NUCLEAR ENERGY OPTIONS: A COMPARATIVE STUDY OF FRANCE AND GERMANY

Dissertation submitted to Jawaharlal Nehru University
in partial fulfilment of the requirements
for the award of the degree of

MASTER OF PHILOSOPHY

ZOTHANPUII

Diplomacy and Disarmament Division
Centre for International Politics, Organisation and Disarmament
School of International Studies
Jawaharlal Nehru University
New Delhi-110067
India

2009

For my family

In memory of my grandfather Laldala

Centre for International Politics, Organization and Disarmament

27.07.2009

DECLARATION

I declare that the dissertation entitled "Nuclear Energy Options: A Comparative Study of France and Germany" submitted by me for the award of the degree of Master of Philosophy of Jawaharlal Nehru University is my own work. The dissertation has not been submitted for any degree of this University or any other university.

Zothanpuii
ZOTHANPUII

CERTIFICATE

We recommended that this dissertation be placed before the examiners for evaluation.

Prof. Rajesh Rajagopalan
(Chairperson, CIPOD)

Prof. Swaran Singh 29/7/09
(Supervisor)

School of International Studies, Jawaharlal Nehru University, New Delhi - 110067, India
Tel: (011) 26704349 Fax: (011) 26741586 website: inu.ac.in

ACKNOWLEDGMENTS

I would like to thank God for making this journey possible.

I am particularly indebted to my supervisor, Prof. Swaran Singh for his support, guidance, understanding and insightful criticism. He often pushed me out of my complacent state. I will always be grateful to him for all the knowledge I had gained while working under him and forever inspired by his dedication towards his students, for always being there to lend a helping hand both academically and financially.

I would like to thank all my other teachers in Centre for International Politics, Organisation and Disarmament. They are the one to impart the basic knowledge and understanding required for writing this dissertation. I would also like to thank my friend Manjunath, my consoler in stressful times. My thanks will also be due to Lalfakzuali and B. Lalmalsawma for their stenographic work without which this dissertation would take much longer period. Also, to Mimi Lalhlimpuii for doing proof reading for me, thanks a lot.

I also wish to thank Jawaharlal Nehru University Central Library and Institute of Defence Strategic Analysis library for being so helpful. And the University Grant Commission for providing financial assistance for my work.

I would also like to thank my family for their love and prayers, especially to my mom Lalnipuii and my grandmother Zoramthansangi, who came over to JNU all the way from home to take care of me during my illness. Also to all my friends in JNU who make my journey more pleasant.

My research is an attempt to understand and enhance the scope of the already existing expansive knowledge about nuclear energy options. I will be indeed grateful if it has any positive contributions. I deeply regret and take responsibility for any errors in my work

Zothanpuii

Zothanpuii

CONTENTS

Chapter three: Germany atomic development programme

Chapter four: Cooperation under Euratom

List of Abbreviations

ABWR- Advanced Boiled Water Reactor

AEA -Atomic Energy Act

AEC- Atomic Energy Commissions

AEG - *Allgemeine Electrizitats-Gesellschaft*

APWR- Advanced Pressurised Water Reactor

ASN- *Autorite de Surete Nucleaire*

BFS- Federal Radiation Protection Agency

BMU- *Bundesministerium fur Umwelt*

Btu – British thermal unit

CAMEA- Committee for the Military Applications of Atomic Energy

CANDU- Canada Deuterium Uranium

CDE-*Commission de regulation de l'energie*

CDU- Christian Democratic Party

CEA- *Commissariat a L'Energie Atomique*

CERN-*Conseil Europeen pour la Recherche Nucleaire*

CGT-capital gains tax

CNRS-*Centre national de la recherche scientifique*

CO_2- Carbon dioxide

CSU- Christian Social Union

DAE- Department of Atomic Energy

DAEF- *Deutsches Atomforum*

DC- Direct Current

DFD-*Deustche-Franzosische Direktion*

DREM- *Direction de Recherches et Exploitations Minieres*

DSIN-*Direction de la Surete des Installations Nucleaires*

EAEC- European Atomic Energy Community

EC- European Commission

ECSC-European Coal and Steel Community

EDC- European Defence Community

EEC- European Economic Community

EEF- European Energy Forum

EIA- Energy Information Administration

ENA- *European Navigator*

EOE-Encyclopaedia of Earth

EPR-European pressurized reactor

ESC- Economic and Social Committee

ESSOR-*Essai ORgel*

EU- European Union

Eurodif- European Gaseous Diffusion Uranium Enrichment Consortium

FDP-*Freie Demokratische Partei*

FMCT- Fissile Materials Cutoff Treaty

FR2-*Forschungsreaktor 2*

GDF-*Gaz de France*

GE- General Electric

GHG- Greenhouse gas

GIF- Generation IV International Forum

GRS- *Gessellschaft fuer Anlagen und Reaktorsicherheit*

GtC- Gigatonnes of Carbon

HLW- High Level Waste

IAEA- International Atomic Energy Agency

IEA- International Energy Agency

IMBEI- Institute of Medical Biometry, Epidemiology, and Information Science

INF-Intermediate-Range Nuclear Forces

IPCC-Intergovernmental Panel on Climate Change

kwh –Kilowatt per hour

Kw-Kilowatt

KWU- *Kraftwerk Union*

LRTNF- Long Range Theatre Nuclear Forces

LWR- Light water reactor

MIT-Massachusetts Institute of Technology

MLF-Multilateral force

Mw- Megawatt

NAC- North Atlantic Council

NATO- North Atlantic Treaty Organisation

NPT- Non-Proliferation Treaty

NRC- Nuclear Regulatory Commission

OAPEC- Organisation of Arab Petroleum Exporting Countries

OEEC- Organisation for European Economic Co-operation

PCF-*Parti Communiste Français*

PWR- Pressurized Water Reactor

R&D- Research and Development

RFS-Regles Fondamentales de Surete

RRC-*Regles de Conception et de-Construction*

RWE- *Rheinisch-Westfälisches Elektrizitätswerk*

SdN- *Sortir du Nucleaire*

SDP- Social Democratic Party

SFIO- *Section Française de l'Internationale Ouvrière*

SNF- Short-Range Nuclear Forces

SSK- *Strahlenschutzkommission*

TNPG - The Telehealth Network Grant Program

TNT – Trinitrotoluene

U235- Uranium 235

UNAEC- United Nations Atomic Energy Commission

UNGA- United Nations General Assembly

URENCO- Uranium Enrichment Corporation

URs- utility requirements

WEU- Western European Union

WNA-*World Nuclear Association*

List of Graphs and Tables

PREFACE

The atomic energy programme in France and Germany begins during peacetime. However, from being the leading countries they suffered a severe setback during the post-second world war. Nevertheless, in spite of overcoming the political, economic and technological constraint imposed upon them, as well as both of them being part of NATO-security umbrella, while France embarked upon and has continued its nuclear energy programme, Germany has lately decided to phase-out from that pursuit of nuclear science. Given the historical competitive streak present in these neighbours where one policy affected the other's action, this study will try to determine a more nuanced picture of the differences in their nuclear energy policy.

Nuclear energy remains the most controversial sources of energy and the most widely debated sources of energy. After the Oil crisis in 1973, many countries began to understand the importance of secure sources of energy supply. This led them consequently to step up their effort to find alternative sources of energy. It was also the first time that energy security was considered to be equivalent to military security (Beck 1994:22). Nuclear energy was considered to be the most efficient and viable sources of energy and many countries including Germany and France began to embark upon developing nuclear power. However, the optimistic projection for nuclear power due to scarcity of other sources of energy had also to face opposition due to events like the incident at Browns Ferry in 1975 and the Three Mile Island incident in 1979 which fuelled suspicion among the people. They started to question the safety of nuclear energy and many anti-nuclear protests started to take place in European countries. Besides, they also continued to discover new oil fields and secure supply.

By the 21st century, nuclear energy options began to gain revival again as a mean to solve the future energy problem. However, the problem of understanding the benefits and risk inherent in nuclear energy was vitiated by the debate between the supporters and the anti-nuclear lobbies. The nuclear energy option in Europe also need to be seen in terms of its endeavour to diversify its energy sources to decrease its dependence on oil and natural gas supply from highly unstable regions like Middle East as well as danger of monopoly by Russia. The impending impact of global climate change, uncertainty in future energy security and the extent of actions taken by other countries in the international realm drive them towards keeping the options open.

However, the social and economic costs of nuclear power are not the only factor governing its use. Public acceptance also turns on issues of safety and nuclear waste. Therefore, the future of nuclear power in Europe remains much in question. At the same time, after the Ukrainian crisis of 2006[1] Britain and Germany reopened the debate on nuclear power plants, France is also planning towards building more nuclear power plants, Finland and the Baltic states are heading towards the same direction, Sweden also announce its goals to cease using oil for energy production and to cover all its energy requirements with alternative energy resources by 2020.

However, due to the huge controversial debate surrounding the pro-nuclear and anti-nuclear supporters, it is difficult to understand the advantages and the disadvantages of nuclear energy. The pro-nuclear emphasised upon the availability, reliability, cost-effectiveness, efficiency and being a clean sources of energy. On the other hand, the anti-nuclear supporters doubts the safety of nuclear power plants by looking at past history, they further questioned nuclear power as being cost-effective judging by the huge expense utilised in building power plant, they also pointed out the problem of disposal of radioactive waste. Therefore, whereas the former believed that it is necessary to retain nuclear energy options citing both economic as well as non-carbon emission sources of energy. The latter support phasing out nuclear energy development, they believed that energy security could be sustained without nuclear energy by alternative sources of energy.

This study will take the case of France and Germany to understand what could be the consequences of retaining and forgoing nuclear energy options. France is the most active country in developing nuclear energy, presently, she was known to derive about 75% of her electricity from nuclear energy and continues to retain her nuclear energy

[1] In 2004, the Russian government, Gasprom, Russian Gas Company and Ukraine government entered into an agreement to allow such as Naftogas, Ukrainian Gas Company to pay past dept and transit of gas to Europe and Turmenistan. But, in 2006, due to deterioration in bilateral relations between Ukraine and Russia coincided with high gas prices, This led to reduction of gas supply in Europe. Further, Russia accused Ukraine of diverting gas supply which the latter denied.

options. On the other hand, Germany also depends upon nuclear energy representing about 12% of her energy supply and over a quarter of electricity generation. But, from 1998, it started to embark upon phasing out. It is only through the experiences they gain from retaining or forgoing nuclear energy options, thereby we could understand the likely problems and prospects we are likely to encounter in developing nuclear energy for the future.

The hypothesis of my study is that nuclear energy remains indispensable energy options for both France and Germany. Therefore, to understand nuclear energy options, this study will include the nature and significance of nuclear energy that could have affected the energy policy-making. It will also try to see how far technological, security, economic and socio-political factors influencing countries nuclear policy and the impact of nuclear energy for both countries and to determine the likely implications for developing nuclear energy option. This study will also look for both countries future trends in nuclear energy and to understand whether it is feasible to retain or forgo nuclear energy option.

ORGANISATION OF THE CHAPTERS:

The first chapter includes the importance of energy and nuclear energy in comparison with other forms of energy. This is followed by the role of nuclear energy in International Politics: the Nuclear energy for power tries to explain the reason for the quest of nuclear energy development by states so as to enhance their international standing as well as military security and energy security. It also traces development of nuclear energy since the discovery of uranium, acceleration of military programme during the second world, followed by the re-awakening in peaceful use after 1973 Oil Crisis, as well as the current development. Finally, it also contains the problem and prospects for developing nuclear energy.

The second chapter examines French atomic development programme, tracing it from the last decade of the nineteenth century discovery of radioactivity during, how the rivalry of France and Germany and the Second World War accelerate their military nuclear options. The post-Second World War saw the French immediate effort to renew their nuclear energy development. However, both military and peaceful options were both pursued and the military application was given more priority. Besides, the line between military and peaceful nuclear energy development was not easy to differentiate at that time. It also tries to understand the nature of French atomic policy making, the anti nuclear movement from the mid 1970's and its impact. The study further includes the implications of nuclear energy in French economy and recent developments.

The third chapter outlines German atomic development programme, tracing from its historical background, the change from peaceful nuclear energy development to military application during the Second World War. The conditions in West Germany during the post-Second World War period when nuclear energy options were severely curtailed by the allied countries and the implications of Atom for Peace for West Germany. It also includes how West Germany, in spite of restraining from developing nuclear weapons continue to quest for nuclear security from cooperation France then North Atlantic Treaty Organisation (NATO). Further, it contains the development in the post cold war period on how Germany decided to forgo its military nuclear options and later followed by her attempted to phase-out the peaceful-use as well. It also contains discussion on the economic implications of nuclear energy in Germany as well as recent developments in Germany.

The fourth chapter examines Franco-German cooperation under the Euratom. It describes its historical background, the objective for forming the Euratom and the role of United States (US). It also contains France relations with Euratom, Germany relations with Euratom and safety standards applicable to both countries under the Euratom. This is followed by the quest for joint military nuclear security. Lastly, it will include comparison between the two countries. This is aimed at determining why France retains nuclear options while Germany tries to phase out by looking at different factors: historical, security, economic and socio-political.

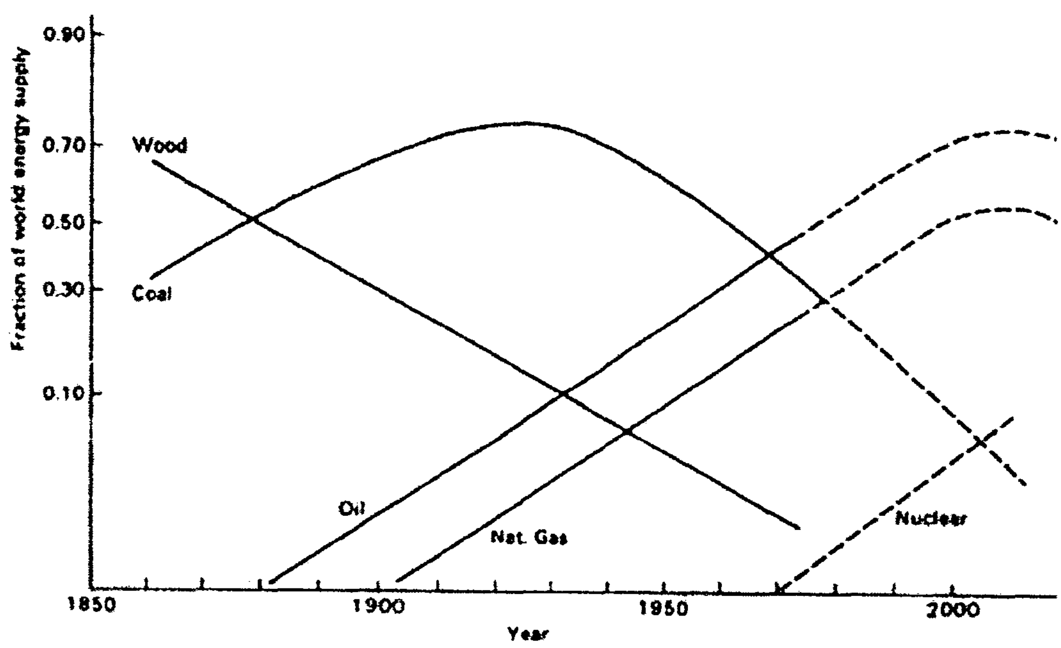
The final chapter of the fifth concludes the dissertation and it contains the findings of this research.

CHAPTER ONE

INTRODUCTION

In scientific terms, energy is 'the capacity to do work' and sufficient energy in many different forms is necessary to sustain the survival of world-wide population. Over the centuries, natural resources like wood, coal, oil, nuclear energy and other renewable resources have been utilized one after the other due to decrease in availability and discovery of more efficient sources of energy (**see Graph 1.1**). The relative consumption of wood has fallen continuously with the exhaustion of available supply followed by coal which still remains one of the major sources of energy (Hodgson1999: 15). In the 19th century, coal became the power behind the Industrial Revolution.

Graph 1.1: World Energy Supplies



The fraction of world energy supplied by different sources: how coal replaced wood, and then how oil and gas replaced coal. What will replace the oil and the gas when they eventually run out?
(Hafele, 1981)

During the first decade of the 20th century, the British started to replaced coal with oil for greater mobility during the war, along with natural gas, they began to take over from coal as more convenient sources of energy. However, especially after the Yom Kippur war followed by the Arab oil embargo in 1973 to those western countries that supported Israel during the war, the world was awakened to its first energy crisis. Therefore, an alliance of International Energy Agency (IEA) was formed to secure future energy supply, to meet the shortage of oil supplies, to meet domestic demand and diversification of resources towards other sources of energy such as nuclear energy.

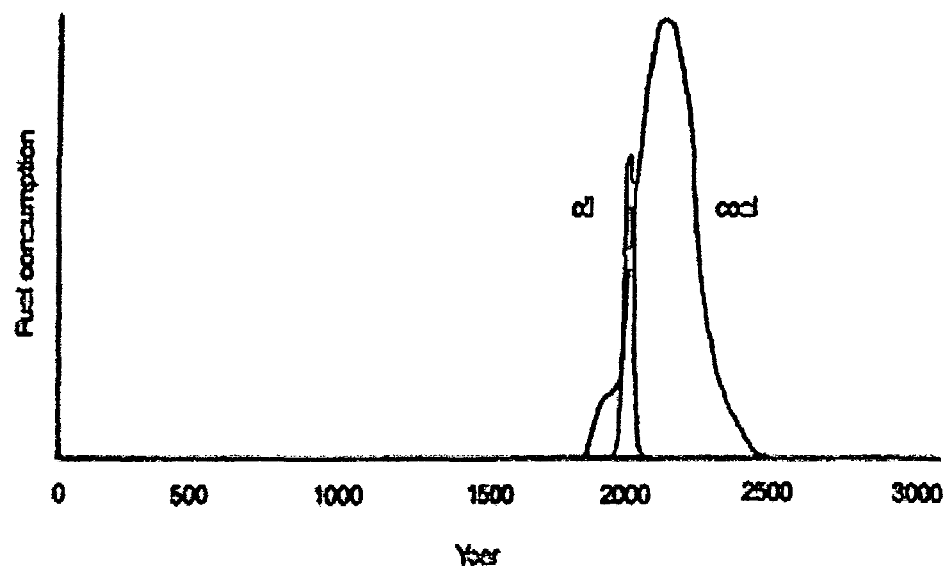
According to the energy and emission scenarios of Intergovernmental Panel on Climate Change (IPCC), the primary energy consumption is expected to increase by a factor varying between two and seven times by the end of the 21st century, depending on various demographic, technological and demographic assumptions (Vaillancourt et al 2008: 2296). In all projections, the world energy consumptions is expected to increase (Duffey, 2005; Fiore, 2006 cited in Vaillancourt et al., 2008: 2296). At present, most of the world energy is supplied by coal, oil, natural gas and hydrocarbon (Hodgson 1999: 22). Nuclear energy supplies only a sixth of the world energy. France is the most dependent major country with 40% energy supply derived from nuclear energy. The new development of current technology such as the pebble- bed nuclear generation is expected to improve the situation for the possibility of increase in the present nuclear energy demand.

The modern industrial economy cannot function without secure and adequate source of energy. Due to unequal distribution of natural resources, some countries are not adequately endowed with natural resources. Energy growth is based mainly on fossil fuels are not feasible for energy security, and for countries with more abundance of supply, they are threatened with considerable increases in greenhouse gas (GHG) emissions. Therefore a major stake of the 21st century is to devise strategies to produce more energy to satisfy global needs while reducing GHG emissions (Vaillancourt et al. 2008: 2296).

COMPARISON BETWEEN NUCLEAR ENERGY AND OTHER FORMS OF ENERGY

The sources of energy we use depend upon a number of considerations such as availability, cost, reliability and non-carbon emissions and it has to be decided for each region (Hodgson1999:16). Hodgson (1999) mentioned the direct and indirect cost of obtaining energy: The direct costs include mining, extraction of fuel from the ground, transport to the power station, construction and maintenance of the power station and transmission of energy to the consumers. The indirect costs include pollution and other effects on the environment and dangers to the health of the workers and to the entire human population.

Graph 1.2: Expected duration of fossil fuels, AD 0-3000.



Oil and natural gas will last but a moment in man's history. Source: Sir George Porter, President of the Royal Society. (Hodgson 1999: 16)

The expected duration of fossil fuels is predicted to peak quite early in the next century, and then we are faced with the problem of replacing them by other sources of energy **(see Graph 1.2)**. Coal is expected to last for another three hundred or four hundred years. Oil and gas are also non-renewable sources of energy and the supply will have limitations. Due to technical limitations, renewable resources are also not always reliable. To counter the future scarcity of resources, Daniel Yergin (2006) stated that diversification will remain the fundamental starting principle of energy security for both oil and gas, and diversification would meant the policy of using diverse sources of energy like nuclear energy and so on.

Table 1.1: Total Energy Consumption (Quadrillion Btu per year)

Source of Energy	2006	2010	2015	2020	2025	2030	2006-2030*
Petroleum	40.39	40.82	42.46	44.41	46.38	48.23	0.7%
LPG	22.42	23.90	24.72	24.83	24.40	24.07	6.3%
Coal	22.52	22.94	24.24	26.23	28.89	31.71	1.4%
Nuclear	8.21	8.31	8.41	9.15	9.68	9.89	0.8%
Hydro	2.89	2.92	3.00	3.00	3.00	3.00	0.4%
Biomass	2.52	3.08	3.39	3.83	4.04	4.17	2.1%
Others Renewable Energy	0.88	1.50	1.73	1.99	2.28	2.49	4.5%
Others	0.19	0.18	0.17	0.18	0.18	0.20	0.2%
Total	100.0	103.64	108.12	113.61	118.85	123.76	0.9%

*Average annual percent projections of 2006 to 2030.
Source: Energy Information Administration (EIA), U.S. Department of Energy: *Annual Energy Outlook, June 2008.*

According to the average annual projections of 2006-2030 **(see Table 1.1)** by the Energy Information Administration (EIA), the growth rate for nuclear energy will continue to be less than oil. Despite the increase in the consumption of other sources of energy, the demand for oil remains unchallenged. As a source of energy, the capacity of energy is measured by using a unit called 'joules'. Through this measurement, a particular value of energy/grades can be related to its physical characteristics: solid, liquid, gas or field state. As compared to other sources of energy, renewable sources of energy like wind and solar along with nuclear energy processed from uranium ore are in 'field' category, the lowest grade. Hence, it is necessary to convert them into electricity as they are difficult to store inside an engine such as internal combustion engine.

The consumption of coal will grow at a rate of 1.4 percent, which is projected to rise from 22.52 Btu in 2006 to 31.71 Btu by 2020. However, due to environmental regulations, the uses of coal are expected to fall by 10 percent. Despite the low social acceptance of nuclear energies, due to the risk of accidents and problems in the production and management of radioactive waste, the need for adequate and secure supply and to reduce GHG emissions makes the nuclear option represent good option for electricity generation, especially in energy with high demand growth (France 2008:2293).

NUCLEAR ENERGY IN INTERNATIONAL POLITICS

Energy is the *sines qua non*[2] for the exercise of power in International Political Economy, both security and material wealth of nations could be gained only through security of energy supply. Kalicki and Goldwyn (2005) define energy security "as assurance of the ability to access the energy resources required for the continual development of national power", (Kalicki and Goldwyn 2005: 9).The developments of atomic energy programme are related to both economic and political factor. The Oil Crisis in 1973 shows how the disruption of energy supply could affect the political and economic security of the western countries. It also shows the importance of finding secure and efficient sources of energy in which nuclear energy is considered a major potential candidate. The war over Iraq is largely assumed to be a quest for energy security by the United States.

The most significant aspect of nuclear energy could be considered in relations to military aspects. It is highly essential source of energy for advanced military weapon systems such as missiles, aircraft and submarines. Non-acquisition of nuclear weapon capability could pose a serious threat to national security. Van Evera (1999) mentioned that according to conventional wisdom in the field of international relations, the build-up of nuclear arsenal is motivated by a state attempts to improve its security through relative gains vis-à-vis its counterparts within the international anarchic self help system. T.V Paul also contends that the nuclear options of a great power are determined chiefly by larger power relations (Paul 2000: 4).

Within the conventional theoretical explanatory model, Waltz identified seven major motives for states to develop nuclear weapons such as:

- great powers always counter the weapons of other great powers;
- a state may want nuclear weapons for fear that its great-power ally will not retaliate if the other great power attacks;
- a country may want nuclear weapons because it lives in fear of its adversaries, present or future conventional strength;

---

[2] It is a Latin word, which means 'without which is not possible'.

- some countries may find nuclear weapons a cheaper and safer alternative to running economically ruinous and militarily dangerous conventional arms races;
- countries may want nuclear weapons for offensive purposes;
- by building nuclear weapon, a country may hope to enhance its international standing (Frey 2006: 11).

