed for ten to fifteen minutes after the explosions and then left."[194]

When Dr. A Q Khan reached the test site, he reportedly asked the Chairman of PAEC, Dr. Ishfaq Ahmad about the colour and shape of the mountain after the nuclear

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189 Ibid.
190 Dr. Samar Mubarakmand, Interview by authour, op. cit.
191 Ibid.
192 Rai Muhammad Saleh Azam, op. cit.
193 Shahid-ur-Rahman, op. cit., p. 11.
194 Ibid.

explosion. Dr. Ishfaq replied that the mountain would turn white after the devices exploded in the tunnels in the mountain.[195] Muhammad Hussain Chughtai, who had been involved in preparing the Chaghi test site for years, later claimed that A. Q. Khan first visited the Chaghi site on May 28, 1998.[196] Immeditately after the Chaghi tests, the PAEC's Directorate of Technical Development (DTD) issued the following statement that the five tests of May 28 measured 5.0 on the Richter scale and had not released any radiation.[197] These boosted devices were also stated to be akin to a half way stage towards a hydrogen bomb as these were boosted with tritium.[198] The DTD for its part issued the following statements immediately after the tests:

> The mission has, on the one hand, boosted the morale of the Pakistani nation by giving it an honourable position in the nuclear world, while on the other hand it validated scientific theory, design and previous results from cold tests. This has more than justified the creation and establishment of DTD more than 20 years back. Through these critical years of nuclear device development, the leadership contribution changed hands from Mr. Munir Ahmad Khan to Dr. Ishfaq Ahmad and finally to Dr. Samar Mubarakmand (Member Technical). These gifted scientists and engineers along with a highly dedicated team worked logically and economically to design, produce and test an extremely rugged device for the nation, which enabled the Islamic Republic of Pakistan from strength to strength. By the grace of Almighty Allah, the PAEC as an organization has proven to be the pride of the Pakistani nation.[199]

The Pakistani Foreign Ministry would later describe the Chaghi tests as "Pakistan's finest hour." Pakistan had become the world's seventh nuclear power and the first nuclear weapons state in the Islamic World.[200]

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[195] Tariq Butt, "Pakistan would have attacked India in 1998," *The News* (Islamabad), April 18, 2009.
[196] Muhamamd Hussain Chughtai, Interview with *Daily Nawa-i-Waqt* (Rawalpindi), June 30, 1998.
[197] Federation of American Scientists. "May 1998 Pakistan Special Weapons News: APP News Summary," May 30, 1998. http://www.fas.org/news/pakistan/1998/05/980530-app.htm (accessed on December 6, 2008).
[198] Munir Ahmad Khan quoted in Federation of American Scientists (FAS). "Pakistan's Nuclear Weapons Program-1998: The Year of Testing." http://nuclearweaponarchive.org/Pakistan/PakTests.html (accessed on December 6, 2008).
[199] Ibid; M. A. Chaudhri, "Pakistan's Nuclear History-Separating Myth from Reality," *Defence Journal* (Karachi), Vol 9, No. 10 (May 2006); *The News* (Islamabad), Special Edition (Nuclear), May 31, 1998.
[200] Rai Muhammad Saleh Azam, op. cit.

9.8.2. The Kharan Test

On Saturday, May 30, 1998, Pakistan conducted its sixth nuclear test at 1:10 p.m. (Pakistan Standard Time) in the Kharan Desert.[201] On May 29, 1998, Samar Mubarakmand, along with a new testing team, shifted to the test site in the Kharan desert, 150 km away from Chaghi, carrying a sub-system of a “miniaturized device”. The Kharan test site was shaped like a vertical well, 300-400 feet deep. At the bottom of this site, there was a horizontal tunnel, 700 feet long. Since the detonation took place at the end of this tunnel, therefore it was designed as an L-shaped configuration” [202] The miniaturized device was also assembled in the zero room, at the end of the horizontal tunnel, as was done two days earlier at Chaghi. [203]

The device tested on May 30th, 1998, was claimed to be a most modern weapon design and a real wonder, which was produced by the Theoretical Group. It gave a yield of about 60 % of the first test, i.e. 18-20 kt.[204] This test was witnessed from a distance of fifteen kilometers on a site which rested on sand. This in turn prevented any termors from being felt by the observers. However, the oscillators succeeded in registering the data from the test. Nevertheless, in order to confirm that the test had indeed been a success, Dr. Samar Mubarakmand flew over the site on a helicopter and saw that a mountain had emerged at the site, while it was pure flat sand earlier, thus marking the ground zero. [205]

The May 30 test is believed to be of immense significance for Pakistan. It was the latest and best design that PAEC had developed and had earlier been tested in cold tests, but the hot test validated the theoretical design parameters of the test. As it was a miniaturized device, it was very small in size, and is very efficient and powerful in yield. It is this design, which is being fitted on to Pakistan’s ballistic missiles and aircraft. Therefore, the success of this test proved that Pakistan could now deploy nuclear

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[201] Ibid.
[202] Dr. Samar Mubarakmand’s Punjab University Speech, op. cit
[203] Shahid-ur-Rahman, op. cit., p. 14.
[204] Ibid, pp.14-15.
[205] Ibid. 15.

warheads on ballistic missiles.[206] American aircraft also claimed to have picked up traces of weapons-grade plutonium from the atmospheric debris of the Kharan test. However, there was intense controversy between the Lawrence Livermore National Laboratory and the Los Alamos National Laboratory about the authenticity of the claim that the debris contained traces of weapons-grade plutonium. Dr. Samar Mubarakmand, however, did not confirm or deny anything about the fissile material used in the sixth test, which implies that the sixth test was most likely of a weapon, which used a mixture of weapon-grade plutonium and highly enriched uranium and boosted by tritium.[207]

Nonetheless, the fact that no photographs of the Kharan site were released and no journalist or media person was allowed to visit the site also fuelled speculations about the type of material used in the test. Therefore, the exact nature of the fissile material used in the sixth test is likely to remain a mystery. On return of the PAEC test team was accorded a warm welcome at the Islamabad International Airport.[208]

9.9. Concluding Comment

Pakistan began research and development work and acquisition of necessary know-how for the atomic bomb right after India's nuclear explosion of May 18, 1974. However, preliminary work was already underway in PAEC and India's test forced Pakistan to begin a crash programme on nuclear weapons. In this regard, PAEC began indigenous work on all aspects related to the design, development and testing of nuclear weapons. These projects were being developed in parallel with several other fuel cycle projects. However, while nuclear weapons development was the mandate and responsibility of PAEC, A. Q. Khan also tried to set up a parallel weapons project in KRL, ostensibly with the blessing of Gen. Zia. This programme apparently failed cold tests. Therefore,

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[206] Samar Mubarakmand, Interview with Hamid Mir. op. cit.
[207] Shahid-ur-Rahman, op. cit., p. 15.
[208] "Nuclear Scientists Get Hero's Welcome on Return from Chaghi," *Business Recorder* (Islamabad), June 1, 1998.

PAEC, which had a head start and a much broader nuclear weapons programme with specialized groups working on different aspects of nuclear weapons development, continued carrying out cold tests and was therefore, assigned the responsibility of the hot tests at Chaghi. Moreover, Pakistan did not use any Chinese designs in its nuclear weapons programme, which were however, obtained by A. Q. Khan, and then reportedly found in Libya.

From a theoretical perspective, PAEC's decision to embark on the design work on the atomic bomb as early as December 1972 signifies that the "security imperative" was the critical factor in this decision. It was clear to Munir Khan and Bhutto that India was fast developing nuclear explosives and eventually Pakistan would have to be ready as well. Therefore, this signifies the validity of the rational-actor model. As is evident in previous chapters, the bureaucratic rivalry and domestic politics also played a key role in nuclear weapons development in Pakistan. It is highly likely that the weapons programme at KRL, did not contribute to Pakistan's nuclear weapons design, development or testing. This validates Sagan's assumption that "even if the pursuit or acquisition of the bomb serves the national interest of a state, it may serve the parochial or bureaucratic interests of some individual actors in that state." A. Q. Khan had increasingly become an influential player in the nuclear establishment and he wanted to expand his area of responsibilities. This meant that he wanted to compete with PAEC in weapons design and development as well.