As such the quest for first-rank status and leadership in international standing by the France was often regarded as both the reason and consequence for developing nuclear weapons. This was found to be true by looking at the French leadership aspiration for *granduer*. After the Second World War, France was declining in power and ill-equipped to exercise dominant power. However, through acquisition of nuclear weapons, it aims to increase its power in international relations. Scheinman (1965) wrote that France

> "...is in fact approximating by a policy to which she has long aspired: the policy *du grand siecle*. This policy of *grandeur* has been manifested in deliberate and bold acts ranging from the development of a national nuclear striking force...." (Scheinman 1965: xi).

However, Waltz argued that though France might enjoy the prestige that comes with the nuclear weapons, and indeed the yearning for glory was not absent in de Gaulle's soul, the military business was a serious one and that deeper motives other than desire for prestige lie behind it (Frey 2006: 11). Therefore, the Realist theoretical approaches to deterrence that security-maximization of states for self-preservation as the first preference within a national interest formulation behind nuclear proliferation has been widely accepted as explanation. (Frey 2006: 11).

T.V Paul (2000) in his book, "Power versus Prudence: Why Nations Forgo Nuclear Weapons," created the concept of security interdependence whereby a country's interaction with its allies and adversaries in its immediate geo-strategic environment determines the level and type of security threat that it faces. Further, based on the level of conflict in a region where a given state is situated, Paul creates three analytical zones in order to examine it systematically such as-high conflict, moderate conflict and low conflict (Paul 2000: 5).

According to this concept of security interdependence, regional states located in a high conflict region, facing a nuclear enemy and do not have a great power protector, are likely to acquire nuclear weapons in order to deter their adversaries. On the other hand, a technologically capable state in a high conflict region that forgoes nuclear weapons may have credible security nuclear guarantee provided by a great power or possess a countervailing capability in conventional and chemical and biological weapon (Paul 2000: 5). On the other hand, states especially in moderate and low conflict region are more likely to forgo its nuclear weapon options when the leadership perceives that nuclear acquisition would generate intense negative security externalities or cost for others and exacerbate its own security threats by encouraging other states to take countermeasures. He points out measures such as other states acquisition of nuclear weapons, targeting of nuclear arms by existing nuclear powers or increasing hostility if they are already targeted, and deterioration of politico-economic relations with allies. Therefore, since a country's nuclear options are largely determined by its geo-strategic environment, a change occur in the latter could also bring changes to the former choices.

However, after the end of Cold war, the security conditions of many countries began to improve. Further, according to United Nations (2000) Department of Disarmament Affairs, '2005 Review Conference of the Parties to the Treaty on the Non-Proliferation Treaty of nuclear weapons' states cooperate to avert the danger of nuclear war by entering into an "agreement on prevention of wider dissemination of nuclear weapons". It also further stated that

> "All the parties to the treaty agreed to undertake to facilitate, and have the right to participate in the fullest possible exchange of equipment, materials and scientific and technological information for the peaceful uses of nuclear energy. Parties to the Treaty in a position to do so shall also co-operate in contributing alone", (Paul 2000: 10).

Especially after countries began to cooperate for the treaty on Nuclear Non-Proliferation, and the formation of regional and international organisation for peaceful nuclear energy development. This would let the liberalist to argue that cooperation among states shows that in international relations, military security would not always be assigned foremost priority and economic could also be the reason for states not to acquire nuclear weapons. Proedrou (2007) also stated that states are not concerned principally for their security, but with their welfare. Yergin (2006) also stated that" energy security does not stand by itself but is lodged in the larger relations among nations and how they interact with one another". Paul (2000) further argued that since stability is the crucial component for economic development, in places of high economic interdependence, states are mindful of negative security externalities. Therefore, financially and technologically capable states often forgo nuclear and pursue only peaceful applications of nuclear energy. However, this study supports that states forgo nuclear energy options because it might be more feasible for both their economic and military security interest. Since energy security and military security are interrelated, vulnerability in energy security could pose a threat to military security.

The peaceful application of nuclear energy is therefore often justified as a means to assure energy security. As we have already mentioned, the importance of nuclear energy is it's feasibility in being an efficient and clean energy resources. But, the separations of military and peaceful applications often are not always clear-cut. Besides, the military options were often given priority in the past, and the peaceful atomic energy programmes of states continue to translate easily into military programme as in the case of North Korea. Therefore, this study will dealt with both peaceful and military development of nuclear energy. However, after both Germany and France became a part NPT-signatory, they began to pursue only peaceful use. Besides, there already exists a vast literature on military developments. Therefore, this study will focus more on peaceful nuclear energy development and future options.

DEVELOPMENT OF NUCLEAR ENERGY

As a source of energy, nuclear science provides the cleanest form of energy as compared to other forms of energy. Nuclear energy could be released through fission when atoms are split apart to form smaller atoms or through fusion when atom are fused and produce energy. One of the fuel used by nuclear energy is called uranium, a non-renewable metal which is present almost everywhere, but nuclear power plants use particular types of uranium, U235, which is relatively rare. During nuclear fission the neutron hits the uranium atom and split it, releasing a great amount of energy in the form of heat and radiation, and more neutrons are also released and bombard other uranium atoms again thus causing a chain reaction. The heat produced in the reactor could be used to boil water into a steam which could turn huge turbine blades and drive generators to make electricity.

Uranium, the main elements for producing nuclear energy as a separate element was discovered in 1789 by the pioneer German chemist, Martin Klaproth. It was a yellow metal with strong colour which he found in pitchblende in the metal mines in Joachimsthal, in the Erz Giberg in Bohemia[3] and named it after the Planet Uranus which was discovered eight years earlier. By the beginning of the eighteen century, Marie Curie discovered radioactivity in radium and lesser amount was found in Uranium along with other elements as well which opened the way for the exploration and manipulation of the nucleus of an atom. However, during this period, Uranium was sought only because of radium[4] and its powder to be used as colouring agent in the production of glassware and pottery.

In the late 1930's, two separate activities came to give new importance to Uranium. Firstly, the series of discoveries in physics that led to an understanding of the phenomenon of nuclear fission and secondly, the development in international relations that led to the Second World War (Moss 1981:7). In Rome, Enrico Fermi bombarded many different kinds of atom with neutrons, knocking away one or two particles from an atom to create a new isotope. He was confused by the result when he bombarded Uranium with neutrons[5] because at that time fission was thought to be almost impossible. In 1938, Otto Hahn and Fritz Strassman analysed the results of Fermi's bombardment of uranium, and announced it as traces of barium. They published their findings in a scientific journal without offering explanation. Hahn also

---

[3] Bohemia is a historical region in Central Europe. Occupying the western two-thirds of the traditional Czech lands currently known as Czech Republic.

[4] Radium is usually found along with uranium.

[5] This kind of experiment is conducted with minute quantities of matter. and the immediate effects took place in a microcosm too small for human observation and have to be guessed at from analysis of the observed effects.

sent a letter to his former colleagues Lisa Meitner, she pondered the matter over with her nephew, Otto Frisch, who borrowing from biology later coined the word 'atomic fission' in their collaborated paper about their findings and sent to British Scientific journal '*Nature*'. This was followed by debates amongst the atomic physicists in other centres who repeated the Fermi's experiment and confirmed the effects.

In February 1939, the Hungarian-born physicist Leo Szilard, then at Columbia University in New York spotted the vital points that if the uranium nucleus is split by the impact of neutron, it releases the binding energy which is miniscule, but loose neutrons from this atom are sent shooting off so that a lot other of atoms undergo fission and a sort of chain reaction might be possible, and the cumulative amount of energy released would be enormous. He mentioned in his letter to Frederic Joliet-Curie that in certain circumstances this could lead to the construction of atomic bombs, which would be extremely dangerous in general and in particular in the hands of particular government. Joliet-Curie along with Lew Kowarski and Hans Halban followed up this point about chain reaction and demonstrated in their laboratory experiments and proved it successfully.

The international situation at this period with the impending of Second World War also stepped up interest to be the first one to develop a uranium fission explosion despite the present remote possibility and competence as well as for limited resources. Germany under the influence of Nazism annexed Austria and invaded Czechoslovakia and there were rearmaments among the major powers. In Paris, Joliet-Curie, Halban and Kowarski worked on some of the requirements of chain reaction and even acquired some heavy water (Moss 1981:10). In the United States, driven by the possibility from the Germans being able to develop nuclear power first, eminent scientists encouraged by their fellow scientists[6] wrote to President Roosevelt on the need for investigation on the possibility of setting up a Committee on harnessing Uranium. Britain was the first to work successfully on the possibility of separating U-235 to make a bomb and discovered that 5 kilograms could create the impact equivalent to several thousands of TNT. In March 1940, this result was sent to the War Cabinet's scientific office, and in April, the government set up a committee to

[6] Szilard and Eugene Wigner went to meet Albert Einstein to ask him to lend his name to the letter to the President.

look into these prospects. By this time, the pursuit of nuclear science had clearly shifted away from a mere scientific enquiry to become a military pursuit for nuclear bomb.

ATOM FOR PEACE PROGRAMME

The possibility of using nuclear energy for peaceful purposes was known from the very beginning. During the Manhattan project started in 1939, which was built for military purposes[7], it was seen that the heat that produce steam could be harnessed into an electric generator. Besides the production of radio isotopes, it could also be used as tracers in industry and medicine. After the world witnessed the destructive consequences of Atom Bomb in Hiroshima and Nagasaki, and in the post-Second World War period as a serious effort to eliminate the potential of its future use and the threat of nuclear proliferation, the Mc Mahon Act of 1946 was passed. This was to restrict the use of atomic energy for national defence and to retain its secret within the US and placing nuclear weapon development and nuclear power management under civilian control.

Based largely on the Archeson-Lilienthal report on March 1946 which evolved into the Baruch Plan, it was submitted by the United States on its first meeting on June 14, 1946 to the United Nations Atomic Energy Commission (UNAEC). It contained certain proposals such as:

i) Extend between all nations the exchange of basic scientific information for peaceful ends;

ii) Implement control of atomic energy to the extent necessary to ensure its use only for peaceful purposes;

iii) Eliminate atomic weapons from national armaments and all other major weapons adaptable to weapon of mass destruction;

iv) Establish effective means of safeguard by ways of inspection and other means against the hazards of violations and evasions.

---

[7] United States collaborate with Canada and Great Britain in a bid to race for nuclear weapons with Germany

However, it was rejected by the Soviet Union on the ground that United Nations was dominated by United States and its allies. Therefore, it cannot be trusted to handle atomic weaponry in an even handed matter. So, they abstained from voting on Dec 31, 1946 in the UN General Assembly and later vetoed it on the Security Council. They had also proposed that United States must eliminate its nuclear weapons.

On December 8, 1953, President D. Eisenhower presented a new nuclear initiative to the United Nations General Assembly (UNGA) with a speech titled "Atoms For Peace", he called upon to redirect nuclear research away from military pursuits and toward "peaceful...efficient and economic usage," (IAEA 1957). He invited the governments principally involved to "make joint contributions from their stockpiles of...fissionable materials to an international atomic energy agency...set up under the aegis of the United Nations", (IAEA 1957). Following this, a policy reversal in the United States took place. The Mc Mohan Act was amended with the US Atomic Energy Act (AEC) of 1954 under which nuclear materials and data relating to civil applications could now be transferred to friendly countries directly through cooperative agreements entered into and approved by the AEC. These agreements carried with them the right of the United States to verify that the transferred materials were being used for peaceful purposes.

In March 1955, following the US proposal, UN conference on the Peaceful Uses of Atomic Energy took place in Geneva. It was one of the largest ever scientific meeting of its kind and much information about previously held secrets were shared. The French scientists revealed the process of uranium extraction and United States also declassified significant amount of data for this meeting. From this moment, despite considerable restriction to its research activities, Germany was allowed to gain accessed to knowledge on peaceful applications of nuclear energy. Weiss Leonard (2003) mentioned in his article "Atom for Peace" that United States signed cooperative agreements with 40 countries including Germany which resulted in the sales of research reactors and the participation of foreign nuclear scientists and engineers in U.S.-approved nuclear research projects at this time. Many nuclear scientists in countries that eventually became concerned in proliferation received training in nuclear technology in the United States, or with the U.S. funding. Besides these, exports were seen as a means for United States to maintain its global leadership and to mitigate Soviet's influence as a part of cold war politics and assure continued access to foreign uranium and thorium supplies[8].

The Atom for Peace programme sowed the seed of the most important element of today's nuclear non-proliferation regime: the International Atomic energy Agency (IAEA). It was set up as a specialised agency of the UN on 29 July 1957 with the aim of promoting peaceful applications of nuclear technology, providing international safeguards against its misuse, and facilitating the application of safety measures in its use. In retrospect, many other countries this seen as a propaganda tool, they believed that the United States to show that it was also interested in peaceful use and not only in military use. Contemporary observers were content that the policies and capabilities it produced inadvertently fueled the global spread of nuclear arms, by helping some countries to achieve more advanced arsenals than would have otherwise been the case by diverting U.S. nuclear assistance to military use (Lavoy 2003:1).

FROM 1960s TO 1979

From the 1960's to the late 1970's with the intensification of cold war, the fear of nuclear war along with the secrecy surrounding military programmes and the radio-active fallouts from weapon testing along with the concern for environment became the rallying point for the anti-nuclear movement. Such resistance gained strength from the use of nuclear weapons stepped up to absolute denial of nuclear energy. At the same period the nuclear industry expanded and gained in scale and arrogance. They started to sell reactors in America on purely commercial basis and by 1966 more reactors were being ordered in U.S. than any other time. The same condition seems to holds true for Europe. However, the discoveries of new oilfields in Middle-East, more efficient drilling technique and the advent of super tanker lowered the cost of oil and in order to compete, the price of nuclear power had to come down. Besides, the Enrico Fermi 1 reactor in the U.S. at Idaho test site was put out of action due to reactor core meltdown in October 1966 and this becomes a subject of criticism for anti-nuclear movements[9]. Opinions were greatly divided between those who think

[8] For detail understanding, see NSC," Peaceful Uses of Atomic Energy", NSC-5507/2.

[9] This incident was written in the book titled *We Almôst Lost Detroit* and often cited as a based to criticize nuclear energy.

nuclear energy as a source of evil and identified closely with bomb-making and those who support it as a future source of world energy.

An important event occurred on 16 October 1973, when Organisation of Arab Petroleum Exporting Countries (OAPEC) decided to use 'Oil weapon" "in response to the U.S. decision to re-supply the Israeli military during the Yom Kippur war. This was done by cutting on production of oil and placing an embargo on shipments of crude oil to the west. This shook the world to grave concern about adequacy of future energy supplies and the importance of secure sources of energy. They also began to understand that military security is closely linked with energy security. The western countries largely saw nuclear energy as a possible potential alternative and increasingly embarked upon launching nuclear energy programme. The French Government made the biggest commitment during this period to nuclear power than any government has ever made by ordering thirteen 900-MW power plants.

The anti-nuclear movement was given a boost during this period due to some incidences which made the safety of nuclear installations highly questionable. On March 22, 1975, a candle started fire in a new nuclear station at Browns Ferry, which damaged most of the safety system and made the plant inoperable. A more serious incident happened in the Three Mile Island starting from 4am, March 28, 1979 when a cooling malfunction cause partial core meltdown in the number 2 reactor which destroy the reactor. This caused fear and created doubt about the credibility claimed by the nuclear industry. The public further questioned whether such plants followed the safety proposals instructed by regulators. The other issue which was getting attention was to whether many countries or private industries would be trusted with the operations of reprocessing plants dealing with highly dangerous radioactive by-products as well as with plutonium, keeping in mind the threat of proliferation.

Some environmentalists also raised a strong argument that nuclear energy is not necessary. So, instead of taking all the risks necessary for that choice, the world energy requirement could be met by developing renewable energy resources like solar, wind, waves, tides, biomass etc which attract a lot of public support. However, the conventional energy analysts acknowledged nuclear energy as a key component in energy supply and indispensable if basic energy demands are to be met (EP 2007:1).

Unfortunately, only few policy makers and commentators understood the fundamental, technical, economic and political aspects of the issues and there was insufficient knowledge about problems and prospects of nuclear energy.

As a result of anti-nuclear movements, the nuclear industry suffered setback in the mid-1970s. Competition was fierce especially after France and Germany learnt to developed light water reactors, and Canada also began to produce Canada Deuterium Uranium (CANDU) reactors. Production costs had become much higher than earlier. New stringent safety regulatory requirements increased both manufacturing and operating costs. General Electric (GE) lost $600 million in its first thirteen reactors, Westinghouse and Babcock and Wilson also lost big sums on reactor manufacture. General Atomics owned by American companies Gulf Oil and Royal Dutch Shell went out of nuclear power business. In Germany AEG Telefunken[10], one of the two partners the reactor company Kraftwerk Union (KWU), sold its share to the other partner Siemens at a loss and pulled out. In the U.S. in 1975, while 5- nuclear power reactors were ordered, eight were cancelled and there was no order for reactors after 1978.

Another problem cropped up which shocked the nuclear industry. In March 1975, the US Atomic Energy Commission unilaterally announced that it was suspending all licences to export uranium. It also said that it would review the situation and issue licences only if it was sure there was enough enrichment capacity free to meet domestic needs. This came out as a blow because it did not consult any of its customers. The European Commission also protested on behalf of Euratom. Many countries began to develop the feeling that it might not always be wise to rely on United States exclusively for enriched uranium. So, several European countries began to build their own enrichment plant including France and Germany.

Further, in 1978, largely in response to India's Peaceful Nuclear Explosion (PNE), the US invoked the Nuclear Non-Proliferation Act of 1978 which emphasised upon denials of sensitive technologies and materials and constraints on nuclear exports

[10], In 1903, Allgemeine Electrizitats-Gesellschaft (AEG) and Siemens & Halske AG Jointly founded the Gesellschaft fur drahtloseTelegraphie System Telefunken better known as Telefunken. In 1967, this was further merged with AEG and came to be known as AEG-Telefunken.

through IAEA safeguards[11]. The United States also put major obstacles in the way of commercial reprocessing and export of nuclear fuel. When France's Commissariat a L'Energie Atomique (CEA) offered to built a reprocessing plant in South Korea, it expressed disapproval to South Korean Government followed with a strong secret warning that it will reconsider their defence relationship thereby scotched the plan. Besides, when the Shah of Iran negotiated with France and Germany for building a network of nuclear power plants along with reprocessing and enrichment facilities, the United States, then the principle supplier of Iran's military technology persuaded Iran to make the projected plan multinational as a part of European Gaseous Diffusion Uranium Enrichment Consortium (Eurodif) instead of making it a national enrichment plant.

However, the CEA had entered into a contract with Pakistan and KWU in Germany and landed into a massive order to set up a whole nuclear power network. Though these countries remain under the International Atomic Energy Agency (IAEA), United States was particularly worried by these two deals and approached France and Germany to call off these sales. The French government loath reneging the contract for they feared that it might hurt their trading reputation. However, it abandoned this plan eventually when East Pakistan broke away and became Bangladesh. Pakistan dropped its more ambitious nuclear power plant and when Pakistan rejected proposal for joint control of reprocessing plant, France refused to go ahead with the contract.

On the other hand, Germany defended export to Brazil as a matter of protecting its vital national interest. Further, the Europeans were suspicious of the U.S. that in spite of being dominant in so many ways, they tried to obstruct European industries in one of the few areas in which they could successfully competed rather than a real concern for nuclear proliferation. Their suspicion was reinforced when the Germans found out that while American officials were asking German not to build an enrichment plant for the sake of world peace, the huge American corporation Bechtel was discussing building an enrichment plant with Brazil. So, in June 1975, the KWU with a lavish ceremony signed the Contract with the Brazilian dignitaries. About the same period, it

[11] During the 1960's, Canada helped India built two 220-MW CANDU power reactors, called RAPP 1 and 2 and also brought two smaller PWRs from Westinghouse, based on these technology, India was able to conduct PNE in 1974.

was revealed that Germany secretly had already sold uranium enrichment technology to South Africa, a non-NPT signatory and not confirmed it till 1977.

Between 1976-1980, due to the stringent conditions imposed by the U.S. which greatly strengthened the anti-nuclear movement, when it come to the choice that of relying on energy imports or on a major contribution by nuclear energy. Only France along with Japan persists during this period, out of the entire democratic world, had the tenacity to persist with the nuclear route (Beck1994:24). Disappointing results and public pressure cause most of them to slow down or phase out their nuclear development programme.

FROM 1980s TO THE PRESENT

The beginning of the 1980's featured the surpluses in coal and oil instead of the foreseen shortages and a fall in their prices. Growth in the nuclear industry became far lower than expected and most of it took place in the developing countries. Then, the Chernobyl happened in 1986, the catastrophic effects and aftermath of the surrounding areas and the nuclear contamination that spread far beyond the USSR gave a tremendous boost to the anti-nuclear lobby. The preceding months had witnessed scattered opposition to nuclear power across Europe. But scientists in the west put their best effort to distance themselves from the incident by emphasizing that the Russian reactors design were outdated and the safety effort cannot be compared to the West. However, the impact of strong oppositions and the doubts about economic attractiveness combined against nuclear investment. Some countries were also obstructed by the limited amount of spent fuel they were allowed to keep in storage. Only France and Japan continued their efforts for energy self-sufficiency through nuclear power.

The Chernobyl accident focused people's attentions towards the inherent danger of nuclear technology, the seriousness and how wide-ranging it could be. The Three Mile Island had already convinced the world that accidents and leak out could happened but the vast quantity of radioactive leaked and the vast areas it could covered shocked the people. The period immediately after this was an era of reflection on the whole issue of nuclear power. This cast a long shadow over safety throughout the nuclear fuel cycle (Park 1989: 182). Opponents of nuclear energy could no longer be dismissed as green extremists.

However, this does not signify an end to nuclear power programmed. In the midst of this widespread opposition the seven heads of states from France, West Germany, Canada, Italy, Japan, UK and USA met in Tokyo in May 1986. They were united in their view that nuclear power is and will remain increasingly and widely used sources of energy provided it is properly managed. On the other hand, it led to a more sophisticated debate on its merits, safety issues and ultimately more acceptable nuclear industry in Europe and other parts of the world. From this point onwards, public opinion became an important factor to whether a country should embark upon nuclear energy especially in democratic countries.

The 1990's, with the end of cold war and the disintegration of the Soviet empire, opened the way for better and less politically constrained environment to share information with the Russian nuclear industry and all its past-satellite countries. Besides, various disarmament agreements had been signed between the U.S. and Russia which involved dismantling of a part of their 50,000 or so nuclear weapon stocks. However, since the dismantling, safeguarding the stock and finding the route to make use of it could be costly especially for Russia. So it was agreed to schedule of dismantling the rate at 2,000 weapons per year for both countries spreading over a period of ten years.

Problems cropped up regarding secure disposition of plutonium. There were many long term options available but none are easy and posed the threat of proliferation bearing in mind that nuclear weapons with destructive power of 1 kiloton can be built with as little as 1 kilogram of weapon grade plutonium. So, strictest safeguards had to be maintained in terms of storage and shipment. The fissile material was now put under the IAEA safeguards and inspection. The problem has been further compounded since by the easy availability of nuclear weapon expertise. There is a real threat with the end of nuclear weapons industry after the disintegration of Union of Soviet Socialist Republic (USSR), the nuclear experts in its successor countries with their experience in civil and military fields could be employed by non-state actors and rogue states.

Besides, the end of cold war heralded the event of the fall of Berlin wall in November 1989, followed by the reunification of Germany in 1990. The Kohl-Gorbachev Agreements at Stavropol in July 1990 included gradual withdrawal of Soviet troops from East German territories and Germany's unilateral re-commitment to its earlier pledges[12] not to produce its weapons of mass destruction, including nuclear weapons. Following this, on 12th September 1990, Germany signed the Two-plus-Four Treaty in Moscow. On article III, it agreed to abide by the commitments made by both East and West Germany regarding renunciation of nuclear, biological and chemical weapons and honor obligations towards NPT. In 1998, the successor government under the Social Democratic Party (SPD) coalitions which came to power became more anti-nuclear than any of its predecessors with the Green party as its key partner in the coalition. It put forward proposals such as North Atlantic Treaty Organization (NATO) should adopt no-first-use policy and Germany should also close down its nuclear power plants. But it cannot implement both proposals due to opposition from other NATO countries and internal economic pressure.

The most important development in recent years is the increasing worldwide concern for global climate change and the need to find out a means to reduce carbon dioxide emissions. World today strives for clean sources of energy which will not generate greenhouse gases and at the same time it has to meet the increasing energy demand. This has again enhanced the prospects for future use of nuclear energy. However, the conservation lobby also still strongly claims that the development of renewable energy such as solar energy, hydro-power and biomass could overcome the greenhouse problem and meet the energy demands but priorities given by governments for nuclear energy rob them off this opportunity.

PROBLEMS AND PROSPECTS FOR NUCLEAR ENERGY OPTIONS

By 2002, according to the research conducted by MIT (2009), nuclear energy supplied 20% of world energy electricity and 17% of world electricity consumption. Despite increasing world energy demands especially in developing countries, experts only forecasts a 5% increase in nuclear energy generating capacity worldwide. While the

[12] The Paris Accord of 1954 along with the unilateral declaration of nuclear non-acquisition by Chancellor Konard Adenauer.

electricity consumption would increase as much as 75%, the not so optimistic projections is due to anti-nuclear sentiments, cost consideration, problem of safety issues, waste disposal and the threat of nuclear proliferation. To retain nuclear options for the future, the need is to overcome these problems.