Thus, he may have succeeded in convincing some decision-makers to sanction resources to him to set up a parallel weapons effort at KRL. In doing so, he may also have employed the nuclear myth that others in PAEC were not delivering the goods, which he could deliver more efficiently. A similar duplication of effort was seen in the field of uranium metallurgy. Nevertheless, this chapter validates the basic assumptions of the bureaucratic politics model. This chapter also signifies the transformation from stage two to stage three in nuclear decision-making wherein an operational capability evolved into a weapons capability. Moreover, the 1998 nuclear tests for the first time led to the open bureaucratic tussling between PAEC and KRL, which had begun in 1976 and this rivalry became pronounced at the time of testing. Following the tests, both sides openly used the media to downplay the other. However, in the final anaylsis, both KRL and PAEC worked together as a team in the overall nuclear programme. Without, PAEC's mastery over the front end of the fuel cycle, the feedstock for enrichment could not have been made. Similarly, without KRL's success in enriching uranium gas, PAEC could not produce its own fissile core, although the plutonium option was always there. Moreover, without the development of a successful weapon design and its complicated trigger mechanism, and the elaborate testing infrastructure, the fissile material itself was of little use, perhaps only for a dirty bomb.

CONCLUSION

Pakistan began its nuclear quest, not as a strategic necessity per se, but as a result of the technological promise, which Atoms for Peace and atomic energy seemed to offer to developing countries. This opportunity was appreciated by the Pakistani bureaucracy and several positive initiatives taken during the formative years of PAEC paid dividends in subsequent decades. Had the training of scientists and engineers not been harnessed by Pakistan through the Atoms for Peace Programme, it would have been virtually impossible to develop the technological base and knowhow needed to set up even a small civilian nuclear programme. Pakistan was thus also able to capitalize on the prevalent conducive international climate for cooperation in civilian and peaceful uses of atomic energy by acquiring a research and power reactor and building PINSTECH.

However, even as the formative phase of Pakistan's nuclear programme was useful in many ways, yet it was also an era of lost opportunities and shortsighted decision-making by the civil-military bureaucracy. This was a time when Pakistan could have matched India in acquiring the necessary know-how and technology that could have provided it with a "Nuclear Option." Hence the path to nuclear self-reliance was not taken because of intense bureaucratic rivalries among different government departments and PAEC and because of lack of long-term strategic planning, both in PAEC and at the political level. Moreover, in spite of having been warned and informed of India's growing nuclear march towards nuclear weapons capability, the decision makers in Pakistan, primarily outside PAEC, chose to look the other way. PAEC itself did not enjoy the administrative and financial autonomy as it remained an attached and sub-ordinate government department whose affairs were relegated to several committees.

Furthermore, the genesis of Pakistan's nuclear weapons programme had its roots in the wake of the 1965 war, and in the ensuing consensus reached on the issue between Zulfikar Ali Bhutto and Munir Ahmad Khan. The former provided the political pathway to a nuclear deterrent capability, while the latter the roadmap for obtaining the technical means to build it. They were further assisted by events leading up to the separation of East Pakistan and the growing restlessness and anger among the young scientists and engineers who also wanted Pakistan to become a nuclear power. The 1971 Indo-Pakistan war, however, sealed the fate of the civil programme which was carefully nurtured by Dr. Usmani, who himself became the victim of the PAEC and the nuclear hawks' coalition. The radical change in the direction and mandate of the PAEC came during the Multan Conference, which was a watershed event in the country's nuclear history. For the first time, the stakes, stands, perceptions and motives of the scientists and engineers in the nuclear establishment converged with that of the political leadership. It also signaled an end to the bureaucratic control over PAEC as it was placed directly under the control of the Chief Executive of Pakistan. In the wake of the Multan meeting, Munir Ahmad Khan replaced Dr. Usmani and PAEC was re-organized with a clear roadmap to acquire nuclear capability.

Following the 1972 decision to acquire nuclear capability, it was clear that without acquiring mastery over the nuclear fuel cycle, a vibrant and self-reliant nuclear programme, both on the civil and military side, could not be sustained. Therefore, Pakistan initially opted for the acquisition of fuel cycle facilities and the technology to master this goal, through international cooperation, and under safeguards. However, India's nuclear test forced Pakistan to face the brunt of international non-proliferation sanctions when its nuclear programme had just begun its journey towards the acquisition of the nuclear option. In this situation, Pakistan had no choice but to develop these facilities indigenously. India's so-called Peaceful Nuclear Explosion of 1974 also forced Pakistan to launch a crash programme to develop a nuclear weapons programme and complete the fuel cycle. Now the nuclear establishment, with Bhutto in the lead, had to prove to the people and the world that denial of technology could not prevent a dedicated and determined nation to acquire and master the most challenging of all technologies.