Economic cost:

At present, the cost of nuclear energy entails much higher overall lifetime costs as compared to coal and natural gases. Unlike other energy technologies, nuclear power needs significant government involvement. However, if this is compared with the future cost of reducing carbon-emissions, then it might become more cost-effective. The cost of nuclear energy in comparison with other forms of energy also differs on the basis of location. In countries like US, China and Australia, they have easy access to coal. But in some European countries like France, nuclear energy is cost-competitive despite high capital cost. The need to internalise all waste disposal and decommissioning costs in comparison to the social environment and health hazards caused by fossil-fuel caused many thinkers to believe that nuclear energy would be a better option.

On the other hand, by looking at the history of nuclear power plants in the 1970's and the 1980's in US, there are massive over-run cost due to reasons such as design flaws which led to reactor leak and operational confusion such as the three mile island's incident. These were later changed and became time consuming and ran high capital cost. The financial industry saw it as a risky investment to construct new power reactors and demand a premium on capital lend for the purpose. Besides, till the mid-1990s, the need to obtain two separate licences for building nuclear power plant and subsequently for operating often delayed the process and resulted in loss of capital. Sometimes after completion, like the Shoreham facility, they are not allowed to operate. On reactor design, France followed a standard design which satisfied French Regulatory Commission while US vary their design each time and make it difficult for approval and less cost-effective.

However, since the 1970's, the US nuclear industry was able to deliver electricity cheaply and reliably. From 1987 the cost of producing electricity had fallen from 3.63 cents per KWHr to 1.68 cents per KWHr in 2004 and plant availability has increased from 67% to over 90%. Besides, the cost of constructing nuclear power plant seems to go down in recent years. According to NIF (2009) report, the General Electric Advanced Boiled Water Reactor (ABWR), the first third generation to be approved were commissioned in Japan in1996 and 1997 and completed at construction cost around USD$2000. Westinghouse claimed its Advanced Pressurised Water Reactor (APWR) AP1000 will cost only USD$1400 per Kw for the first reactor and further fallen to USD$1000 on subsequent reactor. Proponents of the CANDU ACR and gas-cooled pebble bed made such optimistic claim. Meanwhile the Chinese nuclear power industry won a contract to build nuclear plants at capital cost, reported to be USD$1500 per Kw and USD$1300 per Kw which could pose a formidable challenge to western design if completed on budget.

Safety Issues:

On safety, nuclear power was perceived to have adverse effect for the environment and health especially after the Three Mile Island incident in 1979 and Chernobyl in 1986 and fuel cycle facilities accidents in the U.S., Russia and Japan. There is also a concern for safe and secure transportation and storage and the threat of proliferation. Safety issues could be more complex because it involves human, technical and organisational factors. Nuclear accidents very often cannot be pin pointed to one particular factor.

An intensive study of France and Germany also showed variances between operators and maintainers of highly automated production technologies. It was found that the differences were determined by national culture rather than work or job status (Rochlin and von Meier, 1994:161). Compared to American workers, the European, Canadian and Japanese workers were much more at ease with automated highly computerized plant. However they were all united in rejecting the idea of complete automation. Therefore, when nuclear power plants which involve high technology were designed and exported to other countries, it often includes important cultural aspects to the design. So when short term or long term improvement in safety is sought through international cooperation, it is important to understand the technical, individual, organisational as well as cultural aspects.

Waste Management:

In most countries, there is no position on the final disposal strategy for long lived high-level waste. Only temporary solutions are in place and no long term policy and finding sites for nuclear waste disposal become a highly politically sensitive issue and deeply problematic. France has the highest fraction of waste generated by its nuclear power. In 2002, France stored 978,000 cubic meters of waste. In 2020, the annual amount is expected to be 1.9 million cubic meters, highly radioactive materials, such as spent fuel rods, are stored in The Hague and at the Marcoule nuclear facility. The United States has recently taken a decision to proceed with a spent fuel and high level waste repository at the Yucca Mountain. However this will ease but not solve if other countries continue to substantially expand nuclear power. Significant progress was found in Finland and Sweden as well.

The MIT (2009) research mentioned that those countries with a plan to close down one of their nuclear power plants permanently has to follow the requirements of the Nuclear Regulatory Commission (NRC) guidelines. This laid down the rules and regulations for protecting workers and public during the entire process. The facility needed to be safely decommissioned by safely removing it from service and involving clean up of radioactively contaminated plant systems and structures and removal of the radioactive fuel to a level that permits release of the property and release of the operating licences. The benefits of nuclear fuel reprocessing have also become a contentious issue. It also remains unclear whether disposal of waste is easier by reducing the volume of high level waste (HLW) or make it more dangerous for possible accidental release of gaseous or liquid radioactive streams into the environment. Besides, there is also grave concern on how to deal with the plutonium from reprocessing, a dangerous substance with which a small amount of it could be utilized to create nuclear bombs.

Public Opinion:

Apart from the above mentioned concerns, especially in democratic countries, public opinion became the most significant factor in deciding the nuclear option of those countries. After incidents in the Three Mile Island and Chernobyl, anti-nuclear movements in many parts of Europe caused delay, heavy cost increases and eventual cancellation (Beck 1994:43). However, though public opinion is an important criterion, it is not always the only deciding factor such as in France and Germany. After Chernobyl accident, while opposition to nuclear power movement cause a delay in the election period soon after they resumed with the construction of nuclear power plant and both countries largely seems to contained public anxiety over safety issues, so there were some other factors in play which determines German decisions to phase out its nuclear power programme whereas in France, nuclear energy was never placed in the public domain for discussions.

CHAPTER TWO

FRENCH ATOMIC DEVELOPMENT PROGRAMME

"Our country has no serious alternative to nuclear power except economic recession"

Andre Giraud[13]

HISTORICAL BACKGROUND

From the last decade of the nineteenth century to the eve of Second World War, France was among the leading nations in atomic science. In 1886, Henry Becquerel, a French physicist discovered phenomenon of natural radioactivity. Two of the France's leading scientist, Frederic and Irene Joliet-Curie also produced artificial radioactivity in 1934 which constituted a very important step for understanding the potential of atom. Both of them were awarded the Nobel Prize for Physics due to their findings. Following this, by 1939, Joliet Curie and his colleagues, Hans Halban and Lew Kowarski successfully completed experiment showing that some neutrons are emitted during fission enough to make a chain reaction possible and published their findings. So, this enabled the Joliet's group to conduct reactor experiments.

The outbreak of war in August 1914 between France and Germany however shifted the emphasis from peaceful efforts to military applications (Scheinman 1965:4). The Minister of Armaments, Raoul Dautry, apprised of the strategic value of atomic power, put all possible facilities and credits at the disposal of Joliet-Curie team to integrate them into the war efforts. Under the Joliet-Curie initiative, France acquired from Belfast the Uranium oxide necessary to fuel an atomic device. In 1940, an agreement with the Societe Norvegienne de l'Azote resulted in the delivery of the entire Norwegienne stock of heavy water, a moderator in conducting controlled atomic reactions. Three months prior to the fall of France, the Joliet-Curie team had reached the point where it was believe to be possible to conduct an actual chain reaction, but the invasion of France precluded any possibility of tests (Scheinman

[13] André Giraud was earlier Director of the Commissariat a l'Energie Atomique (CEA)in the 1975. and later, he became Minister for industry. His appointment was largely seen as the key role nuclear power continues to play in France.

1965:4). The signing of armistice in 1940 put an end to French nuclear effort and paralysed it until the post-war period.

Following the Nazi conquest, the French atomic research continued in the form of scientific participation in Anglo-Canadian atomic projects, the uranium oxide was shifted from Joliet-Curie's laboratories and hidden in Morocco and the heavy water was sent with Halban and Kowarski to use in the British atomic research programme and many other scientists like Pierre Auger, Bertrand Goldschmidt and Jules left the continent to participate in allied nuclear research enterprise and later were ultimately associated with the Canadian project at Montreal. The French Physicist also contributed to the Manhattan project along with scientists from United States, Canada and Britain.

THE POST-SECOND WORLD WAR PERIOD

Soon after the liberation of France, as early as 1944, the decision to renew the efforts on atomic research took place as with General de Gaulle as head of the provisional government taking deep interest in these efforts. With the basic steps taken by Joliet Curie, who resumed his position as the Director of the Centre National de la Racherche (CNRS) and Dautry, who was named Minister of Reconstruction in the Provisional Government, both of them attempted to convince the Government of the feasibility of developing atomic energy programme because of the potential military and economic role it would play in the future.

In March 1945, Dautry drafted a comprehensive memorandum and sent it to General de Gaulle. He stressed the rationale for instituting a framework for atomic research and noted in his draft the research that France had reached by 1940. He emphasised that this form of energy would not only immediately effects national defence but also long range effects of substantial importance to economic life of the world. In a "spirit corresponding less to a military preoccupation... than to a desire to secure for France the legitimate share in the world which would eventually revert to her in... peaceful use"(Scheinman 1965: 6), he advocated three steps to be taken by the provisional government:

- that France re-introduces herself to the field of atomic research by creating a team of workers to be placed under the authority and disposition of Joliet-Curie;
- that Anglo-French contact be made to assure that France will be included in eventual international arrangements on atomic energy;
- finally, that France demonstrates her continuing interest in atomic affairs by purchasing the heavy water loan to her by the Norwegian in 1940.

It was believed to be these factors such as the reconstruction and rehabilitation of France to industrially and commercially viable nation capable of resuming its role as a leading nation in international stage which induced General de Gaulle to give his consent to establish a national Atomic Energy Programme. The *Commissariat a l'Energie Atomique* (CEA) was instituted on October 8, 1945 and was charged with a broad range of responsibilities for the pursuit of scientific and technical research with a view to the utilization of atomic energy in the several areas of science, industry and national defence including the design of nuclear reactors. However, the poor material and technical situation of France in the post-second World War period narrowed the range of policy alternatives available for atomic energy development. The France atomic energy programme was further constrained by the United States (US) Atomic Energy Act of 1946 (McMahon Act) which contained a strict provision on the release of atomic technology to other powers, even to allies.

From the very beginning of the atomic energy programme in France, the majority of the French people were strongly opposed to the development of weapon programme. Besides, the lack of a material basis from which to operate meant that decisions with long range implications could not be taken. Therefore, these conditioning factors predetermined the immediate future of French atomic development towards peaceful use. The French declaration by M. Parodi in the United Nations in June, 1946 stated that,

> "...it is that they are entirely oriented towards peace, toward the work of peace, toward activities whose essential goal is the welfare of humanity...The credibility of declaratory policy was further enhanced by the prevailing international situation..." (Scheinman 1965: 20).

The credibility of France to developed nuclear energy policy towards peaceful use was further enhanced by the prevailing international situation. The United States, sole possessor of a nuclear weapon, had presented the Baruch Plan before the United Nations Atomic Energy Commission. This plan, if adopted would have precluded the development of national nuclear arsenals. In June 1946, Soviet-American relations, riding on the crest of wartime collaboration, and therefore the necessity of a French defence force based on atomic weapons had not become evident. Nor did France yet feel the pressure of crumbling colonial empire, a situation which was later to lead some Frenchmen to conclude that the respect of the French community and the emergent Afro-Asian nations turned on whether the mother country was endowed with a nuclear weapon capacity.

THE FIRST PHASE

The years between 1945 and 1950 were spent in setting up the necessary infrastructure for the industrial and military exploitation. The French at the initial period had only a handful of trained scientists. Besides, those who were participated in the Allied wartime projects were obligated to conceal whatever knowledge they acquired as a result of their work. The CEA also had to compete with universities and other industries to recruit competent scientists and engineers. Therefore, great emphasis was placed on the training of staff and technicians. To provide them with a hands-on experience, the first research reactor Zoe[14] was built and began operation at Chatillon on 15, December, 1948. In the following year, a new centre for research and development was also set up at Saclay[15].

The CEA also created the Direction de Recherches et Exploitations Minieres (DREM) to deal with the function of systematically prospecting and mining in both domestic and overseas territories.Therefore, during this period, there was an intensive effort and prospective for Uranium in the French territories such as Madagascar, Algeria and West Africa. However, majority of uranium deposits are located in places such as La Crousille near Lemoges, Vendee, Brittany, Grury in Saone et Loire, Fores, and possibly

[14] The French first research reactor EL-1 or Zoe which implies zero power, uranium oxide fuel and Eau lourde or heavy water.
[15] At present, Saclay become the largest nuclear research centre in France

at Lachaux, southeast of Vichy. According to the CIA (1956) Scientific Intelligent Report, French proven reserves of uranium oxide amounted to 10,000 tons with possible unproven reserves from 50,000 to 100,000 tons. In 1956, French production of uranium oxide amounted to 600 to 700 tons per year with a planned production of 1,000 tons by 1961, 2,500 tons by 1970, and 3,000 tons by 1975. Thus, France was able to meet the uranium requirements of its planned reactor program from native sources and subsequently became the leading uranium producer in Europe (Curie 1949: 3-7).

In international relations, the growing tension in the Cold War evoked the necessity of Western solidarity (Scheinman 1965: 39). The Brussels Pact was signed in 1949 and the North Atlantic Treaty Organisation (NATO) was formed in 1949. The allied also put effort to pursue a policy of total secrecy on atomic development from the Soviets. So, in April, 1950, Joliet Curie, a communist was dismissed as politically unreliable from the High Commissioner office which brought a virtual standstill to the CEA function in the following year after his departure.

THE SECOND PHASE

The year 1951 was a period of reorganisation ending the scientific leadership and 'consecrated the guardianship of the scientists to that of the administration (Scheinman 1965: 50). Under the leadership of Francis Perrin as High Commissioner, Felix Gaillard, Secretary of States for Atomic Energy Program and Pierre Guillemat as Administrator-General, a five-year plan to expand the Atomic Energy program was drawn up. The first problem which the CEA had to grapple with was whether the Commissariat should concentrate on research and industrial reactors, or should it embarked upon programme of fissile material production? The former would have meant rapid strides in the industrial utilisation of atomic energy but would have to depend upon imports of fissile materials and implied technical and political dependence upon countries like Britain and America which was not so encouraging at that time; the latter would raise the spectre of diversion from peaceful to non-peaceful use (Scheinman 1965: 65). The latter was chosen which meant a delay before France could utilize its home-made fissile material but that would ensure her independence.

The second set of questions deals with the options between plutonium and enriched Uranium (U-235) as nuclear fuel. Plutonium was easier to produce, but its industrial use other than its military was little known at that period. U-235 could be produced only by separation of isotopes which would involve the laborious and extremely costly production of suitable plants, on the other hand, the French scientist were quite unaware of the technology involved in producing enriched uranium. Adding to that they lacked necessary funds to produces enriched uranium and due to McMahon Act, access to information was impossible as well. In these circumstances, the CEA decided to produce plutonium producing piles. However, this gave rise to the assumption that those scientists might have military purpose foremost in their mind.

The first Five Year plan got approved in July 1952 by the National assembly. The significant feature of the plan was the authorization and the construction of industrial scale plutonium production facilities at Marcoule on the Rhone River - Construction work which began in 1954, was completed in mid-1958. The major facility at Marcoule includes: graphite moderated, gas cooled reactors and a chemical separation plant. The reactors are designed to produce plutonium, with electric power being a by-product. The plan was revised in 1955 with a plan to provide for the third pile along with a secret protocol marked the beginning of substantial military contribution to the programme, relations between CEA and the military had existed since the first few months of the Commissariat existence but it was purely on scientific and technical basis. The 1955-1956 defence budgets had included although hidden substantial credits for the first time. An experimental power generator was installed at G-1 by *Electricite de France* for the production of electricity. The generator has a maximum installed power of about 5 electrical megawatts, and it first produced electricity in the fall of 1956.

The first of these plutonium producing reactors in Marcoule, G-1, went into operation on 7 January 1956 and was shutdown on 15, Oct. 1968. It had a designed power level of 40 thermal megawatts but the reactor was running at only about 35 thermal megawatts because of difficulties encountered from fuel element rupture. The second and third reactors at Marcoule, G-2 and G-3 were natural uranium reactors, using graphite moderator, and cooled by pressurized carbon dioxide. G-2 went into operation on 21 July 1958 and by April 1959 had attained a power level sufficient to produce 9 megawatts of by-product electricity later shutdown at 2nd February 1980. At full scale operation, it will have a power level of about 150 thermal megawatts, permitting the production of about 40 kilograms of plutonium per year and 25 to 30 megawatts of by-product electricity. G-3 went into operation in June 1959, and it is expected that the power level increased progressively until it is in full scale operation sometime in 1960 but was shutdown in 1984.

The first French nuclear power plant is under construction at Avoine, just north of Chinon. This reactor, called Chinon A-1 which started to operate in 1963, was a graphite moderated, gas-cooled reactor with nominal capacity of 70 megawatts. Construction of additional power reactors was planned. Since 1965, A1 (1963-1973), A2 (1965-1985), A3 (1966-1990) (Davis and Byrd 2001:1) and B reactors went critical in 1982, 1983, 1986, and 1987 respectively. All of the nuclear power reactors were expected to produce significant quantities of plutonium as a by-product. Upon completion of the nuclear power program, French reactor facilities had the capacity to produce about 550 kilograms of plutonium per year.

As the French nuclear program developed, it became clear that the possession of enriched uranium was essential. Research on isotope separation was initiated at Saclay by 1955, and in 1957 the first of two pilot plant facilities was begun. The first Saclay pilot plant was a 12-stage installation used to test gaseous diffusion barriers. Barriers could be tested in both tubular and flat shapes. The second plant at Saclay was larger and contained 16-stages of prototype cells of a type planned for the first full-scale plant.8 In 1957 the CEA also secured an appropriation of 25 billion francs for initial construction work on a full scale gaseous diffusion planted to obtained enriched uranium. France tried to take interest in Euratom partners for joint construction of this full scale gaseous diffusion plant. Only the Italians showed interest; they were reported to have offered tentatively about $20 million toward the project. Finally, in 1958, France decided to incur the expense of building its own plant and announced its plan formally in the Second Geneva Conference in the year 1959.

FRANCE AND THE EUROPEAN DEFENCE COMMUNITY

The idea to create the European Defence Community (EDC) was originally conceived at the Hague conference of 1948. In 1950, René Pleven, the French President of the Council proposed the plan and put forwarded by the French Foreign Minister Robert Schuman at the meeting of the Council of Europe in 1951. Later, this resulted in the conclusion of the treaty for the formation of EDC in Paris on 27 May, 1952[16]. Through EDC, as an alternative to the rearmament of West Germany, the Western European powers intent to create supranational army, supported by United States to counterbalance the military threat from the Soviet Union.

In 1954, the debate on EDC brought the question of military application of atomic energy for the first time into public forum. For France, it became an issue of great concern taking into account, it was the first time the 1954 military budget discussion, recognised the potential role of atomic weapons for national security. Although the EDC was only peripherally related to the military development of atomic energy in France, its importance cannot be denied since the EDC Treaty contained provisions regulating the whole questions of atomic weapons. Article 107, prohibited the production, importation or exportation of, as well as technical research on war materials. No participating countries could produce in excess of 500 grams of material "designed for, or primarily useful in atomic weapons"[17]. Quoted in Scheinman, Lawrence 1965: . Since, the support for atomic weapon gained strength during this period. The European Defence Community Treaty (EDC) question was very generously cast as "the greatest ideological and political debate France has known since the Dreyfus affair" (Aron 1957:10).

The drawbacks of the Treaty, which "would submit even the functioning of Mercoule centre to international authority," was impressed upon the French government from the point of view of national interest. France could be affected in two ways: not only it would prevent the development of French atomic military weapons, but peaceful research could be hampered as well. The 500-grams limitation on the production or

[16] The EDC treaty was signed by six countries France, Germany, Belgium, Luxembourg, Italy and the Netherlands.
[17] Treaty establishing the European Defence Community, and Related Protocols. Signed at Paris, May 27, 1952. (Paris Impremerie P. Dupont, 1953), Article 107, Annex II

possession of material "designed for or primarily useful in atomic weapons" fell far short of the quantities of such material necessary for applied atomic research, besides it was also assumed that the EDC could effect the influence exercised by the CEA and the Administrator-General substantially on the formulation of atomic policy who were interest in retaining largest amount of autonomy as can be seen in the case of Euratom in 1956 (Scheinman 1965:105).

However the main themes of the debate also focused upon the issue of German rearmament, and the transfer of sovereignty inherent in a supranational community. France felt that the presence of military in German soil would be a threat to her national security. Therefore, when debate on the EDC took place in the French National Assembly on 30 August 1954, the French failed to ratify the treaty paving the way for future development of nuclear weapons.

BEGINNING OF FRENCH MILITARY ATOMIC PROGRAMME

France is the only western democratic countries to have developed a military nuclear programme in time of peace despite an incipient pre-war atomic program. During 1954, the atmosphere was favourable for military program. Especially after United States refused when France urged President Eisenhower to intervene by threatening the use of nuclear power to relieve the besieged French forces in Dien Bien Phu - soon after John Dulles's public rhetoric about Massive Retaliation - led the French to decide that France should become a nuclear power (Hueser 1997:93). However, in 1955, Premier Edgar Faure government declare itself against military atomic orientation (Scheinman 1965:116). Further, the Mollet government in 1956 also made a decision to forgo nuclear weapons and to join Euratom (Scheinman 1965: 1965: 116) but later softened its stand not to curtailed the military options.

Under Pierre Mendes-France, the government began to move determinedly towards developing an atom bomb. The French also began to take interest in command and control arrangements. When in December, the North Atlantic Council (NAC) decided to authorize the use of tactical nuclear weapon in the event of aggression, following this, a further decision was taken by the French government to step up their weapon programme with a view to some independence from alliance policies. Thus at the beginning French quest for atomic weapons, more of a quest for political weight independence from its western allies and it was less of a reaction over any perceived threat from the Soviet Union (Hueser 1997:94).

Moreover, the French disenchanted with their allies in the following year towards her American and European allies for security, in the context of the Suez crisis and France attempt to hold on to Algeria . Besides, the French thinking lacked consensus within among themselves and moreover also not in tune with the prevalent thinking in London and Washington. In 1957, while the head of French Government, Guy Mollet was unhappy with the British Sandys White Paper's return to Massive retaliation, instead wanted a greater reliance on deterrence through *la presence humaine*, that is, man power and conventional force strength. His defence minister Maurice Bourges-Maunoury greatly liked the Sandy's declaratory strategy and paved the way for France's emulation of it.

By the second half of the 1950's, the construction of French uranium enrichment plant became very costly The fourth republic tried to draw in foreign investment and also contemplated other ways of gaining access to nuclear weapons which was expected to tide them over while their own research proceeded. This led to treaties about warhead joint missile and warhead development with West Germany and Italy though later it was abandoned by de Gaulle on his return to power and the treaty with Israel was terminated two years later. France also continued to implore the Americans at a NAC meeting in May 1957 to give their allies access to the nuclear weapons which were deployed in Europe. The United States responded by its offer of permutations of a NATO or multilateral nuclear force. However due to Washington insistence on retaining control of the warhead in peace-time, France rejected the previously unsolicited offer of such deployment on French soil.

During this period, the prospect of European integration also accelerated the French atomic programme. The signing of the Euratom treaty to create European Atomic Programme could risk denying French unilateral nuclear weapon development. By bringing its nuclear programme forward it could confront it partners with fait accompli (Keiger 2001: 69). Besides, the launching of the Soviet Satellite Sputnik in 1957 had demonstrated to the world its capability to deploy intercontinental missiles with nuclear warheads that could directly threaten American cites. So, the possibility emerged whether US would sanction the use of nuclear weapons in case if the Soviet Union invaded Europe, this further motivated France to build its own nuclear weapon to ensure ultimate defence.

Therefore, France continues to push forward her research in nuclear power, despite the obstinate technological aid denial by the United States. Felix Gaillard, in April 1958 finally signed the order to prepare a first French nuclear test for 1960. Although de Gaulle was often given the credit for having launched the French nuclear programme, he merely confirmed this order. The US continued to turn down de Gaulle request for aid. However, by 23 October, 1958, de Gaulle at a Press Conference was able to say that, "everybody knows that we now have the means to provide ourselves with nuclear weapons and the day is approaching when we, in our turn, will carry out tests",(Scheiman 1965: xvi). Therefore, the first French nuclear test took place without the US assistance on 13 February 1960 in the Sahara dessert at Reggane. When the US offered France Polaris missiles, on the same term as to the British in December 1962, de Gaulle by now suspicious of the US motives to deprive her of nuclear independence refused, though he later accepted a further American concession in 1963.