Moreover, Pakistan's mastery over the fuel cycle also demonstrated its resolve to develop an indigenous fissile material capability and was therefore an integral part of its nuclear weapons programme. As part of the overall nuclear plan, PAEC began work on establishing numerous plants and facilities, which included: uranium refining and processing; uranium oxide and hexafluoride production or uranium conversion; uranium enrichment; nuclear fuel fabrication; and nuclear fuel reprocessing. PAEC embarked on its indigenous nuclear fuel cycle programme in the wake of India's nuclear test and had completed all plants and facilities comprising the fuel cycle by 1981. By this time, the gas-centrifuge enrichment project had also become operational. On the other hand, only one project—the gas-centrifuge—remained outside PAEC control under Dr. A. Q. Khan. PAEC's long-term nuclear plan of 1972 was designed to provide Pakistan self-sufficiency in complete nuclear fuel cycle technology. This was accompanied by an ambitious nuclear power and reactor programme, which would not only cater to Pakistan's nuclear power and energy requirements. It was also designed to develop the capability to enable Pakistan of producing weapon-grade plutonium and tritium. The success of both these programmes required the establishment of a strategic and high technology industrial infrastructure that would be able to support the engineering and manufacturing needs of PAEC.

Therefore, all these projects were launched in parallel, or in order of priority, as and when the resources became available. They became a litmus test of Pakistan's ability to master nuclear power and reactor technology, in defiance of sanctions and restrictions by supplier states. When these countries walked out of international agreements with Pakistan, it also became a challenge to become self-reliant in the design, manufacturing, testing and production of all that was necessary for a sustainable nuclear programme. Just as the military or weapon-oriented programmes and projects were launched and implemented on a priority basis, other projects, like civilian nuclear power were temporarily suspended. These also became a victim of international sanctions due to Pakistan's persistent refusal to open its nuclear programme for inspections and sign the NPT, unless India did the same.

Moreover, those technocrats/scientists/engineers in favour of indigenization and self-reliance within Pakistan's nuclear establishment were ultimately successful in implementing their ambitious plans for the Khushab-1 reactor project and other associated facilities. Their vision of making Pakistan a plutonium producing country, and acquiring the knowhow for and developing an indigenous corps of trained manpower in the design and manufacturing of nuclear reactors, heavy water and tritium production plants has proven its worth today. Following the successful commissioning of KCP-II, Pakistan has now completed of two additional plutonium production reactors, and CHASNUPP-2. In military terms, these successes imply that Pakistan can now produce its own reactors and has the capability to develop and deploy advanced miniaturized warheads. Coupled with the tritium production capability, Pakistan can now develop boosted fission weapons. These projects also have allowed Pakistan to embark on a nuclear triad-based deterrent capability. The successful completion of KCP-II and CHASHNUPP-1 projects will also help Pakistan to design and develop Pressurized Water Reactors for a future nuclear submarine programme, which is seen as an assured second-strike platform. Pakistan had identified its priorities in terms of the plants and facilities needed to build indigenous capabilities in the nuclear fuel cycle. These were intended to achieve self-sufficiency in nuclear technology and to provide a parallel nuclear deterrent.

In this respect, the Chashma reprocessing plant project was conceived and all available avenues explored. While Chashma was essentially an effort aimed at acquiring state-of-the art reprocessing know-how, it was never intended to be used in producing plutonium for the nuclear weapons programme. There is no evidence to suggest that violating IAEA safeguards for KANUPP or any other future power reactor was ever part any one's plans or motives, either within or outside the nuclear establishment. Nor was any diversion of fuel necessary since Chashma was to be part of the civilian nuclear power programme, and not the bomb programme. Moreover, even though PAEC acquired the necessary knowhow and detailed designs for the Chashma reprocessing plant, lack of political commitment in Pakistan prevented PAEC from completing it indigenously. In this respect, the bureaucratic rivalry between PAEC and KRL also played it part. This was a time when the gas-centrifuge enrichment plant at Kahuta was nearing completion and commissioning and finances were being prioritized by the Government. It is also likely that reprocessing was shelved as a priority for the time being and not seen as an immediate technical or political requirement.

Similarly, PAEC's indigenous and safeguards-free New Labs reprocessing plant was completed by 1981 which provided Pakistan with the capability to reprocess enough spent nuclear fuel for several nuclear devices per year. It had been completed and made ready for reprocessing in the early 1980s, and reprocessing test runs carried out by 1987. However, Pakistan did not use it to reprocess KANUPP's safeguarded spent fuel to produce plutonium, while the capability for doing so had been achieved. Pakistan had voluntarily extended IAEA safeguards on KANUPP and its spent fuel even after the Canadian's had cut off supplies of fuel and spare parts for the plant in 1976. This was done in spite of the fact that Pakistan had starting producing its own nuclear fuel for the plant. It was only when PAEC had completed the Khushab-1 plutonium production reactor that New Labs was activated for spent fuel reprocessing. Therefore, both New Labs and Chashma were milestones in Pakistan's nuclear history, which demonstrated the will and the ability to develop nuclear technology in the face of stiff sanctions and opposition by critics, both at home and abroad. It was also a manifestation of Pakistan as a responsible nuclear power and the vision of the technical leaders of the nuclear programme, who led Pakistan to nuclear status, without compromising its obligations as a responsible nuclear capable state.

Furthermore, the uranium enrichment programme in Pakistan originated from within the overall plan for nuclear self-reliance of PAEC. The adoption of gas-centrifuge technology for uranium enrichment was also an institutional decision rather than based on the suggestions of any single individual alone. To develop indigenous capability, PAEC launched a multi-pronged strategy, which harnessed all external and internal sources, technical, material, manpower, physical and financial, which ensured its long-term success. Moreover, it was a team effort right from the beginning and was not dependent on the know-how or influence of any one person. The formative phase of this project, which would ultimately provide Pakistan the weapon-grade highly enriched uranium for the core of its nuclear weapons, also brought the hitherto untapped skills and ingenuity of the ordinary Pakistani workers and its scientists and engineers. It was an index of what Pakistan could do on its own, and the organizational skills of the PAEC and ERL in making the seemingly impossible happen.

While PAEC founded the enrichment project, it was developed and expanded for over two decades under the leadership of Dr. A. Q. Khan, who strongly differed with PAEC's management and approach in running the centrifuge project. Eventually, both

Munir Ahmad Khan and A. Q. Khan succeeded in completing their assigned tasks, even though they were professional rivals and competitors. It is important to mention that PAEC had set up an elaborate import-oriented network in Europe during the early 1970s. However, when ERL was separated from PAEC in 1977, its import procurement chain was also gradually separated from PAEC control.

Pakistan began research and development work and acquisition of necessary know-how on the atomic bomb right after India's nuclear explosion of May, 18, 1974. However, theroretical work on the design of the nuclear device was already underway in PAEC and India's test forced Pakistan to begin a crash programme on nuclear weapons. In this regard, PAEC began indigenous work on all aspects related to the design, development and testing of nuclear weapons. These projects were being developed in parallel with several other fuel cycle projects. However, while nuclear weapons development was the mandate and responsibility of PAEC, Dr. A. Q. Khan also tried to set up a parallel weapons project in KRL, which apparently was not successful, and was eventually abolished by the Gen. Zia himself. Therefore, PAEC, which had a head start and a much broader nuclear weapons programme with specialized groups working on different aspects of nuclear weapons development, continued carrying out several cold tests. That is why it was assigned the responsibility of the hot tests at Chaghi.

Nevertheless, Gen. Zia encouraged the fierce rivalry between Munir Ahmad Khan and A. Q. Khan, who in all likelihood was also feeding the President with information against his rival, and vice versa. It may have been that Munir Ahmad Khan and Gen. Zia did not get along very well, at least at the political level, since Munir Khan was a close friend and confidant of Zulfikar Ali Bhutto, and did not hide his dislike for the Martial Law regime. Nevertheless, the evidence suggests that Zia retained Munir Khan as Chairman of PAEC, and due to the vast scale of the work being carried out in PAEC, both on the civil and military oriented projects. Munir Khan was succeeded as Chairman of PAEC in 1991 by Dr. Ishfaq Ahmad. He continued to follow the official policy and culture of secrecy and compartmentalization instituted by his predecessor in PAEC. He also oversaw the completion and commissioning of several projects launched by Munir Ahmad Khan including the Pakistan's nuclear tests of 1998 at Chaghi and

Kharan. This was seen as the “Finest Hour” in the country’s history and the demonstration of nuclear capability to the world, and more precisely to India, which had triggered nuclear tests in 1998.