RE-AWAKENING IN ATOMIC ENERGY FOR PEACEFUL PURPOSES

Unleashing the Oil crisis on 17 October 1973, the members of Organization of Arab Petroleum Exporting Countries (OAPEC)[18] proclaimed an oil embargo on Western powers. It was in response to the U.S. decision to re-supply the Israeli military during the Yom Kippur war. The French Government responded by making the biggest commitment that any government had yet made to nuclear power. This became central to the long term strategy of industrial expansion and rapid advance in technologies. The French government believed that this could not be achieved while France was almost totally dependent for her energy on imported raw materials. The key role of nuclear power in French plans was seen in the appointment of the Director of CEA, Andre Giraud, as Minister for Industry. 'Our country,' Giraud said shortly

[18] OAPEC consisted thirteen of The Organization of the Petroleum Exporting Countries (OPEC) plus Egypt and Syria.

after his appointment to the cabinet,' has no serious alternative to nuclear power except economic recession", (Moss 1981: 92).

The nuclear power programme was ambitious: nuclear energy was to supply 50% of French electricity by 1985. The Government ordered thirteen 900-mw nuclear power plants; the largest order of this kind ever placed anywhere. These were all to be manufactured by one company, Framatome and all to be delivered to *Electricite de France*, the nationally-owned power company. The French Government pushed ahead with the programme with characteristic energy and single mindedness. Public debate was not encouraged. When a radio interviewer put it to Giraud that there might be increased public involvement in decisions, he said,

> "How do you expect to find its way when some scientists contradict some other scientists? The only way to do is to carry on with our work, and then persuade people that nuclear power affairs are in the hands of serious people who deserve their confidence", (Moss 1981: 92).

Therefore, first reaction to Press reports that there were leaks in some reactors was to clamp down on leaks to the press. The programme continued full throttle until the election of Francois Mitterand, who took the presidential foot off the accelerator (Moss 1981: 92).

The Giscard Government made one important policy change. It decided to abandon its gas-cooled reactor design and switch to PWRS, which Framatone would built under licence from Westinghouse. The better performance of the PWRS and attractive purchase terms persuaded the authorities, even though this meant relying on America for the supply of enriched uranium fuel (Moss 1981: 92). However, a problem presented itself when the United States worried that it might overcommit its enrichment facilities in March 1975 decided to suspend all licences to exporting uranium without consulting its customers. The European countries were largely taken aback by this announcement, and it came as a blow to Euratom countries and the European commission protested on their behalf, but America only promised to review the situation after her domestic enrichment requirements were fulfilled. This led France to Joined forces with Belgium, Spain and Italy to formed European Gaseous Diffusion Uranium Enrichment Consortium (Eurodif) to build a huge gaseous diffusion plant at Tricastin, on the banks of the Rhone. Later, it was joined by Iran only to be dropped out a bit later, but when the plant began operating in 1979, it was not able to fulfil all her requirements (Moss 1981:). However, France later acquired the technique of making light water reactors from America and later became a formidable contender in exporting reactors.

As regards the French atomic programme, in technical terms their record has been impressive. A total of thirty-six reactors began operation since 1977. By the 1980's when most countries were slowing down their programs five or six reactors were under construction in France each year. Overall responsibility for operation, construction, design lay in France single utility, nationalised plan, Electricite de France (EDF). By 1986, with the result of around $50 Billion investment, France produced 65% of its electric by nuclear power and became the second nuclear states after United States, but well ahead of Soviet Union, who came third in net output and it had the lowest electricity prices in Europe. The electricity generated from nuclear power stations was exported by France to more than 23 Kilowatt billion hours a year to its European neighbours.

France also indulged in developing a new enrichment process that was designed specifically as an anti-proliferation measure cooperating with the US Department of Energy. This was done by utilizing a method of separating uranium isotopes by chemical means alone, which could only enrich uranium so far up to only 5 percent. It was expected to be adequate enough to use as fuel in light water reactors but could never be able to use to make weapon grade material. The Commissariat a l'Energie Atomique also embarked upon another development designed to reduced proliferation risks. Through utilizing a fuel element which uses low enriched uranium, well under 20 percent, but since its configuration could serve as well in a research reactor as the 93 percent enriched uranium which is the normal fuel at present, it is called 'caramel' simply because the uranium is arranged in the moderator in small cubes and look quite similar with caramel.

THE NATURE OF FRENCH ATOMIC POLICY-MAKING

The nature of French atomic policy-making could be a manifestation of her aspiration for the *politique du grand siécle* that resulted in deliberate and bold acts ranging from the nuclear power to development of national nuclear striking force de frappe. It is the only non-communist state to have a military nuclear program in time of peace. Especially after the 2nd World War, she was forced to retreat due to her poor political and economical condition and to settle considerably less than what she bargained for, the only way to compensate for diplomatic failure and their continuation was to develop a nuclear capability.

Besides, France tried to prevent the revival of German power and influence on the continent, and pursued a policy of European integration. She pursued the policy as the best means of channelling German energies in a direction conducive to French force and by preventing German recovery from presenting a serious challenge to French continental leadership. Unhappy with American pressure to develop a strong western German nation to counter USSR and the prospect of German rearmament became increasingly more difficult to handle. Therefore, to guarantee her own security requires the development of nuclear capability, she was also frustrated by the NATO with the development of an Anglo-American decision making which frequently informed France after the fact rather than consulting her prior in taking decision which also affected her own interest.

The colonial problem became more and more difficult to control due to the developing aspiration of national self-determination. French interest in places like South Vietnam and North Africa compounded by the divergence of interest with the United States led her to conclude that only an independent nuclear capability would prevent the sacrifice of France interest outside the NATO. Besides, the United States had a nuclear monopoly or a preponderant nuclear advantage over the Soviet Union France could seek the protection of the American nuclear umbrella. However, the Soviet Union acquisition nuclear capability changed the situation, especially when they gained the ability to deliver nuclear weapons on the United States. France and her European allies became concerned about the American promise to respond to any Soviet attack on Europe by a massive nuclear attack on Soviet Union. It appears necessary to develop a separate nuclear force to trigger the American nuclear response.

To understand the nature of French atomic policy, it is also important to examine the conditions under which those policies were made and the interplay of power politics between different political parties in France. Under the Fourth Republic, the coalition's governments which were formed lacked stability, for they cut across political associations which often were antagonistic in shaping policy goals. These were rigorously limitations in both the selection of policy alternatives and in the ability to produce positive policy decisions. Therefore, potentially divisive issues to threatened coalitions were often avoided. Indeed, one of the most singular features of atomic policy during this period was the almost total lack of parliamentary discussion of the implications of atomic power for France in either a peaceful or military context. (Scheinman 1965: xiv)

Socialists and Popular Republicans, who held similar views on the question of European integration or economic policy, were opposed to each other on clerical issues; Radicals and Socialists were uneasy allies when economic policy was in question; social and economic issues were the main stumbling blocks of Moderate-Socialist alliances. Communists and Gaullists were pole opposite except on their mutual disaffection with the parliamentary regime of the Fourth Republic further contributed to instability (Scheinman 1965: xiv). The government which governed the least survive the longest. During this period there was a total lack of parliamentary discussion of the implications of Atomic power for funds in either a peaceful or military context. Meanwhile, France has made successful progress in nuclear technology which paves the way for military atomic program. France nuclear could rather be attributed to a relatively small group of people, well situated in authoritative position and operating through informal channel of communication outside the mainstream of political activity.

Under the Fifth Republic which emerged in 1958 from the collapsed of the Fourth republic (1946-58), the national atomic policy could be seen as a continuity of the Fourth Republic. It brought about a new set of actors in the government, but there is hardly any change in the personnel responsible for conducting French atomic policy. The relationship between the Fourth and the Fifth Republic could be seen in the following areas: on the bomb program, the major differences from the Fourth Republic to the Fifth Republic is that the possession of Atomic bomb become official policy under General de Gaulle, though the Algerian yoke and the economic crisis could be the reason that could be given for earlier hesitation, on the Fifth Republic on the other hand there was never any question that France would undertake to provide herself with atomic bomb.

In the matter of peaceful use of atomic energy, there was basic continuity between the Fourth and the Fifth republic. The second five year plan was voted in July 1957 and was to extended till 1962. The plans and programs which were pre-decided were not altered due to change in regime. A fourth nuclear centre, Cadarache, has been decided by the CEA in 1958 as a place for prototype reactors to implement a number of studies called for by the second five year plan approved this in 1959. It is evidenced by its continuity de Gaulle administration was not interested not merely in military development but also in its industrial and economic potential as well.

With regard to Euratom, the Fifth Republic underwent some new changes from the previous government. M. Mollet's promise that Euratom Treaty would in no way impair France's rights in the area of national defence. France decided to join Euratom and as it was presented to the parliament for ratification in 1957, it was rejected nevertheless, but more on grounds due to the proposed European community. However under the fifth republic, the basic policy has been to support that organization as far as research activities were concerned. The closer a research catered to her interest and needs, the more willing France would be to grant support. Besides, despite the absence of official doctrine on atomic affairs and inability of the government to reach consensus with the issues, the development of atomic program could also be attributed to external political and military environment, such as the evolution of international affairs between the liberation of the colonial countries and the launch of Sputnik by the Russians served as a catalyst to the eventual development of a military nuclear capability for France.

Towards the end of Cold war, the entire structure of French defence relying so crucially on nuclear deterrence seem to become unhinged with the possibility of nuclear arms reductions agreements between United States and Soviet Union (Hueser 1997: 119). There seemed to be an imminent possibility that the nuclear arms reductions agreements such as the Reykjavik announcement of 1986, INF Treaty of

1987, SNF renunciations of 1991 and 1992 might resulted in the denuclearization of the entire European continent. This would surely put pressure on France to abandon her nuclear forces. After the unification of Germany and the loss of French role as the four occupying power or victors of the Second World War, Mitterand unsuccessfully tried to persuade other to come to an exclusive arms reductions conference (Hueser 1997: 120). However after the end of cold war, and as the fear of a final American forces withdrawal widespread in June 1991, France decided to become a full signatory of Nuclear Non-Proliferation Treaty on 3 August 1992. Further, Under Jacques Chirac, French governments became more conciliatory towards its European partners. But bilateral talks held in autumn 1992, between France and Britain still excluded Germany at the request of France. However, on 9 December 1996, President Chirac and Chancellor Kohl had signed the Franco-German Defence guidelines of Nuremberg.

THE ANTI-NUCLEAR MOVEMENT IN FRANCE

Despite France being presently regarded as the most pro-nuclear country in Europe, relatively low anti-nuclear feeling with few public protests as compared to other major nuclear power countries. The government of the Fourth Republic manage to curb extensive debate on nuclear issues, during the Fifth Republic first decade opposition against the nuclear programme was strong when the first *Mirage IV* bomber became operational in late 1963, anti-nuclear demonstrations and a 'week against the *force de frappe*' (Hueser 1998: 93) was organised by the communist-dominated CGT-trade union. The PCF itself and various left parties and constantly opposed to France nuclear policy till early 1970's. However, the main opposition in the mid 1960's came from outside France and successive French governments had to face international and occasional domestic protest against the continuation of French nuclear tests first in the atmosphere and later underground in the pacific.

The first major public anti-nuclear demonstrations took place in July 1977, when around 60,000 demonstrators from many countries decided to march on the site of France's first commercial breeder reactor. They were met with a massive police attack, in which one protester died and several injured. Earlier on 4th May 1975 at the Fressenheim plant, the reactor core was slightly damaged by a bomb and on 6th June

1975, the Paris offices and factories of Framatome, a subsidiary of United States Westinghouse were also bombed along and such other incidents of anti-nuclear terrorism had been witnessed in some other part of France (Elliott 1978: 121).

Chernobyl incidents invoke a latent anti-nuclear anxiety among the people of France. Like any other European countries. Even though the government insisted that fallout from the accidents was not deposited over French soil, the public demonstrations focus over the country's first Super Phoenix breeder reactor at Malville which was going on-stream since January 1986 as well as the citing of radioactive waste-dumps in France. Also on 24th May 1986, around 5,000 people marched through the streets of France with the theme 'Chernobyl; never again' and gathered around the perimeter fences of some French nuclear power stations to protest against their government nuclear power policies (Park 1989: 170). Due to mass anti-nuclear protests, till the late 1980's successive governments seems to shun nuclear issues in public debate.

However, France government appeared to have successfully weathered the storm of anti-nuclear protest. During the same period nineteen new Pressurized Water Reactor (PWRs) plants were under reconstructions and confidence level seems to run high even after Chernobyl's nuclear incident. The French government though declared its plan to expand it even further. The New Leftist government elect in May 1986 was known to be not entirely comfortable with the nuclear policies it inherited from its predecessor, but it made no major alternations to existing nuclear power policies (Park 1989: 170).

IMPLICATIONS OF NUCLEAR ENERGY FOR THE FRENCH ECONOMY

France has only 0.01% of the world known fossil reserves, while its primary consumption is about 2.5% of world energy reserves and it is the seventh largest consumer of energy. It is relatively poor in primary energy sources as compared to many other European countries such as coal in Germany and Spain, Oil, gas and coal in the United Kingdom, gas in the Netherlands etc. According to the Energy Information Administration as shown in **Table 2.1**, French energy supply on coal production has fallen from to less than 6.2 million in 1998 to 0.2 million tons in 2004. At the same period the natural gas field which used to supply between 79.9 Billion cubic feet tons of gas per year has fallen to 33.3 billion cubic feet tons. In recent years oil production barely exceeded 70.80 thousand barrels per day as compared to 89.2 thousand barrels per day in 1998 and the total consumption was much higher at 2040 thousand barrels per day. It is the same with all the other energy from fossil fuels; the consumption rates far exceed the production.

In order to secure security of energy supplies, France's energy policy has given priority to the development of national energy supplies especially on nuclear energy. France claims to derive over 75% of its electricity from nuclear energy. France is the major exporter of nuclear energy, the largest within the European Union (EU), used for electricity generation, and it accounts for over 40% of primary energy supply, though France exhibit import dependency close to average EU levels. Due to its strong commitment to nuclear energy, France remains one of the lowest CO_2 per capita emissions among European countries which accounts for the 78.3% of electricity generation far above the EU-27 average. It is also the largest net exporter of electricity due to its low cost generation to its neighbouring countries.

Table 2:1: French Energy Consumptions

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Petroleum (Thousand Barrels per Day)											
Total Oil Production	89.22	88.32	85.21	84.87	81.14	80.23	78.27	73.18	72.76	71.14	70.80
Crude Oil Production	34.49	30.49	29.00	27.92	26.92	24.08	23.33	21.34	21.50	19.84	19.50
Consumption	2040.27	2029.19	1998.58	2052.16	1983.25	1999.05	2006.57	1988.65	1981.18	1949.95	1956.22
Net Exports/Imports(-)	-1951.05	-1940.87	-1913.38	-1967.29	-1902.11	-1918.82	-1928.30	-1915.47	-1908.42	-1878.82	-1885.42
Total Oil Exports to U.S.	38	23	36	45	24	27	51	62	73	71	NA
Refinery Capacity	1865	1947	1902	1895	1896	1903	1951	1951	1979	1959	1932
Proved Reserves (Billion Barrels)	0.127	0.107	0.107	0.145	0.140	0.148	0.148	0.146	0.158	0.122	0.120
Natural Gas (Billion Cubic Feet)											
Production	79.9	73.0	66.3	67.5	65.3	56.9	49.4	40.6	43.4	33.7	NA
Consumption	1312.9	1382.7	1402.8	1470.9	1528.1	1510.8	1690.2	1740.3	1759.0	1507.6	NA
Net Exports /Imports(-)	-1214.3	-1408.2	-1422.2	-1403.4	-1462.7	-1453.9	-1640.7	-1699.7	-1715.6	-1481.0	NA
Proved Reserves	505.0	509.0	509.0	506.0	403.0	506.0	506.0	451.0	378.0	341.0	257.0
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Coal (Million Short Tons)											
Production	6.2	5.6	3.8	2.5	1.8	1.9	0.2	0.0	0.0	0.0	NA
Consumption	28.9	25.6	24.7	20.7	22.3	23.7	22.5	23.3	21.6	22.1	NA
Net Exports /Imports(-) (Trillion Btu)	-495.9	-479.2	-510.2	-431.5	-494.2	-463.1	-513.7	-531.2	-545.7	-486.6	NA
Electricity (Billion Kilowatthours)											
Net Generation	483.9	496.3	511.8	521.0	528.0	535.5	540.6	544.4	542.4	537.9	NA
Net Consumption	394.9	403.0	411.9	422.0	420.1	437.3	447.0	451.8	447.3	NA	NA
Installed Capacity (GWe)	109.9	108.3	110.5	111.4	111.6	112.6	112.5	112.7	112.0	111.9	NA
Total Primary Energy (Quadrillion Btu)											
Production	4.8	4.9	5.0	5.1	5.1	5.2	5.2	5.1	5.1	NA	NA
Consumption	10.6	10.7	10.8	11.1	11.0	11.1	11.4	11.4	11.4	NA	NA
Energy Intensity (Btu per (2000) U.S. Dollars)	7265.3	7125.0	6935.4	6962.3	6832.5	6831.1	6850.3	6699.3	6596.4	NA	NA
Carbon Dioxide Emissions (Million Metric Tons of CO2)											
Total from Consumption of Fossil Fuels	409.8	403.8	402.3	406.0	402.3	408.8	416.3	414.4	417.8	NA	NA

NA = Not available

Sources: Energy Information Administration (EIA), International Energy Annual, Short Term Energy Outlook, Table 3a, Table 3b (Forecast values)

CURRENT SITUATION AND DEVELOPMENTS

Currently, France operates 59 nuclear power reactors, 58 Pressure Water Reactors (PWRs) producing 63,130 MWe and one Liquid Metal Fast Breeder Reactors (LMFBRs) totalled 233 MWe **(see Table 2.2)**. Recently on 29 January, 2009, French President Nicolas Sarkozy announced a government decision to built second EPR in France by 2017 and to let Electricite de France (EDF) lead the project. The new power plants to be built at EDF's Penly site near Dieppe on the channel and GDF Suez[19] is identified as a viable partner. French power plant of the CGT had announced that it had opposed private ownership of nuclear power plants on the grounds of safety, cost and preserving skills at EDF. The state owns 85% of EDF and 35.7% of GDF Suez and both utilities showed enthusiasm by pressing the French government to let them build the second EPR. Meanwhile, Sarkozy 'top-down' approach to decision making on the EPR issues was criticised by many as undemocratic but was considered necessary by some others in order to begin the public consultation process.

Coincided with the signing of nuclear cooperation agreement in Rome between French President Nicholas Sarkozy and Italian Prime Minister Silvio Berlusconi, according to EDF press statement in February 24, 2009, both EDF and Italy's Enel have created a 50-50 consortium to investigate building four Areva EPRs in Italy (Steelfox 2009:1). Though it still depends upon changes in the Italian legislative assembly[20], their second "Industrial agreement" gives Enel a 12.5% in the planned EPR reactor at Penly. France, under a 2007-agreement between the parties Enel has the option to take up to six EPRs in France. France's Penly-3 project is also open to wider participation however French Media reporting that German utilities interest in investing are not yet confirmed.

On the other hand, the French federation of antinuclear groups, Sortir du Nucleaire (SdN) had said that France's accord with Italy was empty of real consequences and designed only to create an image of triumphant French nuclear business enterprise. Further, SdN claimed that France has signed non-binding memoranda of

[19] GDF Suez was formed in 2008 to challenge EDF's monopoly on nuclear power plants
[20] Italian legislative outlawed nuclear power after 1986.

understanding with many countries[21], but so far has nothing to show for its agreements but "virtual reactors" and that it is a means to legitimise the construction of EPR in France by presenting an image of many countries lining up to buy the reactors, however the group had incorrectly said that France had not sold an EPR since December 2003 agreement to supply Olkiluoto-3 in Finland, Areva had signed a contract in November 2007 to sell EPRs to China Guangdong Nuclear Power Holding Co.

Moreover, the anti-nuclear groups criticise the government decision to build a new EPR by asserting that France doesn't need another 1,600-1,700 MW of base load capacity before 2020 and the new plants would only serve to export more power. The administrative officials deflected the charges that the reactor was not needed for domestic electricity demand by claiming that electricity demand in France had grown by 1-2% in 2008 and expected to grow by roughly the same percentage. Further, even 2% increase in electricity demand is equivalent to 'one base-load EPR' and by 2017 energy generated from Penly -3 will be in demand (MacLachlan 2009: 1). During the past decades, EDF had exported up to 15% of its electricity production, but recently net exports fall to 46 Terawatt-hours (Twh) in 2008, which was 8Twh lower than in 2007. Besides, a French Industry official also said that it was a mistake reason solely in terms of French domestic energy demands because Europe electricity grid is interconnected and there is a well functioning market and exports of electricity are a way of managing uncertainty to avoid any risk of power shortages in the future.

However, After the EDF board approval the Penly-3 is yet to go through national debate on the project. The nuclear plant licensing process also includes a public enquiry of the sites restricted to the area around the sites, but this process is often controversial before Flamanville-3 was constructed, after a contentious four long month process plus two months for the conclusions of the debate, and involved 19 public meetings, and a 3.5 months for site inquiry, the special EPR committee asserted that the decision to built Flamanville-3 had been made without public input. The Sdf had also reiterated their earlier charges that EDF did not follow their claimed during the Famanville-3 debate that they would need to gain experience in building

[21]France had earlier signed non-binding memoranda of understanding with countries like Libya, Algeria, Morocco, Abu Dhabi, Saudi Arabia, Jordan, South Africa and Estonia.

and operating the initial EPR before deciding whether to built a series of EPRs to replace retiring second generation reactors and if Penly-3 is started in 2012, operation experience are unlikely to be gained from the previous EPR.

EDF had also said that it offset longer-than-expected outages in its overall nuclear fleet last year by running reactors that remained online at higher capacity factors (MacLachlan 2009:11). It wanted to raise average fleet availability by 2 percentage points a year to 85% in 2008. The average availability[22] of EDF dropped to 79.2% in 2008, down from 80.2% in 2007 and 8.6% in 2006[23] , however despite that dip, EDF's nuclear power production was claimed to be "nearly stable" in 2008 due to higher utilization of those EDF reactors at 95.2%, by operating close to base load capacity than in the past. EDF is aiming for 81% availability in 2009, 83% in 2010, up from 79.2 % in 2008, it also tripled its spending on nuclear plant maintenance in the past three years. EDF also intends to invest heavily in extending the operating lives of its PWRs and to seek agreement with regulators to shift the amortization period to 50-year lifetimes, though individual reactors would still undergo decennial safety checks under the new safety system, the EDF Chairman Gadonneix had said that this would cost only 10% that of building a new EPR.

[22] Availability measures the amount of energy; a given unit can offer the grid over a given period.
[23] The utility's 2008 financial results in Paris as presented by company Executives.