When India had upped the ante in 1974, Pakistan did not have the capability to respond, but resolved to achieve it within the shortest possible time. The Chaghi and Kharan tests also signaled a shift of Pakistan’s nuclear weapons programme from covert to overt status, with PAEC carrying out the nuclear tests, even though it had been proclaiming a peaceful nuclear programme in the past. The 1998 tests also saw the fulfillment of the work carried out by hundreds of scientists, engineers, technicians, with the support of successive governments, politicians and the military. This work spanned several projects and laboratories and was not concentrated in any one project. Moreover, it was essentially an indigenous enterprise with soft-knowledge and individual materials, machines and equipment being procured where needed, which was eventually either reverse engineered or built from scratch in-house.

Theoretically speaking, it is obvious that three theoretical models largely validate the empricial evidence presented in this study. These include the bureaucratic-politics decision-making model, the nuclear mythmaker model and the technological determinist model. Nevertheless, Pakistan’s nuclear programme and its weapons capability did not originate only due to realist considerations and a threat perception from India. Even as this remained a critical justification for the programme in the wake of the separation of East Pakistan in 1971, other factors remained equally important in determining the nature, scope and direction of the programme. These dynamics can be witnessed right from the inception of the nuclear programme in 1956 and impacted on all aspects and phases of Pakistan’s nuclear history in varying degrees.

The formative phase of Pakistan’s nuclear programme was driven by the technological pull factor along with domestic and bureaucratic politics. Realist considerations were not so pronounced at this stage. Hence, from 1956 to 1972 decision-making regarding the scope and direction of the country’s nuclear programme was shaped by bureacractic tussling between PAEC and the civil bureaucracy. This phase also saw the President of Pakistan sharing the same perceptions with his advisors about

Pakistan’s nuclear future and the role of atomic energy in national development and defence. This led to the loss of several opportunities that could have been greatly helpful in acquiring the nuclear option.

However, this phase also saw the emergence of a coalition between two nuclear mythmakers, who were moved by their threat perception of India’s nuclear programme. They were also lured by the promise of technology towards further expanding the small nuclear base, which could propel Pakistan on the path to nuclear capability. They were also supplemented by a parallel coalition of hawks within PAEC who were engaged in bureaucratic tussling with the incumbment PAEC establishment. Thus a “proliferation decision” was reached at Multan in 1972, which also saw the convergence of the two like-mined coalitions of nuclear hawks. Throughout the 1960s, bureaucratic-politics among the country’s power centers, i.e. the civil-bureuacracy, the Presidency, Foreign Office and the relatively subordinate nuclear establishment resulted in the loss of several opportunities that could have provided Pakistan with a nuclear option at an early stage.

The nuclear mythmakers themselves were struggling to build consensus to get the nuclear programme moving in the face of bureaucratic intertia and lack of strategic foresight. The resultant compromise among the various actors on the nuclear stage did help in the establishment of a nascent civilian nuclear base that would provide the basis for expanding the programme and acquiring the nuclear option in later years. Nevertheless, the main victim of this bureaucratic tussling within PAEC and between it and the rest of the decision-makers was Dr. Usmani who lost the confidence of his co-workers and the political leadership. Therefore, the Multan Conference of January 1972 resulted in his unceremonious departure where he further compromised himself by trying to dissuade Bhutto from going the nuclear way.

With the arrival of the Bhutto-Munir coalition in power in 1972, bureuacratic tussling subsided greatly with a focus on building the technological base needed for nuclear capability. The mythmakers were now joined by technology enthusiasts within PAEC, who wished to meet the challenge of India’s nuclear test of May 1974 and the resultant sanctions placed by the nuclear suppliers. Thus realist considerations and an ever-increasing security dilemma consolidated the ascendency of the nuclear mythmakers in decision-making for decades to come. When a new mythmaker in the shape of Dr. A. Q. Khan joined the nuclear programme in 1976, a hitherto unknown era of intense bureaucratic rivalrly ensued between him and Munir Ahmad Khan. This gradually transformed into an institutional struggle for power, prestige and allocation of political support and resources for different nuclear initiatives being administered by the two men.

Thus the internal politics and bureaucratic tussling of the formative years of the gas-centrifuge enrichment project led to its separation from PAEC following its take over by A. Q. Khan. This rivalry was also seen in nuclear weapons projects with KRL coming up with a rival, though much smaller nuclear weapons development and testing program in the early to mid-1980s. This was essentially the product of nuclear myth making by the heads of PAEC and KRL. Again, bureaucratic politics prevented PAEC from completing the Chashma reprocessing plant soon after the French left, or to secure funds and support for completing the last missing link in the plutonium route before 1985, i.e., the Khushab-1 reactor project. Bureaucratic politics and the growing effects of A. Q. Khan's nuclear mythmaking also prevented the fuel cycle infrastructure to be used in activating the plutonium route at least ten years before it did.