Table 2.2: PRESENT NUCLEAR POWER PLANTS IN FRANCE

	Net Mwe	Type	Construction Stage	Init. Criti Cality	Commercial start	Reactor supplier	Generator Supplier	Architect Engineer	Constructor
Commissariat a l'Energie Atomique									
Phenix (Marcoule, Gard)	233	LMF BR	100	8/73	7/74	CNIM / CL /Neyrpic	CEM	Owner/ EDF /Novatome/ Technicatome	SGE
Electricide de France									
Belleville-1 (Belleville s/Loire,Cher)	1310	PWR	100	9/87	6/88	Fra	Alstom	Owner	GTM
Belleville-2 (Belleville s/Loire,Cher)	1310	PWR	100	5/88	1/89	Fra	Alstom	Owner	GTM
Blayais-1 (Blaye, Gironde)	910	PWR	100	5/81	12/81	Fra	Alstom	Owner	SB/Dumez
Blayais-2 (Blaye, Gironde)	910	PWR	100	6/82	2/83	Fra	Alstom	Owner	SB/Dumez
Blayais-3 (Blaye, Gironde)	910	PWR	100	7/83	11/83	Fra	Alstom	Owner	SB/Dumez
Blayais-4 (Blaye, Gironde)	910	PWR	100	5/83	10/83	Fra	Alstom	Owner	SB/Dumez
Bugey-2(Loyettes,Ain)	910	PWR	100	4/78	3/79	Fra	Alstom	Owner	Bouygues/Bruyeres
Bugey-3(Loyettes,Ain)	910	PWR	100	8/78	3/79	Fra	Alstom	Owner	Bouygues/Bruyeres
Bugey-4(Loyettes,Ain)	880	PWR	100	2/79	7/79	Fra	Alstom	Owner	Bouygues/Bruyeres
Bugey-5(Loyettes,Ain)	880	PWR	100	7/79	1/80	Fra	Alstom	Owner	Bouygues/Bruyeres
Cattenom-1 (Cattenom,Moselle)	1300	PWR	100	10/86	4/87	Fra	Alstom	Owner	Dumez/SB/SAE
Cattenom-2 (Cattenom,Moselle)	1300	PWR	100	8/87	2/88	Fra	Alstom	Owner	Dumez/SB/SAE
Cattenom-3 (Cattenom,Moselle)	1300	PWR	100	2/90	2/91	Fra	Alstom	Owner	Dumez/SB/SAE
Cattenom-4 (Cattenom,Moselle)	1300	PWR	100	5/91	1/92	Fra	Alstom	Owner	Dumez/SB/SAE
Chinon B1 (Chinon, Indre-et-Loire)	905	PWR	100	10/82	2/84	Fra	Alstom	Owner	GTM
Chinon B2 (Chinon, Indre-et-Loire)	905	PWR	100	9/83	8/84	Fra	Alstom	Owner	GTM
Chinon B3 (Chinon, Indre-et-Loire)	905	PWR	100	9/86	3/87	Fra	Alstom	Owner	GTM
Chinon B4 (Chinon, Indre-et-Loire)	905	PWR	100	10/87	4/88	Fra	Alstom	Owner	GTM
Chooz B1 (Chooz, Ardennes)	1500	PWR	100	4/96	5/00	Fra	Alstom	Owner	Bouygues
Chooz B1 (Chooz, Ardennes)	1500	PWR	100	12/96	9/00	Fra	Alstom	Owner	Bouygues
Civaux-1 (Civaux, Vienne)	1495	PWR	100	9/97	1/02	Fra	Alstom	Owner	Fougerolle/CM
Civaux-2 (Civaux, Vienne)	1495	PWR	100	9/99	4/02	Fra	Alstom	Owner	Fougerolle/CM
Cruas-1 (Cruas, Ardeche)	915	PWR	100	4/83	4/84	Fra	Alstom	Owner	C-B
Cruas-2 (Cruas, Ardeche)	915	PWR	100	8/84	4/85	Fra	Alstom	Owner	C-B

Cruas-3 (Cruas, Ardeche)	915	PWR	100	4/84	9/84	Fra	Alstom	Owner	C-B
Cruas-4 (Cruas, Ardeche)	915	PWR	100	10/84	2/85	Fra	Alstom	Owner	C-B
Dampierre-1 (Ouzouer, Loiret)	890	PWR	100	3/80	9/80	Fra	Alstom	Owner	CM/SeB/Ballot
Dampierre-2 (Ouzouer, Loiret)	890	PWR	100	12/80	2/81	Fra	Alstom	Owner	CM/SeB/Ballot
Dampierre-3 (Ouzouer, Loiret)	890	PWR	100	1/81	5/81	Fra	Alstom	Owner	CM/SeB/Ballot
Dampierre-4 (Ouzouer, Loiret)	890	PWR	100	8/81	11/81	Fra	Alstom	Owner	CM/SeB/Ballot
Fessenheim-1(Fessenheim, Haut-Rhin)	880	PWR	100	3/77	12/77	Fra	Alstom	Owner	C-B
Fessenheim-2(Fessenheim, Haut-Rhin)	880	PWR	100	6/77	3/78	Fra	Alstom	Owner	C-B
Flamanville-1 (Flamanville, Manche)	1330	PWR	100	9/85	12/86	Fra	Alstom	Owner	DTP/SCREG/SGE
Flamanville-2 (Flamanville, Manche)	1330	PWR	100	6/86	3/87	Fra	Alstom	Owner	DTP/SCREG/SGE
Flamanville-3 (Flamanville, Manche)	1600	PWR	5	.....	/12	Areva	Alstom	Owner	Bouygues
Golfech-1 (Valance, Tam et Garonne)	1310	PWR	100	4/90	2/91	Fra	Alstom	Owner	Fougerolle
Golfech-2 (Valance, Tam et Garonne)	1310	PWR	100	5/93	3/94	Fra	Alstom	Owner	Fougerolle
Gravelines B1 (Gravelines, Nord)	910	PWR	100	2/80	11/80	Fra	Alstom	Owner	SGE/DTP/SCREG
Gravelines B2 (Gravelines, Nord)	910	PWR	100	8/80	12/80	Fra	Alstom	Owner	SGE/DTP/SCREG
Gravelines B3 (Gravelines, Nord)	910	PWR	100	11/80	6/81	Fra	Alstom	Owner	SGE/DTP/SCREG
Gravelines B4 (Gravelines, Nord)	910	PWR	100	5/81	10/81	Fra	Alstom	Owner	SGE/DTP/SCREG
Gravelines B5 (Gravelines, Nord)	910	PWR	100	8/84	1/85	Fra	Alstom	Owner	SGE/DTP/SCREG
Gravelines B6 (Gravelines, Nord)	910	PWR	100	7/85	10/85	Fra	Alstom	Owner	SGE/DTP/SCREG
Nogent s/Seine-1 (Nogent s/Seine, Aube	1310	PWR	100	9/87	2/88	Fra	Alstom	Owner	C-B/Quillery
Nogent s/Seine-2 (Nogent s/Seine, Aube	1310	PWR	100	10/88	5/89	Fra	Alstom	Owner	C-B/Quillery
Paluel-1 (Veulettes, Seine-Maritime)	1330	PWR	100	5/84	2/85	Fra	Alstom	Owner	CM/Ballot/Chag
Paluel-2 (Veulettes, Seine-Maritime)	1330	PWR	100	8/84	12/85	Fra	Alstom	Owner	CM/Ballot/Chag
Paluel-3 (Veulettes, Seine-Maritime)	1330	PWR	100	8/85	2/86	Fra	Alstom	Owner	CM/Ballot/Chag
Paluel-4 (Veulettes, Seine-Maritime)	1330	PWR	100	3/86	6/86	Fra	Alstom	Owner	CM/Ballot/Chag
Penly-1 (Saint-Martin-en-Campagne, Seine-Maritime)	1330	PWR	100	4/90	12/90	Fra	Alstom	Owner	CM/Ballot/Chag
Penly-2 (Saint-Martin-en-Campagne, Seine-Maritime)	1330	PWR	100	1/92	11/92	Fra	Alstom	Owner	CM/Ballot/Chag
Saint-Alban-1 (Auberives, Isere)	1335	PWR	100	8/85	5/86	Fra	Alstom	Owner	Bouygues/Bruyeres
Saint-Alban-2 (Auberives, Isere)	1335	PWR	100	6/86	3/87	Fra	Alstom	Owner	Bouygues/Bruyeres
Saint-Laurent B1 (Saint-Laurent-des-Eaux, Loir-et-Cher)	915	PWR	100	1/81	8/83	Fra	Alstom	Owner	GTM

Saint-Laurent B2 (Saint-Laurent-des-Eaux, Loir-et-Cher)	915	PWR	100	8/83	8/83	Fra	Alstom	Owner	GTM
Tricastin-1 (Pierrelatte, Drome)	915	PWR	100	2/80	12/80	Fra	Alstom	Owner	C-B
Tricastin-2 (Pierrelatte, Drome)	915	PWR	100	7/80	12/80	Fra	Alstom	Owner	C-B
Tricastin-3 (Pierrelatte, Drome)	915	PWR	100	11/80	5/81	Fra	Alstom	Owner	C-B
Tricastin-4 (Pierrelatte, Drome)	915	PWR	100	5/81	11/81	Fra	Alstom	Owner	C-B
LMFBRs: 1 operating (233 Mwe). PWRs:58 operating (63 130 Mwe), 1 forthcoming (1600 Mwe).									

Source: Nuclear News: World List of Nuclear Power Plants – Operable, Under Constructions, or on Order as of December 31, 2007

CONCLUSION

The French atomic programme since its inceptions shows the parallel development of both peaceful and military applications depending upon its internal developments such as the policy making process with the intervention of various political forces and rather the non-participation of mass public. It is also largely shaped by its quest for energy security with nuclear energy being the best options with the relatively absence of oil and coal supply and to fulfil its aim for reducing carbon emissions, the present international situations. With the rise of both India and China and the growing demand for energy the French government announcement to build its second generation reactors shows that France is likely to retain and expand its nuclear energy options in the near future.

CHAPTER THREE

GERMANY ATOMIC DEVELOPMENT PROGRAMME

"But it is possible... [And] there is no need to extend the lifetimes of reactors"

-Gabriel[24]

HISTORICAL BACKGROUND

In December 1938, Otto Hahn and Fritz Strassman accidentally discovered what would fundamentally transform history of the world. By bombarding uranium with neutrons, instead of knocking a few particles loose from the uranium nucleus as expected, they appeared to have split it that later came to be named as nuclear fission. Hahn drafted their findings in a cautious article for the journal *Die Naturwissenschaften.* Shortly after researchers in other parts of the world, Frederic Joliet in Paris, France, Meitner and Frisch who later coined the word 'fission' taken from biology. In Copenhagen, Denmark and Sigfried Flugge and Gottfied Von Droste at Hahn's Institute independently predicted that nuclear fission produced a large amount of energy.

Before this time, scientists had assumed that the neutron bombardment of uranium either led to transuranic element, if the neutron stuck in the nucleus or to an element slightly less mass than uranium, if the neutron chipped off part of the nucleus or caused the emission of a nuclear particle (Walker 1989: 14). Independent researchers in different countries subsequently proved the discovery. Further, on the fifth Washington Conference on Theoretical Physics, Bohr unveiled the liquid drop theory of nuclear fission, which triggered off widespread experimentation. Therefore, by the time, the flood of publications began slackening off in March, 1939, more than eighteen research teams from France, Germany and the United States had independently verified nuclear fission (Heilbron 1986: 69-79: Eckert et al. 1984: 129, Walker 1989: 15).

---

[24]Sigmar Gabriel is currently German Environment Minister.

In June 1936, the theoretical physicist Sigfried Flugge published an article with the heading "*Can the Energy Content of Atomic Nuclei be Harnessed?*" (Walker1989: 16). For the first time the possibility of constructing an energy producing "uranium machine" out of uranium and a 'moderator' which would slow down the neutrons released by fission and thereby inhibit the chain reaction was discussed. He painted a fantastic picture of the great potential of nuclear power. By describing that, if all the available uranium atoms in 1 cubic meter of uranium oxide could be fission, then the energy thereby liberated could lift 1 cubic kilometre of water 27-kilometres into the air. Therefore, if all the available uranium atoms in 4 metric tons of uranium could be fission in uranium machine, then this machine would equal the output of all German coal-fuelled plants for eleven years.

In Germany, science was recognised as an indispensable part of national power. Therefore, the interests of the German military were inextricably linked to Germany's science and industry. By the spring of 1939, several German scientists brought the economic and military potential of nuclear fission to the attention of two different authorities. The Reich Research Council in the Ministry of Education following which Abraham Esau, a technical Physicist in the Physics department impressed by the prospects of applied nuclear power held an organisational meeting for a "uranium club" (uranverein) on 29 April 1939.

Nikolaus Riehl, an industrial physicist and the head of a scientific research department in the Auer Company also brought nuclear power to the attention of the Army Ordnance and offered the services of Auer for uranium production. The army was also contacted by their chemical explosives consultant Harteck and his assistant Groth explicitly mentioning in their letter dated 24 April 1939, the military application of nuclear fission chain reactions in uranium. This would allow the explosives many orders of magnitude more powerful than those available. They also pointed out the political significance by arguing that the country, which first utilized nuclear explosives, would have an 'unsurpassable advantage' (Smith 2007:260).

DEVELOPMENTS DURING THE SECOND WORLD WAR

As a result, soon after the Second World War began, the Army Ordnance under the National Socialist government took the Kaiser Wilhelm Institute for Physics for its war work. It squeezed out the Reich Research Council and ordered them to halt their experiments on nuclear power and began to set up their own research projects. Kurt Diebner, the expert in both atomic physics and the physics of explosives was entrusted with the organisation and administration of the projects. It was justified that if the application of nuclear power to warfare could be a decisive weapon, then the necessity of German research into the economic and military uses of nuclear fission was self evident (Walker-1989:19).

However, although the Kaiser Wilhelm Institute for Physics did became the Army Ordnance nuclear power project with most of the uranium trials being held there, much of the research was carried out under the direction of a few leading scientists at different universities scattered throughout Germany. As such, uranium isotope separation was assigned to Harteck, most of the measurement of nuclear constant took place at the Kaiser Wilhelm Institute for Medical Research under the physicist Walther Bothe, and Heisenberg was asked to work out the theory of chain reactions enjoying absolute control over their respected areas. There were though few overlaps between subordinate to the higher army authority.

Through utilizing their own research and by taking advantages of key American and French publications, the members of the German nuclear power project were able to layout clearly the military and economic applications of nuclear fission whereby an energy producing chain reaction could be produced through uranium isotope separation, the construction of uranium machine or both. Also the Uranium enrichment and uranium machines were both complementary and not mutually exclusive. Such a chain reaction had two possible applications:

a) a slow, controlled reaction in uranium machine would produce a continuous steam of heat thereby capable of generating electricity;

b) a fast uncontrolled reaction in U-235 or in transuranic element would become nuclear explosives.

Although electricity producing uranium machine could be constructed with enriched uranium and water, any isotope separation capable of enriching uranium significantly eventually could produce the nuclear explosive U-235 through a step process. Also any uranium machine, whether composed of enriched uranium and water, or natural uranium and a more effective moderator could be used to produce highly- fissionable transuranic elements and thereby nuclear explosives. Therefore in practice, research on uranium machines or isotope separation was also research on nuclear weapons (Walker 1989: 24).

As early as summer of 1939, Werner Heisenberg had already stated in his paper entitled "The Possibility of Large-scale Energy Production Using Uranium Fission," in which he stated:

> "The data available at present indicate that the uranium fission processes... can also be used for large scale energy production. The most reliable method for developing a suitable machine is the enrichment of the U-235 isotope... it is however possible to use normal uranium without U-235 enrichment, if the uranium is combined with another substance that slows down the neutrons of uranium without absorbing them.... Present data indicate that heavy water and very pure carbon fulfil this purpose", (Winnacker and Wirtz 1979:35).

In his second paper written in February 1940 also described the construction and operation of nuclear reactors. The procurement of natural uranium was the first priority to start the practical work on nuclear energy production. However, since the invasion of Czechoslovakia 1939, Germany had gained control over the uranium deposits of St. Joachimsthal, moreover large stocks of uranium were available in Belgium operated by the Union Miniere du Haut Katanga. Further the Degussa Company in Frankfurt succeeded in developing a process that provided uranium metal of the required purity. The process for the effective realization of nuclear power began to proceed subsequently in Germany on such as developing an effective neutron moderator, on isotope separation and uranium machines or reactors.

Meanwhile many emigrants scientist who had fled from Germany tried to draw the attention of their respective authorities in other countries of what was happening in Germany. They urged Einstein to write his famous letter of August 2, 1939 to

President Roosevelt which clearly mentioned the fact that new bombs could now be constructed, a single of which would be enough to destroy the whole cities. Meanwhile the Germans stopped sales of the ore in Czechoslovakia which was largely interpreted as uranium being probably used for developing atomic energy. The German invasion of Poland on September 1, 1939 was to further makes other countries feel threatened with the possibilities of utilizing uranium in Hitler's military calculations.

Following Heisenberg report that carbon was an excellent moderator, Harteck proposed an experimental test of carbon with the dry ice (frozen carbon dioxide). Since there was little uranium available in 1940, when his experiment clashes with the Kaiser Wilhelm Institute for Physics under Heisenberg who planned experiment with Uranium was natural yet he was able to secure 200 kg. But, this proved too little to yield for significant experimental results. Walther Bothe in Heidelberg experiment with Carbon also came up with a discouraging result. However, Wilhelm Handle, who worked outside the nuclear power project, came up with a different conclusion. Since Heisenberg showed that a machine composed of Carbon and Uranium requires much more Uranium and much more moderator that a heavy water device, this led the Army Ordnance to conclude that given the requirements of German war effort, heavy water was more a feasible moderator.

Further support for large scale heavy water production came especially after August 1940, when the Leipzig physicist Robert Dopel demonstrated experimentally how the heavy water was an excellent moderator. Besides, the German invasion and occupation of Norway in April 1940 and the subsequent seizure of the Norwegian hydro by IG Farben enlarged the heavy water production from a rate of 20 litres per year to 1 metric ton for the same period (Walker 1989:28).. Moreover during 1941, the Norwegian were forced to install a catalytic conversion process design by Harteck and Suess to boost production to 4 or 5 tons per year. The Norwegian Hydro officials were also ordered to use Norwegians contractors and materials whenever possible and to bear the cost of production and installations as well. Heavy water was to be produced in Norway instead of Germany because this policy promised to provide for the entire nuclear fission program as well as being the first large scale uranium machine as quickly as inexpensively as possible (Walker 1989: 28).

On isotope separation, at first the Clusius-Dickel device appeared to be one of the shortest paths to the realization of nuclear power. Those experiments carried out at IG Farben on behalf of Harteck suggested that Nickel was the best metal for a uranium hexafluoride separation tube. But Nickel was vital for the war effort and therefore difficult to acquire. Therefore, the construction of Nickel tube could finally began only on October 1940. However, the experiment loses its appeal when the continuous movement of gas within the tube compounded the problem of corrosion. Moreover known enrichment was found in any of the trials of Uranium hexafluoride so by the summer of 1951, this led Harteck to look for another method for Isotope separation.

Various additional methods were also investigated under the nuclear power project by different scientists. Another isotope separation method by centrifuge got the attention of the Hamburg group (Walker 1989:33). Following this, by October 1941, Diebner led a contract for the construction and Groth began to work on the design based on some recent publication by the American scientist Jesse Beams. The prospects of isotope separation by centrifuge seemed to be more advantageous in principal but the construction plan was again hindered by the war effort. When it began by winter of 1941/42, the prospects of large scale isotope separation especially for U-235 production appeared poor (Walker 1989:33). By December 1941, Harteck had to admit that no Uranium isotope separation, or even enrichment, had been achieved and that necessary pre-conditions for large isotope separation were still lacking.

In 1941-1942, Germany through several large-scale experiments conducted at various locations and by different group of scientist gained essential knowledge concerning the construction of Atomic reactor matching the progress of United States at that point in time. The preparatory experiment conducted by Harteck, Jensen and Suess in Hamburg in August 1940 had failed essentially because of inadequate amount of Uranium oxide. The experiment carried out in Heidelburg under the direction of Bothe also failed because neutral multiplication could not be proven. However, the most successful experiment was conducted by Heisenberg in Leipzig heavy water as moderator, but unfortunately during the fourth experiment in Leipzig in the spring of 1942, a fire broke out ending the large scale experiment (Karl Winnackar 1979:23). The final large scale experiment was prepared in Berlin – Dahlem, in the bunker laboratory. Though it was expected to remain non-critical yet a neutron multiplication by a factor of 7 was achieved and the preceding experiments in Berlin also resulted in positive neutron multiplication. Then it became too late for further experiments.

Due to fragmentation of interest and competition between groups till the last stage of war had prevented amalgamation of larger amount of Uranium and heavy water sufficient for large-scale experimentation. Moreover, the allied air offensive which drew the German researchers deeper into their bunkers culminated in the complete destruction of those laboratories. In the areas where the British forces and the American forces obtained access, the German atomic research was destroyed to prevent the Soviet and the French forces from capturing German Uranium stocks or heavy water. Therefore, throughout the war period, the German efforts to develop atomic weapons ended in failure.

AFTER THE WAR

During the post war period, especially the year 1945-1949, the domestic condition could be described as miserable. It was time when the black market was flourishing. Conradt (1996) in his book "*The German Polity*" mentioned that, a context of mass and difference in politics could be witness the people freezing and hungry. They were concern only with the most basic level of the self and immediate family. In the international context, the superpower's arms race had reached a more serious level. However, as early as the year 1952-1954 in the European defence community (EDC) negotiations, Konrad Adenauer, following the suggestion from Max Planck Institute on behalf of the Federal Government expressed his wish to be granted permission to construct a research reactor with a thermal output of 500 kilowatts. The proposal was though rejected by the French.

In 1953, a significant turn of events occurred which change the history of atomic energy development, America began to take steps to provide the means for developing peaceful nuclear energy program more easily accessible. On 8 Dec, 1953, when the then US President Dwight D. Eisenhower in his address to the General Assembly implored the world to employ atomic weapon for peaceful purposes on the widest scale and not for weapons of mass destruction. Earlier on August 30, 1953, the US had amended the McMahon Act, which governed all matter of atomic energy make possible to conclude bilateral treaty with other countries and allowed them to obtain fissionable material. Further in the autumn of 1954, it also made available 100 kilograms of pure uranium-235 for reactor abroad. Following the events, the United Nations General Assembly by approving United States proposal, the Geneva Conference which was held in December 1954 and it became an important stepping-stone for Atom for Peace programme resulted in the formation of the Vienna Atomic Authority, the International Atomic Energy Agency (IAEA) in 1957.

The Geneva Conference was also attended by the German delegation led by Otto Hahn. Though they kept a low profile, they were still regarded with scepticism[25] and their move being monitored by other countries. However, fortunately they came to learned that they got a chance to conclude a bilateral agreement with United States. This would make it possible for them to acquire a research reactor based on a loan of 6-kilograms of uranium but, on the condition that they first have to prove their reliability. This was followed by the creation of various groups in Germany to promote atomic energy such as German Atomic Community. On January 26, 1956, an elite group from the world of science, industry and public life to advised the Atomic Minister and to give vital support and in 1958, the 500-megawatt programme was submitted but suffered difficulty in procuring state funds due bureaucratic constraint, the German Atomic Forum also created on May 29, 1959, by January 1, 1960 atomic law came into force. The Physical study Society had supported FR2 financially, the first German reactor constructed under the Nuclear Research Centre in Kalsruhe. In 1964, when the Third International Conference took place in Geneva; German industry was present and for the first time and could report its own development (Winnacker 1979: 83).

GERMAN QUEST FOR NUCLEAR SECURITY

Germany was one of the first states to forswear developing independent national nuclear weapons deterrence during the signing of the Paris Accords of 1954. Yet paradoxically, it also relied heavily on nuclear arms for its security (Paul 2000: 38). During the cold war, West Germany was the country with the largest amount of

[25] There was a move to create an atomic community in Europe at that time to monitor German activity.

nuclear weapon station in its territory only after the US and the USSR. Due to her geo-strategic location between the western and the eastern bloc, it was a country likely to be on the forefront in case of nuclear exchange in Europe, despite her insecurity, West Germany ceased to acquire nuclear weapons. This policy of forgoing military nuclear capability was largely conditioned by her external relations. The treaty which gave back sovereignty to West Germany and allowed it to join the European Economic Community and North Atlantic Treaty Organisation (NATO) was made conditional on its acceptance to forgo unilateral nuclear acquisition. The French previous rejection to create a European Defence Community including West Germany as its member also became an important factor for Germany to relinquish her military nuclear options.

Initially, Federal Republic of Germany (FRG) did not regard her renunciation as total but conditional upon the cooperation of Bonn's Western partners particularly United States to provide nuclear protection. During the early 1950's, Germany under the allied occupation and its scientific research restricted to elementary nuclear research, showed no interest on acquiring nuclear weapons. By 1957, Defence Minister Franz-Joseph Strauss took a diplomatic initiative to create a joint French-West German-Italian nuclear programme whereby it could gain access to nuclear weapons during interstate-crisis but the attempt failed, after which Germany turn towards United States to station nuclear weapons on West German soil. A proposal was made at the North Atlantic Council meeting in December 1960 for the creation of a Multilateral Force (MLF) consisting of Intermediate range nuclear force (INF) under the joint control of NATO countries including Germany, though the Soviet Union argued vehemently against it as it would make West Germany a de facto nuclear state, and United States shelved the proposition for MLF in favour of Nuclear Non-Proliferation Treaty by 1965.

German encounters with NATO alliances particularly United States often gave mixed and confusing response. During German entry into NATO, the western powers emphasised upon the strategy of massive conventional build up In spite of strong domestic opposition, Adenauer finally pledge to raise armed forces of up to 500,000 men (Hueser 1997:127). By 1955, NATO changes its strategy to Symmetrical

Response based on Massive Retaliation[26] and United States planned to decrease their conventional forces in Europe and replacing them with Nuclear weapons. But for West Germany, it seemed to imply that American soldiers would be replaced by 'modern arms', while German soldiers would be left in the front line as 'cannon fodder", (Hueser 1997: 127). Again on 1957, a need for 'Differentiated Response' was emphasised by US, Thus, making it difficult for Germany to put their faith and adapt to the oscillating strategy of the US policies. Moreover, the problem was further compounded by the decisive differences in nuclear strategy for their security needs.

Till the late 1960's West Germany refused to sign the NPT. This was largely interpreted as an attempt to retain its options of nuclear weapons. But Germany gave different reasons such as:

- The wish to retain the possibility of creating joint European nuclear force[27];
- Fear of restriction peaceful nuclear energy option;
- the desire of the Erhard government (1963-1966) to trade the ownership of nuclear weapons for some progress in the goal of German reunification;
- Like other countries like India, Japan, Italy and several other countries, Germany resented the NPT' regime as discriminatory;
- The fear that Soviet Union would try to take the advantage of NPT as a tool to gain special right of control of West Germany inking it to the "enemy state clauses" of the UN Charter (Mennerhasen 1972: 415);
- Finally, French rejection of NPT membership increased the hesitation on the part of West German government (Hueser 1997: 140).

Eventually, West Germany however signed the NPT on 28 November, 1969 and re-enforce its pledge not to acquire its own nuclear weapons. This decision was followed by the coming of power of the Social Democratic Party (SDP), Chancellor Willy Brandt pursued Ostpolitik to encourage cooperation with Soviet Union so as compensate any lessening of US commitment to Western Europe. He argued that as long as NATO would continue to provide for West German security and that peaceful

[26] It was also known as 'Radford Strategy' after Admiral Arthur Radford, Chairman of the US Joint Chiefs of Staff, whom a newspaper leaked in July 1956, described him as supporting the reduction of US forces in Europe by substituting with nuclear power.
[27] Germany tries to kept this option alive through a "Europe-clause" in the NPT though in the end it was not retain.

nuclear pursuit will not be affected. It was only when Ostpolitik became West Germany's foreign policy framework in 1975 that formal ratification of NPT occurred. The treaty did not hinder European integration and the states with nuclear arms would undertake disarmament negotiations (Paul 2000: 41). However, due to the continue opposition by the Christian Democratic Party (CDU) and the Christian Social Union (CSU), West Germany was also reluctant to implement the Montebello decision of 1983 to modernize NATO nuclear forces and to renew short-range Lance missiles that could only be used only on its territory. This was also done as a way to get USSR to agree to reduce and eliminate its SS-1 intermediate short-range missiles from Europe.

Germany decision to forgo nuclear weapons during the cold war despite having an active confrontation with nuclear-armed Soviet Union could be explained by the restrain imposed by the victors of the 2nd World War. It could also be seen as a means to integrate itself for security under the American nuclear umbrella and completely integrating its armed forces with NATO. Besides, West German made a conscious effort not to generate intense negative security externalities for its neighbour as well as not to provoke the Soviet Union to a point at which war could become a possibility. Therefore it adopted a "two pillar doctrine" of armament as well as détente to attain its objectives such as protecting its sovereignty, European integration, fostering of the Atlantic community and reunification. Therefore, it strongly avoided any policy that could adversely affect any of this aims and foreign policy goals.

THE POST COLD WAR

The post cold war era heralded the fall of the Berlin Wall followed by the reunification of Germany in 1990, and the collapse of the Soviet Union. Germany's security environment radically improved following the removal of Soviet troops from Eastern Europe. The German non-nuclear policy was further re-enforced by the agreements and assurances given to the Soviet Union on this matter as a pre-condition for re-unification. Kohl also promised to keep East German territory as a denuclearised zone within NATO and off limits to non-German NATO troops (Kelleher 1990: 21). Further Germany signed the 'Four plus Two' Treaty on 12 September 1990, which contained article III where it agreed to abide by the commitments made by both East and West Germany regarding renunciation of nuclear, biological and chemical weapons and application of the rights and obligations under the NPT. It also pledged to limit the size of its army and respect existing borders with neighbours (Paul 2000:43).

Since the Soviet Union policy towards nuclear non-proliferation was also largely guided by German non-acquisition of nuclear armaments. Nuclear weapons in the hands of Germany would have easily increased hostility between the two countries, thus would intensify Bonn's security dilemma. Besides, during this period there was fear to that of Soviet Union to delay German reunification and increased the military activity towards West Germany especially from East Germany. This awareness was the key to West Germany policies towards the Soviet Union to avoid confrontation throughout the Cold war even at the cost of forgoing nuclear weapon (Paul 2000:46).

Though Germany forsakes military nuclear option, it continued to develop its civilian use. By 1998, Germany operated twenty nuclear power reactors that generated over 31% of the country's over power production (Paul 2000:37) and it shows no sign of altering the policy anytime soon. Besides when Kohl successor government, led by Gerhard Schroeder came to power in October 1998, there has been more anti-nuclear voices in it with the Green Party as its key partner in the coalition. However, the proposal that it had put forward, such as NATO's adopting a no-first-use policy, and to close down Germany's nuclear power plants failed due to domestic pressure and rejection by the US.

IMPLICATIONS OF NUCLEAR ENERGY FOR GERMAN ECONOMY

Due to large economy, Germany is the fifth largest energy consumers in the world. As compared to France, Germany has abundance of fossil fuel reserves. Coal produces half of its electricity requirements. It is the seventh largest producer of coal in the world. According to Germany energy consumption measured by the EIA International Energy Annual, Short term Energy Outlook **(see Table 3.1)**, it produces 225.5 Million tons in 2007, but it is also the seventh Annual, Short term energy largest consumer of coal with 281.3 Million tons. In Germany, the coal industry also received subsidise from the government. In natural gas, Germany had 9,000 Brillion cubic feet proven reserves as of 2008 and supplied 12% of electricity, the third largest in European Union after United Kingdom (UK) and the Netherlands. Germany is also the world leader in the production renewable energies. It has become the largest producer of bio-diesel. It also generates electricity from wind energy which produced 7% of the countries total energy demand.

According to the EIA, as of 2008, Germany produces 150.8 thousand barrels of Oil per day and crude oil up to 20.86 thousand barrel per day. Due to her large economy and small amount of crude oil domestic production, Germany is the fifth largest consumer of oil in the world with 2,555 thousand barrels per day and imported 2404 thousand barrel per day that is around 90% of its demand. So, the consumption far exceeds the production. Germany is the fourth largest generator of nuclear power in the world. Currently, the country operates 17 nuclear reactors, according to WNA (2008) estimates; it comprises 20.6% of installed capacity supplies that is about one quarter of electricity (141 billion kwh net as of 2009). But, the country continues to embark upon phase out its nuclear power.

Recently, due to the threat of carbon emission and the need for secure and sustainable sources of energy, Germany's energy policy of depending upon fossil fuels and renewable energy and the feasibility of phasing out nuclear energy has come under question. However, despite the environmental concerns surrounding coal-fired generating capacity and Germany's need to meet its obligations under the Kyoto Protocol, the EOE (2008) predict that the abundance of domestic coal reserves should result in coal remaining as Germany's most prominent electricity fuel source for the foreseeable future.

Table: 3.1: GERMANY ENERGY CONSUMPTIONS (1998-2008):

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Petroleum (Thousand Barrels per Day)											
Total Oil Production	139.0 0	141.6 2	146.9 6	141.6 3	146.3 2	146.0 7	147.3 4	141.7 0	149.7 9	145.6 0	150.8 0
Crude Oil Production	58.64	55.30	63.82	64.86	68.86	72.30	67.90	66.93	26.63	25.28	20.86
Consumption	2922. 83	2838. 45	2771. 85	2814. 62	2721. 64	2678. 72	2665. 48	2647. 12	2691. 81	2456. 00	2555. 21
Net Exports/Imports(-)	- 2783. 83	- 2696. 83	- 2624. 89	- 2672. 99	- 2575. 33	- 2532. 64	- 2518. 14	- 2505. 41	- 2542. 03	- 2310. 40	- 2404. 41
Refinery Capacity	2184	2246	2275	2259	2259	2267	2289	2323	2428	2417	2417
Proved Reserves (Billion Barrels)	0.410	0.388	0.357	0.380	0.364	0.342	0.442	0.394	0.367	0.367	0.367
Natural Gas (Billion Cubic Feet)											
Production	772.2	823.4	778.7	785.1	787.9	784.6	726.0	701.0	692.5	634.3	NA
Consumption	3129. 9	3151. 0	3098. 1	3239. 4	3204. 4	3565. 8	3575. 7	3565. 6	3523. 6	3441. 3	NA
Net Exports/ Imports(-)	- 2473.2	- 2517.1	- 2486.1	- 2544.6	- 2613.7	- 2712.1	- 2871.1	- 2856.2	- 2898.9	- 2688.6	NA
Proved Reserves	12,11 3.0	12,27 2.0	11,98 9.0	11,49 8.0	12,08 8.0	11,29 4.0	10,80 0.0	9,856 .0	9,076 .0	9,000 .0	9,000 .0
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Coal (Million Short Tons)											
Production	233.0	226.1	226.0	227.1	232.6	229.1	232.7	227.0	220.6	225.5	NA
Consumption	268.8	257.6	269.8	278.2	278.4	277.3	280.4	270.8	270.5	281.3	NA
Net Exports/Imports(-) (Trillion Btu)	- 711.6	- 716.2	- 895.0	- 1071. 8	- 1004. 7	- 1027. 7	- 1138. 9	- 1057. 0	- 1185. 8	- 1317. 1	NA
Electricity (Billion Kilowatthours)											
Net Generation	522.9	520.1	536.1	550.0	536.0	562.9	576.5	579.7	594.8	594.7	NA
Net Consumption	498.1	497.9	505.0	520.5	518.5	532.5	545.7	545.8	549.1	NA	NA
Installed Capacity (GWe)	109.5	107.8	109.3	113.7	115.6	121.7	120.9	120.4	120.8	126.7	NA
Total Primary Energy (Quadrillion Btu)											
Production	5.3	5.3	5.3	5.3	5.3	5.3	5.4	5.2	5.2	NA	NA
Consumption	14.3	14.1	14.3	14.6	14.3	14.6	14.7	14.5	14.6	NA	NA
Energy Intensity (Btu per(2000) U.S.$	7048. 0	6813. 2	6648. 9	6722. 9	6587. 0	6723. 0	6746. 9	6572. 6	6427. 6	NA	NA
Carbon Dioxide Emissions (Million Metric Tons of CO_2)											
Total from Consumption of Fossil Fuels	871.7	840.8	856.9	877.7	857.4	874.0	871.9	852.6	857.6	NA	NA

NA = Not available

Sources: EIA, International Energy Annual, Short Term Energy Outlook, Table 3a, Table 3b

(Forecast values)

CURRENT SITUATION AND DEVELOPMENTS

Currently, Germany operates seventeen (17) nuclear power reactors, 6 breeder water reactors producing 6457 Mwe and eleven (11) pressure water reactors producing 13972 Mwe as of December 31, 2007 **(see Table 3.2)**. They were built by Siemens-KWU. In 2000, the German federal government and four reactors owners agreed to shut all operating units after an average lifetime of about 32 years. One reactor has been shutdown in 2008. Germany's Federal Ministry of Environment & Nuclear Safety, or BMU in February 2009 vowed to stay on the present course on the nuclear phase-out and through 2022 replace all the output from17 power reactors by increasing energy efficiency and shifting to renewable resources. On 12 February 2009, Matthias Machnig, BMU State Secretary released a national "road map" for shutting down all the reactors while meeting power demand as also Germany's ambitious goal to cut greenhouse gas emissions. According to the data from BMU, it reveal that seven reactors representing about 7,000 MW of capacity-will be permanently pulled out from the grid between 2010 and 2012, which would later be decommissioned in 2022 (Hibbs 2009b: 14).

In 2010, the lifetime of Biblis-A, Biblis-B, and Neckerwestheim-1 will end. In 2011; Isar-1 will be shut-down and in 2012, Phillipsburg-1 Unterweser, and Brunsbuettel and the total phase-out to be completed by 2020. After this, only three reactors will remain on the grid –Isar-2, Neckarwestheim-2, and Emstar which will be shut don later. However, reactors owners have challenged in court the decisions of BMU leaders not to permit the operators to operate longer by transferring lifetime from newer reactor and also hope that Gabriel's and Machnig's co-ruling would be voted out of power in the next election. Both sides had agreed during power sharing in 2005, the phase out would remain national policy through the end of 2009 and Machnig asserts that just because it is an election year there is no need to give that consensus.

Table 3.2: PRESENT NUCLEAR POWER PLANTS IN GERMANY:

	Net MWe	Type	Construction Stage (%)	Init. Criticality	Commercial Start	Reactor supplier	Generator supplier	Architect Engineer	Constructor
E.ON Kernkraft GmbH									
Brokdorf (Brokdorf,S.-H.)	1410	PWR	100	10/86	12/86	KWU	KWU	KWU	KWU
Grafenheinfeld KKG (Grafenheinfeld, Ba.)	1275	PWR	100	12/81	6/82	KWU	KWU	KWU	KWU
Grohnde (Emerthal, Nied.)	1360	PWR	100	9/84	2/85	KWU	KWU	KWU	KWU
Isar-1 (Essenbach, Ba.)	878	BWR	100	11/77	3/79	KWU	KWU	KWU	KWU
Isar-2 (Essenbach, Ba.)	1400	PWR	100	1/88	4/88	KWU	KWU	KWU	KWU
Unterweser (Stadland, Nied.)	1345	PWR	100	9/78	9/79	KWU	KWU	KWU	Arge/Kernkraftwerk Unterweser GmbH
EnBW Kernkraft GmbH									
Neckar-1 (Neckarwestheim, B.-W.)	785	PWR	100	5/76	12/76	KWU	KWU	KWU	KWU
Neckar-2 (Neckarwestheim, B.-W.)	1269	PWR	100	12/88	4/89	KWU	KWU	KWU	KWU
enBW Kraftwerke AG									
Philippsburg-1 (Philippsburg,B.-W.)	890	BWR	100	3/79	2/80	KWU	KWU	KWU	KWU
Philippsburg-2 (Philippsburg,B.-W.)	1392	PWR	100	12/84	4/85	KWU	KWU	KWU	KWU
Kernkraftwerk Gundremmingen GmbH									
Gundremmingen B (Gundremmingen, Ba.)	1284	BWR	100	3/84	7/84	KWU	KWU	KWU/Hoch	KWU/Hoch
Gundremmingen C (Gundremmingen, Ba.)	1288	BWR	100	10/84	1/85	KWU	KWU	KWU/Hoch	KWU/Hoch
Kernkraftwerk Lippe-Ems GmbH									
Emslnad (Lingen, Nied.)	1329	PWR	100	4/88	7/88	KWU	KWU	KWU	KWU
RWE Power AG									
Biblis A (Biblis, Hessen)	1167	PWR	100	7/74	2/75	KWU	KWU	KWU/Hoch	KWU/Hoch
Biblis B (Biblis, Hessen)	1240	PWR	100	3/76	1/77	KWU	KWU	KWU/Hoch	KWU/Hoch
Vattenfall Europe Nuclear Energy GmbH									
Brunsbuettel (Brunsbuettel, S.-H.)	771	BWR	100	6/76	2/77	KWU	KWU	KWU	KWU
Kruemmel (Geesthacht, S.-H.)	1346	BWR	100	9/83	3/84	KWU	KWU	KWU	KWU
BWRs: 6 operating (6457 Mwe). PWRs: 11 operating (13.972 Mwe)									

Source: Nuclear News: World List of Nuclear Power Plants – Operable, Under Constructions, or on Order as of December 31, 2007

The BMU's ambitious goal for 2020 also include doubling the share of renewable energy for power generation from 15% currently to 30%; generation of 40% of power in new, high-efficiency coal-powered plants; reduction of demand for fossil-fuelled heat by 25%; reduction of power demand by 11%; an increase in co-generation by 25%; and reduction of vehicular emissions by 20%. It also claimed that the road map is consistent with Germany's objective to reduce its greenhouse emissions by 40% by 2020 from 1990. As of 2007, it had already cut emissions by 21.3%.

In recent years, Germany has taken steps in order to maintain future energy security after the phase out is completed by passing legislation to subsidise renewable and co-generations, and to accommodate development of offshore wind turbine parks. However in the future, renewable subsidies will be permitted for state-of-the-art technology only. More legislation supporting high-efficiency will be necessary. An existing power plant must be soon renewed and replaced. Adding to that BMU is also relying on more efficient load management and development of a high voltage DC power grid to permit power to be transported to long distances with far fewer losses. Thereby, it was expected that the expansion of renewable and the increases in efficiency would completely compensate for the phase-out of nuclear power and that it would not result in energy supply reduction and massive increase in energy prices as well as to meet both its target for climate protection and energy security.

However, some environmentalists during a panel discussions held in Berlin by BMU were critical of the road map as relying too heavily on coal and lignite[28]. They pointed out that the BMU "set up a conflict of goals" by calling for both a fleet of new coal-fired power plant along the north German coastline, representing 25,000 MW of capacity, in parallel with plans, also supported by BMU, to establish offshore wind parks. The plan also ignored the likelihood that an overall increase in the electrification of the German economy in coming years would erase the benefits achieved in energy savings. On the other hand, other participants like Nicholas Voltmeyer, an executive from Siemens energy division said that the BMU plan met with the company's approval since they are developing all the key technologies the

[28] The share of lignite and bituminous coal was expected to meet 40% of the energy goal, the share of natural gas in power generation is expected to be increased by 12 to 14% in between 2009-2020, 8% will come from nuclear reactor at that time, that is about one-third currently.

road map depend upon. The European Union (EU) commissioner, Piebalgs though did not mention nuclear power as the EU's present or future power supply strategy, but he suggested that the plan was consistent with the EU energy's goals that of to generate less carbon-dioxide, increase power with renewable and increase in efficiency in generating and using electricity.

Political considerations have played a decisive role on German utilities investment. Earlier, negotiations between German utilities and EDF over Flamanville-3 had seen that German utilities were reluctant to make any serious commitment to the French project until after German national held in fall 2005, as they anticipated that a government that was in favour of phasing out nuclear power would be replaced by a government favouring it. The same calculations also holds true at the present. Since 2000, Germany's nuclear power phase-out has blocked any new nuclear investment in the country, forcing utilities to generate more carbon-free power to get involved in foreign projects; RWE had announced last year that it would participate in the Belene PWR project in Bulgaria, E.On also plan to be active in the UK's nuclear power investment program over the next 10-15 years though is under less pressure than RWE to shift its generating mix towards non-carbon sources.

At present, though it is not totally out of question. German utilities company are not considering making a near term investment in France's Penly-3 PWR project and serious discussions are not yet carried out and any movement in this direction would be unlikely until after a German national election scheduled for September 27. The German industry revealed that E.On[29] and other German companies were still wary because of previous talks with French industry, held during 2004 and 2005 over the possible share in Flamanville-3[30]. They claimed that the price offered by EDF for entering the project was unacceptably higher than the estimated cost for taking part in the initial EPR to be built in Finland and the EDF offer did not take into considerations German's utilities 'previous investment contribution to the development of the EPR, conceived of during 1990's as a "common product" of French and German Industry unless more attractive terms were offered they might not get involved. (Hibbs 2009b: 10).

[29] E. On is Germany's biggest nuclear power generator.
[30] Flamanvilla-3 is France's first EPR.

Recently, in March 2009 Sigmar Gabriel, a politician from the ruling SPD and the head of the Federal Ministry of Environment and Nuclear Safety, or BMU said that German power reactor owners should pay a surcharge on the nuclear fuel they burn to cover the cost of decommissioning two discontinued low- and medium-level radio waste repositories since reactor owners have paid a tiny fraction of the estimated cost for managing wastes in the Asse and Morsleben repositories. The decommissioning of both facilities is likely to cost at least Euro 4.2 billion (US$5.5 billion). The German Atomic Forum, or DAEF, is against the proposal and called it an "election gambit", Other reactor owners also objected to the proposal by asserting that such a tax would violate the nuclear power phase-out agreement between generators and the government that committed the federal government not to undertake any initiatives that would discriminate against nuclear power generation for as long as the reactors were operating. Besides, they also claim that most of the waste inside Morsleben repository was disposed of by the GDR. The federal research officials also reported that about two-thirds of the waste in Asse repository came from nuclear research facilities not from power reactor operations. However since the co-ruling pronuclear Christian Democrat groups objects to the nuclear fuel tax proposal, there is a few chances for the proposal to get through legislation.

In the coming September elections, the newly created left-party has joined four established parties though it seems that the contest would result in another four-year mandate for the current coalition of anti-nuclear Social Democrats, SDP and pro-nuclear Christian Democrats, CDU/ CSU, that would mean continuing the phase-out. However, the recent state elections have also witnessed a significant upturn for the pronuclear Free-Democrats, FDP who had championed construction of new nuclear power plants in Germany vis-à-vis massive voter defection from SDP. In addition, based on some opinion polls, the results of June, 2009 European Parliamentary elections, Germany's voters were widely expected to reject Gabriel's co-ruling Social Democratic Parties (SPD) in favour of a coalition of pro-nuclear parties, the Free Democrats (FDP) and the Christian Democrats (CDU/CSU) currently in coalitions with SPD.

Therefore the country's nuclear advocates seem to become more optimistic about public opinion to move in their favour and anticipate that a pronuclear national government will formed after the elections. So any announcements are withheld that by any one of Germany's nuclear generators that it plan to join EDF in a nuclear power investment in France for fear that it might trigger public backlash damaging to the pronuclear parties. In the meantime German government is urging German firms to make infrastructure investment in Germany to save jobs and to promote domestic economic growth.

Recently, soon after Siemens departure from the Areva NP joint venture and citing its 34% share not permitting to significantly influence the decision-making as the reason marking the end of an important "French-German axis" in nuclear power, on 3 March 2009, Siemens and Rosatom formally agreed to create a joint venture that would compete with Areva in both reactors and fuel supply. Under their Memorandum of understanding, Rosatom would have 50% of the new company plus one share. Novikov, a spokesman for Rosatom Director General Sergey Kirienko, said the new company would be incorporated by year-end and be in positions to sign its first contracts for nuclear power plants in 2010. Kirienko also said that the company would not target Russia or Germany but would focus on third-country markets such as Asia, Central and Eastern Europe, the Middle-East and North Africa (Lachlan 2009: 1). The new company would aimed –like Areva- to capture third of the world market for nuclear power plants, to become a world leader in the nuclear industry, with supplies and services spanning turnkey reactor construction, supply of fuel and plant equipment, and start up services. The European consultant said that this joint venture should be welcomed by the European Union as "a superb opportunity for Russian-European cooperation" in energy. The EU is engaged in energy dialogue with Russia, focused on oil and gas supplies aiming at supply security for the Union.

Meanwhile, Areva accused Siemens of unilaterally breaching the Areva Np contract by signing the joint venture memorandum with Rosatom to set up a company that would directly compete with the Areva group and warned the German firm of "consequences" related to a no-competition clause in the Areva NP shareholders agreement. Whereby the clause forbids Siemens from competing-for eight years after the split-with Areva NP businesses it contributed to the joint venture and in case of Siemens material breach of contract. Areva claimed the right to buy Siemens' share (34%) for an amount equal to 60% of the fair market value. However, some sources suggested that Areva threat of "consequences" for Siemens has no rock-solid basis since the Areva NP shareholders' pact does not prohibit Siemens from buying a stakes in any other company including Areva. Only Siemens had control of the joint venture that it will breach the contract which so far has not happened. But potential conflict would be over technology that is held by Siemens AG- the Teleperm XP non-safety I&C platform because this is an area where Areva would need for its ongoing nuclear plant construction projects and new bids.

Moreover, Siemens exit from the Areva NP joint venture has contributed to concern among Areva's German workforce which constituted around 4,700 people most of them at Erlangen and Offenbach, about the possibility of French politicians and top executives to take actions that would discriminate against German personnel and German business location. Since then Areva's German management has denied publicly that Siemens departure would have any influence on Areva's plan to continue building its German service and technology base and dismissed any concern that there will be difference in the attractiveness of the German unit for nuclear professionals. They pointed out that 60% of the German workforce has been hired since 2001 and most of these newcomers have no experience of working in Siemens. On 13 March, they announced that the Erlangen site was Areva's biggest engineering location and the company will add 800 more employees by the end of 2009.

Recently in June, 2009, German government and Industry sources said that the state and federal cabinet ministers in Germany cut a deal that will permit state nuclear regulators to apply on a trial basis, until October 2010, new and controversial technical nuclear power plant safety guidelines in parallel with existing guidelines (Hibbs 2009b: 6). Further, the state regulators are known to agreed to the deal to effectively prevent Sigmar Gabriel, head of the Ministry of Environment and Nuclear Safety (BMU) from single-handedly promulgating the new guidelines without a stakeholder concensus, this would have prompted the nuclear power owners to take legal action against BMU that might fail (Hibbs 2009b: 6). The project was launched in 2003 by the SPD-led coalition federal government to update Germany's nuclear power plant safety requirements, particularly to amend existing standards to take into consideration state-of-the-art-technology. The draft guidelines along with a draft nuclear power plant requirement ordinance was prepared by experts from

Gessellschaft fuer Anlagen und Reaktorsicherheit (GRS), BMU's technical support organisation. It have been under discussion since 2005 by the stakeholders and the government, but failed to reach an agreement in resolving their differences. The stakeholders argued that under the new rules, the operation of nuclear power plant would be too costly and technically not feasible.

CONCLUSION

By the twenty first century, Germany despite being a nuclear-capable state, Germany still refused to explore its nuclear weapons options. This could be largely attributed to the increase interdependence of its economic security with other European states which decrease the need to pursue independent economic and security policies. The European Union provides for Germany the best avenue for multilateral cooperation, enhances its economic interests through increased trade and investment, and improved its bargaining power vis-a vis other power centres of the world. Therefore it is one of the leading supporters for integration, since unilateral nuclear acquisition could have reanimated "deep-seated fears of revived nationalist militarism", divided and debilitated Europe, the political and economic costs of nuclear capability greatly outweighed potential benefits (Menderhausen 1972: 434).