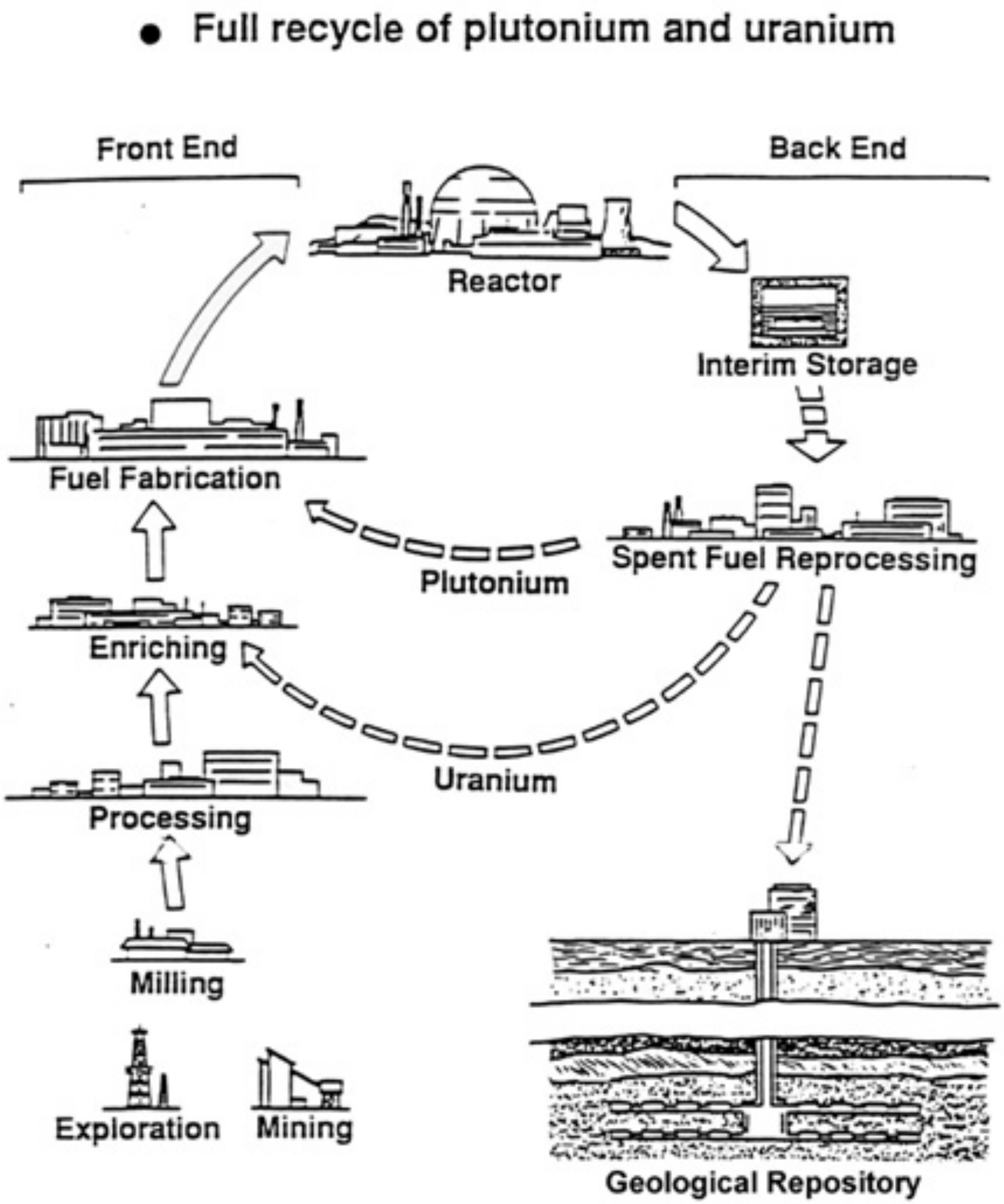
Nevertheless, it is evident that Munir Ahmad Khan was a strategic mythmaker for the development of the entire nuclear fuel cycle, and the nuclear weapons and plutonium projects. A. Q. Khan also proved to be the mythmaker for taking the gas-centrifuge project forward according to his management style. Here too, a technological pull factor also appears to have driven A. Q. Khan to attempt to compete with PAEC in nuclear weapons development. Thus, strategic nuclear mythmaking and bureaucratic politics remained an important and recurrent feature in Pakistan's nuclear development and became pronounced during and after the 1998 tests. Security considerations indeed forced Pakistan to act as a rational actor and respond to India's nuclear and conventional threat. Intense bureaucratic politics within the nuclear establishment was witnessed in the weeks and months following the 1998 tests with A. Q. Khan attempting to get decision in his favour to carry out the tests. Even though PAEC carried out the tests, this bureaucratic tussling surfaced through the media with A. Q Khan claiming credit for the tests and the entire nuclear programme.