Secondly, the anti-nuclear opposition that has gained a stronghold can be seen in the interplay of politics, though the nuclear energy debate in Germany often centres on the technical and safety matters of developing nuclear technologies. Decisions are often taken on the interest of political parties which often surpassed the real issues of nuclear energy. For the near future, though Germany seems unlikely to revive its nuclear options, however, with the resurgence of developing countries like India and China exerting their military nuclear weapons, Germany might reverse its nuclear forbearance policy but the final decision would rest on the interplay of its domestic politics.

CHAPTER FOUR

COOPERATION UNDER EURATOM

THE FORMATION OF EURATOM

The European Atomic Energy Community (Euratom) was created along with the European Economic Community by the Rome Treaties on 25th March 1957. It entered into force on 1st January, 1958. The aim of the six signatories of the treaty- Belgium France, Germany, Italy, Luxembourg and the Netherlands-was the sharing of research and financial costs on the peaceful use of atomic energy. It suggested a new and perhaps less encumbered line of political advance towards European integration as envisioned by its architect i.e. members of the European Coal and Steel Community (ECSC). Besides, this treaty was expected to put the Euratom countries in a favourable bargaining position in comparison with the US, Russia and Great Britain.

The Treaty establishing Euratom at its inception contained 234 articles under six titles along with the preamble[31]. It provided an Assembly, a Council, a Commission and a Court of Justice. According to ENA (2007), the treaty establishing the Euratom, the Assembly and the Economic and Social Committee (ESC) should be shared institutions of the European Economic Community (EEC) and Euratom. However, Euratom specific mission dictated that the powers conferred on its institutions should differ in scope from those of the EEC bodies. Negotiations on the establishment of Euratom concentrated on eight key activities around which the Treaty was structured. This included promoting research, ensuring the dissemination of technical information, protecting health, facilitating investments and joint undertakings, safeguarding supply, ensuring safety, supervising the common market in nuclear energy, and external relations.

[31] Later, the number of article reduced to 177 after the amendment of the treaty of European Union (EU) and the establishment of European Community (EC) in December, 2007.

Euratom's mission was to contribute to the formation and development of European nuclear industries, to help improve the standard of living in the Member States and to further the development of trade with other countries. Its responsibilities were strictly limited to civil applications of nuclear energy. The idea of the Euratom Treaty — concluded for an unlimited duration, unlike the ECSC Treaty which was valid for 50 years — was to enable the Member States, as well as cooperating closely with the US. Further, to embark upon producing nuclear energy, to control the entire industrial cycle (including research, training and production). It also provided for the supply of natural uranium and special fissile materials and laid the foundations for the vital task of supervising this particularly sensitive sector.

Integrated supply policy was made the responsibility of a Supply Agency, an independent commercial body with legal personality and financial autonomy, even though it was to operate under the Commission's supervision. To fulfil its tasks the Agency was given a right of option on ores, source materials (uranium) and special fissile materials (plutonium) produced in the territories of Member States, and an exclusive right to conclude contracts relating to the supply of such products from within or outside the Community. Supply was secured by controlling the final destination of these products and their use for specified purposes only. Thus, as stated by the ENA (2007), "The Euratom Treaty" thus created the framework for a nuclear common market.

Throughout the 1950's, bi- and multilateral negotiations were taking place on several levels and among countries about the sharing of research and research costs on the peaceful use of atomic energy, as yet it was difficult to separate from military applications (Hueser 1997:149). The 'Conseil Europeen pour la Recherche Nucleaire' (CERN) was formed in 1952; this was later followed by Euratom in 1957. Europeans selected atomic energy to promote integration, less because they understood the precise parameters of European energy requirements but this sector was strongly promoted by the United States at the United Nations conference on Peaceful Uses of Nuclear Energy in 1955. The US offered substantial aid to assist Euratom in the development of nuclear reactors to promote allied economic and technical cooperation within the existing framework of NATO and defence goal. By doing this they hoped to pre-empt proliferation of strategic uses of atomic energy which might disrupt the western unity (Nau 1975: 263). In November 1956, the European government set up the "three wise men" commission to study the future role of nuclear power in Europe. Supported by the commission report[32], in 1958, the Euratom and the United States entered into a joint agreement. Through this agreement Euratom was substantially discourage to acquire independent European and nuclear fuel program, especially a proposed European uranium enrichment plant (Nau 1975: 623).

After Germany joined Western European Union (WEU)[33] on 23 October, 1954 and the North Atlantic Treaty Organisation (NATO) on 9 May, 1955, the West European countries were faces with the possibility of German rearmament and the threat of nuclear weapons proliferation in Europe. The idea of the formation of Euratom was conceived to prevent all European countries, especially Germany from nuclear armament (Suzuki 2008: 4). Initiated by the Foreign Ministers of the ECSC Member States in Messina Conference on 1 and 2 June 1955, the Spaak Committee was launched on 9 July, 1955. By end of 1955, three study programs for European atomic cooperation were under way. These were:

a) The Intergovernmental Committee of the Messina Conference or the Spaak committee report the proposal for both the common market and the Euratom (Suzuki 2008: 4);

b) The Monnet Committee plan tries to promote for even tighter political and institutional integration than the previous plan (Scheinman 1965: 134);

c) The OEEC version of a loose and voluntary arrangement without supra-national institutions. This made it more acceptable to the ardent nationalists of France and the industrial leaders of Germany and Belgium. (Scheinman 1965: 134)

The intergovernmental negotiations which began on 25 June 1956 were vitiated by issues such as 'supranational inspection', though the eventual purpose was use of atomic energy for peaceful purpose. Besides, while the France preferred Euratom,

[32] The "three wise men" report suggested that strong cooperative ties with other countries should be the foundation of Europe's atomic progress.

[33] The Treaty of Brussels was amended by the Protocol signed in Paris at the conclusion of the London and Paris Conferences on 23 October 1954, which added West Germany and Italy It was renamed as the Western European Union.

Germany were more enthusiastic for establishing the common market. However, another factor encouraged the formation of Euratom as the nodal agency for Europe's quest for nuclear power. The Suez crisis started on 26, July, 1956 as a result of Nasser decision nationalize Suez Canal, the three countries Britain, France, and Israel attacked Egypt on 29 October 1956. The Western countries were shocked by the possibility of energy crisis due to insecure sources of energy supply. Therefore, the European countries were encouraged by the necessity to form an organization to promote the development of nuclear energy for future energy security led to the formation of the Euratom and the EEC.

FRENCH RELATIONS WITH EURATOM

During the formative period in the 1950's, opinions were largely divided among the member countries. In France, Jean Monnet, who had recently resigned as President of the High Authority of the ECSC to actively campaign to renounce military uses of atomic energy in Europe and promote Euratom as the driving force behind European integration. Later, the Europeanists were strengthened by the Socialist Party (SFIO) under Prime Minister Guy Mollet who was a signatory of Monnet's proposal. On the other hand, the Gaullists[34] based on the military and administrative sections of the French Atomic Energy Commission (CEA), opposed, in particular, the proposed ban on military uses of atomic energy in Europe (Nau 1975: 625). They fear that it would hamper future nuclear options.

At the same period, the CEA administrative leadership also began to raise their concern that they would be obliged to give other European countries the benefit of their country's scientific and technological advances. Furthermore, Pierre Guillaumat, the General Administrator and government delegate to the CEA, was among those who thought that France's military programme should take priority. Therefore, according to ENA (2007), this explains the opposition of some of the French military

[34] The pro-Euratom forces included, besides the Socialist Party, the Popular Republicans (MRP). The Communists and were hostile to any project of European integration, while the swing groups on the Euratom vote included the Radical-Socialists independents, and Social-Republicans. The latter groups backed Euratom once it became clears that France with retain the rights and capacity to undertake military atomic development..

high command to any supranational atomic body in Europe. For France, there was no question of Euratom hindering its activities.

However, one aspect of cooperation which specially interest the CEA was the possibility of developing the European Isotope separation plant. Under the first five year plan set up in 1952, Plutonium was selected on the basis of technical and financial limitations. But, by 1955, France acquired sufficient uranium deposits and the highly toxic nature of the plutonium, which made it difficult to handle convinced the French scientist the necessity to built isotope separation plant. Besides, despite the 'Atoms for Peace' programme, the United States was reluctant to exchange uranium-235 for French plutonium. The U-235 that the Americans agreed to supply in small quantities and at a very high price was not sufficiently enriched to be of any use in military applications. France was consequently determined to end its dependence on the United States. The management of the CEA thought that Euratom might result in the six shouldering the cost of part of the civilian nuclear programme. This in turn, would enable France to free up new funds and focus its efforts on its military nuclear programme.

During the debate held in July 1956 at the Palais Bourbon, Members of Parliament were favour of the interpretation of the Euratom Treaty as granting freedom of action in the military field to all Member States, with the exception of those forced to surrender this freedom as a result of war. The diplomatic humiliation during the Suez crisis in 1956 further strengthened France to retain its nuclear options. Therefore, Paris would agree to Euratom only if it left France completely free to continue research for its own nuclear weapons and without being subject to any supervision by Euratom (ENA 2007: 1). On 30 November 1956, an agreement was secured between the CEA, the Ministry of the Armed Forces and the Ministry of Finance and Economic Affairs in order to speed up the French nuclear programme which provided, in particular, for the construction of explosive nuclear devices. On 5 December 1956, a Committee for the Military Applications of Atomic Energy (CAMEA) was also established in France within the CEA by a secret decree. Two weeks later, an operational requirement for a strategic nuclear bomber was also produced.

In the end, after two years of tough negotiations, France had its way. West Germany yielded so that the common market could be launched. Euratom would not be entitled to verify French military nuclear facilities. The Treaty establishing the European Atomic Energy Community (EAEC or Euratom), signed on 25 March 1957 in Rome, concerns only civilian nuclear power and does not encompass military requirements. In April 1958, the French Government took the decision to go ahead with the testing of the first French atomic bomb in early 1960. This was clearly putting French military programme ahead of its civilian programme.

GERMAN RELATIONS WITH EURATOM

To begin with, the Federal Republic of Germany (FRG) was forbidden from developing nuclear weapons under the terms of the Paris Accords of October 1954. So, they considered that the French demands to retain its military nuclear option ran counter to the principle of non-discrimination between Member States. The Germans feared that the French would use the secrecy essential to the security of its military programme as an excuse for evading the supervision and data exchanges imposed on its partners, although, at the same time, its partners would be indirectly assisting French military research, the government also supported 'supranational inspection over. They also differed from France for putting more emphasised on economic cooperation over atomic programme.

Germany, due to its post-war political position and decentralized domestic condition was slow in recognizing nuclear research and development program as critical to meet national goals. However, at the beginning of the creation of Euratom, the need to overcome administrative and industrial obstacles blocking the integration of its technological resources with national objective was perceived. Germany, also through Euratom, sought to strengthened the economic and political basis of its influence in Europe along with France and other major nuclear power countries when military means already ceased to be an option. They reasoned that the pursuit of civilian energy programme could be the means by which they could exercise political power.

Similarly, in Germany, like France, the Government officials also supported Europeanists goal. The Industrial actors, on the other hand, preferred ad hoc licensing arrangements with American firms as an alternative to potentially dirigistic policies of Euratom administration (Nau: 1975: 625). Initially, the German firms like Siemens and Krupp tried to retain their long traditions of conducting business independently from their own government and European institutions like Euratom. But the federal government in time assume a growing role in national nuclear research programme such as the establishment of the Ministry for Atomic Questions in 1955. Later it expanded to become the Ministry of Scientific Research with larger responsibilities in the field of space and nuclear areas. By 1967 the responsibilities for data processing was added, further followed in 1973 by the division of responsibilities between two new federal ministries, the Ministry of Education and Science and the Ministry of Research and Technology.

Though Germany pursued its own atomic energy programme yet it initially proceeded more slowly than France. It also emphasis upon the domestic program over the Euratom project. This ambition was visible in some accounts such as the German Science Ministry who established their aim in the nuclear field as that "whatever one did internationally, one must do at home on at least twice that scale". Later, the ratio became more like a ratio of1:4 in favour of national programs (J. Pretsch 1966: 421). At the community level, Germany preferred to let private industries handle bilateral arrangement for cooperation at the Community level. Germany also opposed major industrial projects proposed by France such as the prototype breeder reactor. Unlike France, Germany however sought to preserve the structure of the Joint Research Cooperation. Even as it also led the effort to convert the Joint Research Cooperation activities to relatively remote basic research and public service functions, it ensured that these do not conflict with German industrial programme (Nau (1975: 634).

Disagreement between Germany and France could also be witnessed over more symbolic question of European's identity against other countries, namely United States. Germany was known to downplay any association between science policy and broader European goals to avoid any hostile relationships with United States, except for any disagreement over the impact of non-proliferation treaty on German technological and industrial activities. This could also be seen on how German conducted its negotiations with other European countries. For example, it adopted a multi-tiered approach guarded that this project was not aimed at anyone in particular by carefully separating them into scientific, industrial, market and governmental discussions such as those establishing the joint breeder project with Belgium and Holland and the tripartite Uranium enrichment project with Great Britain and Holland.

Despite displaying extra caution due to its peculiar political situation, German firms did not stop seeking partnership with European firms to sharpen competition with American licensors and to loosen its traditional ties with American firms. Rene Foch stated it also seemed to be "striving to gain a position of leadership in research and showed signs of wanting to emulate the national ambitions of Britain and France in the area of space and nuclear development, aviation and computers", (Foch 1970:11).

COOPERATION AND COMPETITION UNDER EURATOM

During 1950, nuclear power development programme was still very minimal in Europe and little concrete information about special nuclear requirements and capabilities was available. No contact exist between French and Germany nuclear centres even one year after the European negotiations in the summer of 1956 when French official visited Germany to ascertain concrete aspects for cooperation in nuclear programme (Gueron 1968: 29-30). Instead individual countries used this period to establish separate and independent nuclear capabilities. France was the only one to conduct nuclear research of any consequence among the European countries and had the only civilian program among the Euratom countries with 800MWe previously announced in 1955. After the rapid development following the lifting of allied-ban, Germany also announced in 1957 that it wanted to pursue the nuclear research program which included a 500MWe program of experimental power reactors.

By the early 1960's, France began to stress on the symbolic dimension of R&D activities. General de Gaulle tried to alert to the dangers of US technological imperialism. At first, France took aim at American investments in Europe, but due to unwillingness of its industrial partners like Germany and the Benelux countries, proposed consideration of a common science policy in Europe which is a bit differed from the cooperation as practised under Euratom. French ideas of common policies are based on promotion to monitor foreign investments and discriminate in favour of European owned companies in the development of research and development, instead of Europe reliance on and promotion of American technology. To quote Robert Gilpin (1968) "What the France had in mind calling for a European science policy is not merely cooperation in science and technology but eventually a common policy toward American economic policies, and-especially-investments."

In 1961, difficulties begin to appear in Euratom when De Gaulle brought about the ouster of Euratom first president, a Frenchman, Etienne Hirsch. It was done apparently on the ground that Hirsch was taking the European concept too seriously and was less concerned with what Euratom could do to further France's on nuclear ambitions. However, the six partners came to agreement to provide a new five-year budget of $430 million. But, by 1965, with agriculture the precipitating issue, France carried out a nearly one year boycott of the market's various institution to force acceptance of its demand that unanimity, rather than majority vote must weighted according to national contributions, should govern the common affairs of the six.

France also differed from the Euratom model for giving priority to major projects such as the establishment of joint enterprises in prototype breeder reactor, the construction of a European enrichment plan, the establishment of a large data processing and storage system. They advocate the participation of only those countries that has the capability to contribute rather than supporting common laboratory programme such as the high flux reactor at Patten or the ESSOR reactor at Ispra. Moreover, due to financial constraints, France was against maintaining an all-purpose community facilitating those which duplicated national programs, they believed that community program should not be substitute but only must supplement national program. It also supported cooperation on case-by-case agreement by member governments acting through the Council of Ministers which is also more suited to industrial requirement, therefore, sought to enhance and improve its national nuclear energy program at the cost of community program. However, the French ambitious program to modernize was later squashed due to the high cost of independent nuclear program; French eventually had to resort to licensing agreement with American partners.

In 1967, France was largely blamed when Euratom was threatened with large scale technical breakdown due to political difficulties among the member countries. Especially, the budget crisis and uncertainties about the future could affect community research networks involving expenditure of about $300 million. The national programme as well, however was under stress by October. The same year the most pressing problem was dealt with in July when agreement was reached on its budget. The French Government finally agreed to advance $2.8 million for plutonium supplied by the United States for a French reactor at Cadrache. The cost was incurred when the US government decided to sell rather than lease the plutonium; the French earlier argued that the Euratom was responsible to supply the fuel (Walsh 1967:95). Euratom budget was obtained from contributions of the member countries and it represented only about 12 percent of the total nuclear spending of the member countries.

Again in 1968, various efforts were made to agree upon the new budget, but France posed problem by insist on radical reforms in Euratom. Italians also complained that France was monopolizing the most commercially promising work, while her partners help share the costs. In the 1960's, the R&D capabilities to harness nuclear energy among the major actors in Euratom became more evenly balanced among the major actors. According to the OECD (1971) statistical data, by 1967,France still retain its position as spending the highest expenditure with $2047.3 million followed closely by United Kingdom with $2190.1 million and Germany with $1727.9 million. Meanwhile, in the civilian nuclear sector, Germany had emerged as the European leader in first generation commercial reactors[35] and the German nuclear company, Kernkraftwerk Union (KWU) a joint subsidiary of Siemens and AEG[36] began to pose competition to American companies in the sale of light water reactors. KWU also through the agreement reached with the British Nuclear Power Group (TNPG), gained access to other European markets. In 1969, KWU sold its first reactor to its partner countries in which the principal contractor was not a domestic industry.

[35] At that point of time, Germany deal primarily on fast breeder reactors.
[36] Both Siemens and AEG were former licensees of American companies and later posed competition to American companies.

Germany also collaborated with its British and Dutch partners in the Joint uranium enrichment project (URENCO). However, France after abandoning development of gas graphite reactors, in November 1969, rejected in coordination with German government officials, Siemens offer to French government for permission to allow French industry to participate. This was because of its fear of being dominated by the bigger KWU. So it concluded license agreements with American companies to develop light water reactors and also developed an enrichment project to compete against Germany and its collaborating partners.

By 2007, Euratom remains an important and reasonable framework for regulating nuclear-energy policy in the EU. However, it was also largely criticized from several quarters. The European Commission also agreed the need to reform the Euratom treaty. It was criticized on the ground that the scope of the treaty was severely limited, in that way, it did not provided the European Commission (EC) to address crucial area such as-operational safety of nuclear power plants, management of radioactive waste storage or disposal facilities and decommissioning of facilities. The European Parliament, by looking at the growing importance of nuclear energy took action to address this deficit by extending its authority. Therefore to this end, on 10 May 2007, MEPs voted by a large majority in favour of reforming the Euratom treaty and extending Parliamentary powers to nuclear energy policy.

The Euratom treaty was also caught in the controversial web between the pro-nuclear and the anti-nuclear supporters. The pro-nuclear supporters argued that Euratom is necessary to continue playing an important role in promoting nuclear energy what they considered as energy of the future, that is capable of supplying Europe industries with cheap and non-polluting sources of energy. The Greens in the European Parliament were on the other hand, they blame the Euratom for excluding nuclear energy from EU competition rules, they argued that those rules runs counter to the development of internal market. They pointed out that the Euratom treaty restrains the EU from switching to safe and sustainable sources of energy by giving preferential financial support. Germany's former Environment Minister Rene Kunast also criticized it by stating that Euratom treaty obliged the member-states including those who decided to abandon nuclear energy (Eurativ 2009: 1).

SAFETY STANDARDS APPLICABLE UNDER EURATOM

In the provisions of Euratom, the European Commission acquired the status of a supranational regulatory authority in three areas: radiation protection, supply of nuclear fissile materials and nuclear safeguards. As stated in EEF (2007), the Euratom Treaty makes little or no specific mention of aspects such as operational safety of nuclear power plants and radioactive waste storage or disposal facilities (i.e. criteria or norms to be respected, during either design or operation of these facilities). As a result, regulatory activities in these areas have developed along national lines under the responsibility of national authorities. In countries favourable to nuclear power, the licensing frameworks are likely to evolve or became an extension of existing framework for currently operating plant. To those who are not favourable to nuclear power, the approach would depend on the perception of relative risks to benefits (Lillington 2004:161). There are increasing endeavours by international bodies such as the European Commission (EC) and International Atomic Energy Commission (IAEA) to promote harmonised agreement on nuclear safety criteria as well as licensing among their member states. There is also similar encouragement from the industry sides to the development of standardized utility requirements (URs).

Among European members and the United States, the laws and statutes existed are often enforced by safety authorities and regulators in accordance with national laws and reinforce by international bodies. The IAEA principles embodies the regulatory requirements of most countries and this further played considerable influence in the EU enlargement countries from a close safety cultures to one of great openness and is in turn influence by the latter. IAEA Basic Safety Standard established in the mid 1990s to ensure the safety of all applications of nuclear technology, particularly industrial and medical applications, and in some countries these developed without adequate infrastructures to ensure the safety of these applications.

Depending upon countries acceptance of nuclear energy, it plays a considerable role in framing the licensing and safety requirements. In France, the fundamental legislation for nuclear energy is based on the Decree on nuclear installations issued in December 1963. Followed by further decrees in 1974 and 1984, (Eur 20055, EN 2001) (Lillington 2004: 155). The regulatory body is formed within the Ministry for Industry and administered by the Ministry for Environment represented by *Direction* *de la Surete des Installations Nucleaires* (DSIN) which is responsible for regulation and inspection of the plants (Lillington 2004:155). The Basic Guidelines for safety *Regles Fondamentales de Surete* (RFS) are defined by DSIN. The French designed codes *Regles de Conception et de-Construction* (RRC) have been developed further by the French industries to meet the requirements of safety authorities. In 1989, France and Germany agreed to harmonised their safety approach for future reactors and form the *Deustche-Franzosische Direktion* (DFD) forming closed link between DSIN and BMU (*Bundesministerium fur Umwelt*), *Naturchutz und Reaktorsicherheit*. In 1992, both agreed to establish a common safety approach for future reactors.

Under the European Commission, the Council Resolutions of 1975 and 1992 emphasised the need for community to address the technological problem for nuclear safety in view of possible environmental and health implications. They emphasised on needs to keep the public inform, to realise the safety as well as economic benefits, together with harmonised approach for nuclear safety authorities. Constructors and producers further recommended that experience gain should be extended to third countries particularly those of Central and Eastern Europe and the republics of the Soviet Union. The 1995 Consensus document on European LWR capital safety also implemented the 25 Principles of nuclear safety in different European Union countries (EU), and the convention on nuclear safety by EU member states and the European Commission.

However, at present under the Euratom, there are no treaty obligations on the EU member states. The Generation IV International Forum (GIF) was launched in January 2000 by a group of ten (10) countries including France to develop a road map to pursue R&D on future Generation IV systems. The project was initiated by the United States Department of Energy with the objectives of developing future reactor systems that are competitively priced, while addressing safety, waste, proliferation and public perception concern (Lilington 2004: 168). It includes water, gas-cooled, thermal and fast spectra liquid metal (sodium, lead and lead-bismuth) cooled and molten designs (Lilington 2004:168).

Further, the Convention on Nuclear Safety is an international convention which aims to improve nuclear safety worldwide. All Member States of the European Union (EU) are party to the Convention. The Community established by the Euratom Treaty shares jurisdiction with Member States in the fields governed by the Convention. The Community acceded to the Convention on 30 January 2000. On 25 June 2009, the EU establishes a common binding framework on nuclear safety and the Council Directive establishing a Community framework for the nuclear safety of nuclear installations was adopted. According to EC (2009), EU is the first major regional nuclear actor to provide a binding legal framework on nuclear safety.

A QUEST FOR JOINT EUROPEAN NUCLEAR SECURITY

The proposal to create independent European security of 1950-55 under the European Defence Community (EDC) project included nuclear component. However the treaty was rejected by the French National Assembly on 30, August 1954 by 319-264 votes not only because it meant rearming Germany but more out of their fear that it would reduced French defence autonomy. For de Gaulle, still in the political wilderness, collective defence, whether of the NATO or EDC, could not fully guarantee French security. Therefore, nuclear weapons appeared to offer a means of securing national independence and grandeur also a means not to be totally dependent upon US (Keiger 2001: 69). But since it would be difficult for France alone to bear the financial cost involved therefore the French chiefs of Staffs recommended the creation of an integrated European nuclear force.

In 1957, when European integration such as the creation of Euratom and European Economic Community took place, negotiations took place on various bilateral and multilateral levels to share the research costs on peaceful use of atomic energy. This led many signatories to hope that this would be followed by political integration with the authority to decide on defence matter, therefore the idea of European nuclear force seems to be revived with the Franco-German. Later, when the Franco-Italo-German held talks on military cooperation took place, the first agreement on military technical cooperation was concluded between France and Federal Republic of Germany on 17 January 1957, the French Minister of Defence, Maurice Bourges-Maunoury also invited Strauss to visit French military installations in the south of

France and in Algeria. Apparently, nuclear cooperation was discussed on this occasion (Heuser 1997: 150).