However, unlike the previous decades, this simmering rivalry now also saw PAEC scientists responding with their own rhetoric and public interviews and statements. This was also manifested throughout the 1990s in the shape of two rival missile programmes, the liquid-fuelled Ghauri in KRL and the solid fuelled Shaheen series in PAEC. This would only end with the formation of the National Command Authority and the Strategic Plans Divison as its Secretariat to supervise and control all aspects of Pakistan's nuclear and missile capability. However, the downside of bureaucratic politics, which emerged in 1976 within the nuclear establishment leading upto the separation of the centrifuge project, was the discovery of the illicit proliferation network of centrifuge technology in 2004.

Nevertheless, technology as an imperative for defence, development and deterrence and as a tool for enhancing the mythmakers' respective positions in the nuclear establishment remained a recurrent feature of Pakistan's nuclear journey. Thus, the technological pull factor propelled successive governments to agree to the demands of the technocrats and the military in later years. This also helped to sustain the nuclear programme and various projects inspite of intense bureaucratic tussling and rivalries among the key nuclear actors. In the final analysis Pakistan's nuclear capability was the result of the work of thousands of scientists, engineers, technicians, and the support of all governments, civil and military. It served to preserve the peace in South Asia since 1971 and has deterred India from direct military action against Pakistan. While the bureaucratic politics led to competition and rivalries, the consenus on both sides of the divide was that country must acquire nuclear capability, which was and still is shared by an overwhelming majority of Pakistanis.

ANNEX-I

THE NUCLEAR FUEL CYCLE



ANNEX-II

PAKISTAN'S NUCLEAR PROGRAMME: ORGANIZATIONS AND RESPONSIBILITIES-1972-2001

Function	Facility/Project	Organization
FRONT END OF NUCLEAR FUEL CYCLE		
Uranium Processing (Mining & Refining) Yellow cake	Baghalchur-1, D.G. Khan	PAEC
Uranium Conversion (UO2/ UF4/UF6 Production)	Chemical Plants Complex, D.G. Khan	PAEC
Uranium Enrichment	Kahuta/Khan Research Laboratories	ADW/ERL/KRL
Nuclear Fuel Fabrication	Kundian Nuclear Fuel Complex	PAEC
BACK END OF NUCLEAR FUEL CYCLE		
Heavy Water Production	KCP-I, Khushab Nuclear Complex	PAEC
50 MWt Plutonium Production Reactor	KCP-II, Khushab-1 Reactor/ Khushab Nuclear Complex	PAEC
Tritium Production Plant	Khushab Nuclear Complex	PAEC
Fuel Reprocessing	New Labs, PINSTECH/ Chashma Reprocessing Plant	PAEC
NUCLEAR WEAPONS COMPLEX		
Trigger Mechanism	R-Labs, DTD	PAEC
Neutron Source	Fast Neutron Physics Group, DTD	PAEC
High Explosives	Wah Group, DTD	PAEC
Precision Engineering/Quality Control/High Speed Electronics	Wah Group DTD	PAEC
Weapon Design	Theoretical Physics Group	PAEC
Nuclear Testing	Diagnostic Group Chaghi/Kharan/ Kirana Hills	PAEC/SDW
Uranium Metallurgy/	Uranium Metal Lab	PAEC
Plutonium Metallurgy	New Labs, PINSTECH	PAEC
Nuclear Weapons/ Delivery Systems	National Development Complex	PAEC
NUCLEAR POWER AND RESEARCH REACTORS		
300 MWe CHASNUPP-1	Chashma	PAEC
137 MWe KANUPP	Karachi	PAEC
10 MW PARR-1	PINSTECH	PAEC
27 Kw PARR-2	PINSTECH	PAEC

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