Again on 22 March 1957, Federal Chancellor Konrad Adenauer mentioned in the press conference after his meeting with Guy Mollet 'a possibility of organising a Franco-German co production of atomic weapons on French territory'(Hueser 1997: 150). At the subsequent meeting the Germans were informed by their French counterparts that France developed nuclear weapons, they also expressed their wish to 'Europeanize' them. Therefore, the French government proposed the German and Italian government to participate, both financially and technically 'as a partner with equal rights' (Hueser 1997: 150). In November the French government under Felix Gaillard agreed to approach the West German Chancellor about nuclear weapon cooperation and called on Adenauer to discuss the matter. This led to the Franco-Italo-German secret agreement signed on 20 and 25 November 1957. The secrecy surrounding this treaty was requested by Strauss so to prevent hostile relationship with the Soviet Union so as not to disturb the German peace movement as well as due to German's domestic opposition to nuclear weapons. However, not for long, Britain remained disinterested. This was soon followed by Rome agreement on 7 April 1958 among the three countries on which became the basis for the future joint development of nuclear weapons.[37] By this the warhead produced to be shared in a ratio of 45%, 45% and 10% for France, West Germany and Italy respectively. However, with de Gaulle return to power in France1958 put an end to this effort for joint production of nuclear weapons.

In the 1960's, in spite of being rejected by the French, West Germany continued to strive for nuclear security. However the US emphasised to step up conventional defence under 'flexible response' was not welcomed by both France and Germany, they felt that the war in Europe must not be conventionalized. Instead, tactical nuclear weapons should be used very early on, to emphasize western determination to escalate rather than to yield or engage in long conventional battle. However, the first Fouchet plan for creation of the European Union which concerned further for the formation of common defence policy backed by six EEC member countries including

[37] This joint agreement includes nuclear war heads along with missiles as well.

West Germany was again vetoed by de Gaulle and the project was abandoned eventually.

By 1962, the Atlanticist and the Euro-sceptic began to gain ground in the German government (Hueser 1997: 153). Being suspicious about France to be interested only on acquisition of unilateral nuclear weapons which is not unfounded, they also began to regard a purely European nuclear force was dangerous because they might broke up western defence and weaken deterrence. Though Europe has considerable military and economic potential, the relationships of dependence between the US and Western Europe was seen by Germans as mutual and essential to European security. To this end, Kai- Uwe von Hassel travelled to France in February 1963, shortly after the Elysee Treaty. He made clear that FRG had no interest in nuclear cooperation with France. This could be confirmed by internal German Ministry of Defence documents which showed how the Germans had turned down the French suggestion that the FRG and France to jointly draw up common strategic and tactical planning documents (Hueser 1997: 153).

But, when Bonn enthusiastically pursued cooperation with US under Multilateral Force, France regard it as a threat to her interests and made another attempt to wean Germany from North Atlantic Treaty Organisation (NATO). In 1964, de Gaulle approached the new government under Ludwig Erhard offering nuclear cooperation. West Germany's response was not entirely dismissive but it still refused to do anything to antagonize US. The French Prime Minister Pompidou was the last to hint this idea at the French National Assembly. The idea European nuclear force died with the coming of Jacques Chirac in 1975. After this the matter seemed to have disappeared from French-German agenda.

By the late 1970's, there was a renewed interest in Europe over the Long Range Theatre Nuclear Forces (LRTNF) and then later the Intermediate Range Nuclear forces (Hueser 1997: 161). However, the French proposal in 1977 to the Germans and the British, co-financed, largely French and British-built missile project backfired because other European countries preferences were with NATO resulted in massive European input into NATO's deployment decisions of 1977-79. Later, by 1980's France defence became more Europeanize to accommodate West Germany so as to get finance 'an autonomous intelligence capability' of anti-missile defences or other "modern weapons". Chancellor Helmut Schmidt and President Giscard d'Estaing had ideas of establishing a closer link between France's nuclear power. It's conventional army on the one hand and the conventional German military forces and German economic power on the other failed to take off since they lost their offices in 1981 and 1982 respectively.

After the end of cold war, with the collapse of Soviet Union the urgency in which nuclear security was pursued in FRG and France lost its momentum. As the USSR (later Russia) and the US, continue to cut down their nuclear arsenal starting in 1991 with the unilateral elimination of Short-Range Nuclear Forces (SNF) resulted in reduction of 80% of NATO's sub-strategic nuclear weapons. With the reduction of threat from Soviet Union and re-unification, Germany for its national interest decided more or less to forgo nuclear weapons. Especially after the Gulf war, France became more conciliatory towards Britain. In addition, gradually fulfilled the political conditions raised by Britain for Franco-British cooperation and better doctrinal convergence between them. This makes it seems possible that, in the second half of 1990's ad hoc cooperation between France and Britain, if the political will exists; and this can again, given the political will, be presented as a joint nuclear guarantee to other European WEU members (Heuser 1997: 166).

WHY DID FRANCE RETAIN NUCLEAR ENERGY OPTIONS WHILE GERMANY TRIES TO PHASE OUT?

Both Germany and France have shown early interest and were among the leading nations in atomic science. However, due to the Second World War, both countries suffered a severe setback. The post-second world war situation showed the two countries with miserable economic, political and social conditions which also hampered their atomic development programme. In spite of this setback both countries made a serious effort for both peaceful and military program. While France conducted nuclear test in February 1960, due to sanctions imposed by the Western countries, Germany had relinquished her nuclear weapon option. However the end of cold war transformed the political conditions with the collapse of Soviet Union, lessen military insecurity but Germany continue to forgo its military nuclear options so as to fulfilled the conditions imposed by Soviet Union for unification but continue to pursue peaceful use.

In the present international context, though both France and Germany have become both economically and technologically capable to develop atomic energy for both military and peaceful purposes. Though France signed the non-proliferation treaty in 1995, but it has continued to retain her nuclear energy options. Germany on the other hand has decided to phase out even peaceful atomic development programme, the differences in their policy and the future nuclear options for both the countries could only be understand by looking at the historical dimension (both domestic and international), Economic dimensions (availability of energy resources and how far they depend upon nuclear energy), Security Dimensions, Socio-Political dimensions (political parties, public opinions and internal government administration).

HISTORICAL FACTOR

In spite of being the leading countries in the early period, with the outbreak of war, the emphasis on peaceful nuclear programme shifted to military programme. Three months prior to the fall of France, the Joliet Curie team reached a point when it was believed to actually conduct a chain reaction (Scheinman 1965:4). But the invasion of France and the signing of armistice in 25 June 1940 had put an end to the French nuclear effort. In Germany, the interest in atomic science also took an early start with the discovery of nuclear fission by Otto Hahn in 1938. The possibility of harnessing atomic energy for both peaceful and military purpose was recognised early on. During the Second World War, the military program became more accelerated but till the end of the war the experiment was not successful, and the laboratories used for conducting experiment were destroyed by the allied bombing.

During the post-war period, despite the poor technical and financial condition the legacies of the past research facilitated the decision to renew the efforts on nuclear energy. This revival took place very early in France with the vision and leadership of de Gaulle. Both on peaceful as well as military purposes, nuclear energy development was seen too be an essential component to embark upon its policy of grandeur.

Especially after the Algerian crisis in 1958, the United States refusal to employ nuclear weapon in Dien Bien Phu in 1954, and the Suez crisis in 1956 led the French to conclude that the respect of the French community depends on whether it endowed with nuclear weapon capacity. Therefore, France disenchanted with her allies continue to push forward for nuclear power resulted in the French nuclear test in 13 February 1960. The oil crisis in 17 October 1973 further pushed France towards a massive expansion of nuclear energy for peaceful process to pursue energy security.

Meanwhile, in Germany after it was defeated in the Second World War due to financial and technical problem compounded by political situation. Further, sanctions were imposed by the victor countries. Its capacity to conduct nuclear research was severely restrained. The signing of the Paris peace accord of 23 October 1954, which gave her back sovereignty, was ironically made conditional on its acceptance to forgo unilateral nuclear acquisition. But this did not deter Germany to continue to seek security under the US nuclear umbrella by completely integrating its armed forces within the NATO as its effort to alliance with France ended in failure.

The post cold war heralded by the fall of Berlin wall, the reunification of Germany in 1990 and the collapse of the Soviet Union, has since radically improved the security in Europe. However, this poses a new problem for France who still feels threatened by a bigger and better re-unified Germany strive for Europeanization to restrain Germany's military rearmament and development of nuclear weapons, even at the extend of providing nuclear security for Europe. France perceived nuclear weapons as a means to maintain influenced among major powers and to keep up with its policy of grandeur, Further, after becoming an NPT-signatory, due to lack of conventional sources of energy, France continuing to make larger commitment on the development peaceful nuclear program. Germany on the other hand has decided to forsake its nuclear weapons and agreed to abide by the 'Four plus Two' treaty signed on 12 September 1990 regarding renunciation of nuclear, biological and chemical weapons. This policy of forgoing nuclear weapon was further pursued because of economic interdependence with Western Europe and other global actors and Germany has a vital interest in avoiding instability in the region (Paul 2000: 47). Since 1998, the coalition government in Germany further embarked upon phasing out peaceful nuclear energy options as well.

ECONOMIC FACTOR

France and Germany as well as the other western countries were severely affected the Second World War and then by the oil crisis in October 1973. They began to perceive the significance of secure sources of energy. Besides due to the linked between energy security and military security, vulnerability to energy supply could also pose a threat to military security. Moreover, at present the oil producing countries are situated in a conflict-ridden and unstable region, therefore, secure and sustainable sources of energy is vital for the survival of modern industrial economy. Both France and Germany began to seek for alternative sources of energy other than oil to sustain their national economy and began to embark upon developing nuclear energy. However, by 1998, while France continue to embarked upon peaceful nuclear energy options and became the second only after United States, In Germany, the coalition government led by SPD began to pursue phase-out program.

The reason for this difference in their policy could be seen by look at how far nuclear energy impact upon France and Germany economy. As we had already mentioned in the previous chapter, Germany was endowed with abundance of natural resources especially in coal, which provide half of its electricity requirement. Besides, Natural gas provided 12% of its energy demand and so on. It is also the world leader in developing renewable energy like wind energy and bio fuels. Germany out of its 17 reactors obtains only one quarter of its electricity from nuclear energy. On the other hand, France lacked natural resources unlike Germany. Therefore, it depends on nuclear energy for 75% of its electricity. Moreover, development of nuclear energy also enabled her to gain substantial energy independence and to become the largest net exporter of electricity.

As compared to Germany, France is far more depended upon nuclear energy for her economic survival whereas Germany could continue to depend upon coal and other energy resources to meet energy demand, though the carbon-emission problem has to be taken into account. Thus, while France continues to develop nuclear energy for energy security, German embarks upon phase-out plan and emphasis on energy derived from coal on which it has in abundance and renewable energy. Despite the threat of carbon emission, Germany was expected to retained coal as the major sources of energy. Therefore, though the decisions to retain peaceful nuclear energy depend upon a whole lot of other factor but economic consideration played a vital role.

SECURITY FACTOR

Since, a country energy security also related to military security, this was especially remain true in the case of nuclear energy; nuclear energy could be used for both military and peaceful purposes. Unfortunately, with atomic energy, it is extremely difficult to draw a clear line between military and civilian applications. Priority was more often given to military application. This is also true in the case of France. Soon after the end of Second World War, France began to get disenchanted with its allies; differences grew against United States following the acrimonious debates over the issue of European Defence Community (EDC) from 1951-54, German rearmament, Indochina, the Arab States, the Algerian crisis and Britain acquisition of nuclear bomb. This was further exacerbated by the 'Anglo-Saxon' domination of NATO at the level of doctrine and command (Keiger 2001: 68). With the decline of Soviet threat after the Korean War and the demise of Stalin in 1953 seems to reduced the need to rely upon US while the US strategy of massive retaliation 1954 was also lead France to believe it as a prelude to American troops withdrawal which would leave the European forces alone on the enemy frontline.

Further, the refusal of US to provide support during the Suez crisis in 1956 also led France to conclude that it is not always wise to rely upon US protection, further the launching of the Sputnik in 1957 demonstrated to the world the capability of Soviet Union to deploy intercontinental missile that could directly threatened America, so it became doubtful whether US would deploy its nuclear warheads for the defence of Europe, therefore France began to feel that collective the NATO or EDC will not guarantee French security, so it embarked upon developing nuclear weapons as the only means to ensure French security and grandeur resulted in conducting its first nuclear test on 13 February 1960.

The German factor could also be pointed as one of the major reasons for French to develop its nuclear weapon. Harold Nicholson put it in 1939 that France policy has for the last sixty years, been governed almost exclusively by fear of her eastern neighbour namely, Germany. Since, 1870, France has fought three wars with its eastern neighbour resulted in over around 2 millions French dead, economic and financial devastation in humiliation as well as political collapse have condition France to ensure that Germany remained either an emasculated enemy or a tame friend. Despite being among the victor countries at the 2nd World War French retained a visceral fear of the loser. Therefore, France wishes to keep its nuclear options as a means to get advantage in this area over Germany as a result of the latter's renunciation to build the weapon. Germany would be allowed to rearm, but France would possess the ultimate deterrent. (Keiger 2001: 146).

On the other hand, Germany in the post-second world war was look upon by the western countries with suspicion and restrained was imposed on its minimal atomic research programme .During this period, the main aims of the West German Government were to achieve national security while retaining freedom and democracy, reunification also became a lower priority if it means at the cost of alienating its western allies, moreover the proposal for European Defence Community (EDC), which precluded the production of nuclear weapons and missiles likely to be overrun by the enemy early on in the event of an attack had failed to take off due to opposition by France a it would mean rearming Germany. This was believe to be the root causes of Adenauer's declaration of renunciation on the production on the FRG's territory of nuclear or chemical or biological weapons.

However, Germany cut short of actual possession of nuclear weapons continue to strive for nuclear security, whereby in 1957 it took a diplomatic initiative to create a French-West German-Italian as a means to gain access to nuclear weapons in times of interstate-crisis but the attempts failed, then Germany turned towards United States to station its nuclear warheads on Germany and began to pushed vigorously forward the proposal for the creation of Multilateral force consisting of intermediate range nuclear force under the joint control of NATO countries, but the Soviet Union Protest so vehemently as it would make West Germany a de facto nuclear states, however the MLF was also shelved in favour of Nuclear Non-Proliferation Treaty (NPT) by 1965, though initially Germany refused but later signed the NPT on 28, November 1969 and totally renounced its military nuclear options.

Therefore, Germany total renunciation of military nuclear options during the cold war could be seen as a conscious effort not to generate intense negative security externalities against its neighbours as well as to provoke Soviet Union to avoid future possibilities of war while making an effort to secure itself under the America's nuclear umbrella. This policy was a adopted so as not to hampered its national objectives such as protecting its national sovereignty, fostering of NATO alliances, European integration and unification, simply it can be said that to renounce nuclear weapons would be better so as to protect its national overall security and interest. The post-cold period saw Germany further re-enforce its commitments, the reunification process was made conditional upon Germany's by Soviet Union over renunciation of nuclear weapons as well as to keep East German territory as a denuclearized zone within NATO and as an off-limits to NATO troops (Kelleher 1990:21). Moreover Germany further signed 'Four plus Two' where it agreed to abide by the commitments earlier made by East and West Germany nuclear, chemical and biological weapons and conformed to the existing NPT policy and to limit the size of its armed forces and to respect existing borders with its neighbours.

At the present international context, Germany continue to conformed to its non-nuclear policy and uphold its earlier commitment, being one of the leading countries to support Europeanization, through this integration the western countries have created an interdependent economy, interlinked by a political structure and a co federal pan-European economy where national industries could developed. So, Germany believes that to conform to its present policy against nuclear weapons and tighter European integration is the best means to achieve economic prosperity and national security.

SOCIO-POLITICAL FACTOR

The political parties, public opinion in French are known to be amenable towards retaining both peaceful and military nuclear options. From de Gaulle Presidents of the Republic have maintained the strategy of an independent nuclear weapon, even though in opposition up to 1978 Socialist leader Francois Mitterrand and his party had opposed the nuclear strike force. Since then a fairly broad consensus, unknown in other European countries, has existed among political parties, public opinion and even the Catholic Church on the need to maintain the nuclear weapon. Indeed, the dodged critic of Gaullist military policy. Mitterrand was able to declare in Gaullist vein as President on 16 November 1983: "The centrepiece of the deterrent strategy in France is the head of state, it is me." Bitter memories of three invasions and the humiliation of defeat and collaboration in 1940 allowed such a consensus to form. As the ultimate defence of French territory, the nuclear bomb has reconciled nationalists, who believe in its capacity to threaten, and pacifists, who, 'see above all in the nuclear an instrument of non-war'.

Even though, France was able to contained anti-nuclear protests that swept through Europe in the early 1980's. But this consensus has been not without a price. Defence has not been a subject of much political or public debate and consequently military thinking and planning therefore became somewhat stultified. Moreover, the France's nuclear weapon did enhance the country's autonomy and security; in addition it also had benefits of non-military nature especially after the war and decolonization. It allowed France to re-discover their self-confidence and this help in building national sentiment and cohesion through the defence consensus since it project France as an advance technological state, and position it among the major nuclear countries.

The Federal Republic on the other hand has been towards a party state. German political scientist Kurt Sontheimer provides a clear definition of this term, "All political decisions in the Federal Republic are made by the parties and their representatives. There are no political decisions of importance in the German democracy which has not been brought to the parties, prepared by them and finally taken by them", (Conradt 1996: 115-116). Even though, following the oil price shock in 1974 increase in perception of vulnerability in energy supplies especially after the Chernobyl incident in 1986, In West Germany, the Social Democratic Party (SPD) which had affirmed nuclear power in 1979 along with the minority Green Party (Die Grunen) demanded a steady abandonment. In June 1986, when Chancellor Kohl tried to insist that simply helping the countries' on nuclear program could not necessarily save from nuclear accidents; because there would still be 66 nuclear plants in surrounding countries. However, public opinion polls in meet May, 1986 put combine support for SPD and Green's, head of the CDE and FDP. But, the German authorities appear to be able to contain the public anxiety a these point of time.

In October 1998, when the coalition government was formed between SPD and the Green Party, the latter saw it as an opportunity to strengthen its position and make its political cooperation with the SPD conditional on their support of the call for immediate closure of nuclear power plants in West Germany. As a result, in 2000, an agreement was reached for the eventual phasing out of nuclear power between the reactor owners and the federal government. In recent developments since the pro-nuclear power seems to gain public opinion in their favour, the continuance of the phasing–out depends upon the political parties who would win in the coming September elections and formed the government

Recently, in France, President Nicolas Sarkozy in January 29, 2009 announced the government intention to build a new nuclear power plant at EDF's Penly site. This shows the government continued support for developing nuclear energy. In Germany on the other hand, the pro-nuclear supporters become more hopeful after the success of the pro-nuclear parties FDP and CDU in Hesse in January 18, 2006. They have seen it as the first step towards winning the coming September election. Current polls suggest that pro nuclear parties might get support to form a new coalition without anti-nuclear parties. But at the same time, political observers have warned again extrapolating the result. If the pro-nuclear parties able to form the new government, this will result in halting the Germany's nuclear phase out policy.

CHAPTER FIVE

CONCLUSION

Currently, fossil fuels continue to satisfy most of the global energy demand (86%), with oil representing almost half of the fossil fuels consumption. The remaining demand for energy is satisfied mainly by biomass and other renewables (hydroelectricity, solar, wind, and geothermal consumption) (12%), while nuclear energy represents only 2% of the global primary energy. Assuming a regional fossil fuels remain the most important energy source (77%), however, with an increasing proportion of natural gas over the proportion of oil. Fossil fuels would continue to be the most important sources of energy (Vaillancourt et al. 2008: 2300). The part of biomass and other renewables remain constant, meaning there are no economic or environmental incentives for these energy forms in a non-intervention scenario. According to World-TIMES model projections (Vaillancourt et al. 2008: 2300), for nuclear energy, its proportion is on the rise and is expected to go up from 2% in 2000 to 13% of the global demand in 2100. It makes nuclear energy represents the energy form with the highest relative growth on the entire horizon.

However, though fossil fuels would remain major sources of energy, due to their carbon emission properties and being non-renewable sources of energy, the supply is limited for the future. Besides, the political condition of the major supplier countries were vitiated by instability, ethnic conflicts, this led many countries to search for clean and sustainable sources of energy. The development of each energy forms depends on the geography, the technological, economic and socio-political situation in each region. For example, because of the intermittence of the wind source in France, a large-scale development of the wind power industry would require additional fossil power to fill the gap and this would lead to more GHG emissions (Jean-Baptiste and Ducroux, 2003:155).

In recent years, to tackle the global CO_2 emission problem, nuclear energy began to gain larger support as it is a clean source of energy. According to the World Time model projections 2008, the global CO_2 emission was expected to follow a moderate growth to reached 12.8 gigatonnes of carbon (GtC) (Vaillancourt et al. 2008: 2301). The emissions come mainly from the electricity sector (31%), the transportation sector (27%), and industry (18%). The emissions of the electricity sector were predicted to increase gradually until 2050 and remain constant in the second half of the century, where the gradual replacement of coal power plants by oil and gas power plants counteract the increase in demand for electricity. In 2100, it would still represent 31% of the global emissions. The energy demand growth in the industrial sector is considered important because no significant fuel switching can be expected in the future. In other words, the fuel proportions remain more or less the same on the entire horizon.

The European Union put great effort to curb carbon emission by adopting carbon trading policy which commenced January 2005. Through the Cap-and-trade policy, power plants and heavy industry carbon emissions were kept under limit and they must buy extra pollution permits to release more. They can profit by selling them if they emit less. The Los Angeles Times (2009: 1) mentioned that this effort was expected to cut carbon dioxide output by a fifth by 2020. However, The EU's first phase of carbon trading from 2005 to 2007 was widely regarded as a failure because polluters received far more permits than they needed and were not forced to reduce emissions. The European Commission aimed to set tighter controls for 2008 to 2012.

During the Russian-Ukrainian gas crisis, the European countries also suffered supply interruptions which raised the spectre of energy dependency on outside sources. It also underlines the fundamental weaknesses of European Union energy policy. Because of national interests, there is no common energy policy and efforts to create internal market are hampered by all kinds of obstacles. Therefore, Euractiv (2006) mention that at the informal Hampton Court meeting of EU leaders in October 2005, the UK presidency called for a stronger European co-ordination of energy policy. On 4 January 2006, at the press conference following the Gas Coordination meeting, the Energy Commissioner Piebalgs stressed improved dialogue with energy partners and said that Europe has to invest more in its own energy resources renewables and, possibly, nuclear energy.

Nuclear energy was largely seen as the future potential alternative to fossil fuels to meet the future energy requirements. Assuming a 'closed cycle', with FBRs converting most U-238 to plutonium, the equivalent of 1 tonne of natural uranium with be some 1.5 million tonnes of oil; thus under 100tonnes of uranium might meet one year's energy need for countries like France and Germany (Beck 1994: 22). Therefore, a stock of few thousand tonnes could be expected to meet the energy demand for most countries and make them independent of energy crisis provided they had the technological capabilities to generate nuclear energy. However, the future of nuclear energy option remains a controversial issue. Nuclear energy also represents large scale and non-carbon emitting energy source to meet the growing demand in both develop and developing countries. But, the risks of accidents and the generation of radioactive waste have also considerably contributed to the negative social opinion of nuclear energy.

At the same time, renewable energy alone will not be sufficient to meet global energy needs especially in countries with high socio-economic growth. Besides, unless there are significant developments in the technical and economical renewable potentials and renewables will continue to play a minor role in global electricity production (Vaillancourt et al. 2008: 2306). In spite of the fact that heir cost started to decrease and some forms of renewable energy like wind seem to be promising, further cost reductions or new regulations will be necessary to see renewables penetrating market in substantial proportions (Vaillancourt et al. 2008: 2306). Same is true as nuclear power the European Union requires the new member states to shut down the least safe nuclear reactors, and by 2009, eight (8) reactors have to be closed in financial support from the European Bank for reconstruction and development (Reiche, 2006: 365).

However, considering the potential role of nuclear energy in a sustainable global future, many countries are investing in the research and development of future nuclear technologies like International Thermonuclear Experimental Reactors (ITER). These new generations of fission reactors should improve such that large-scale contaminations by radioactivity do not occur in case of accidents. The amendment of German Nuclear law of 1994 already specified that the radioactivity level of new reactors must be low enough in case of accidents, so that the evacuation of the nuclear plant is not required (Vaillancourt *et al.* 2008:2297). The pebble bed modular gas-cooled reactor (PBMR) was expected to satisfy those conditions. Moreover, new separation techniques have been developing to treat fission products and potentially improve the current waste disposal approaches (Vaillancourt *et al.* 2008:2297).

This study shows how both in France and Germany, steps were taken to prevent the hazardous elements in developing nuclear energy. In January 2008, Germany's Radiation Protection Commission (SSK) took steps to interpret and evaluate the results of an epidemiological study released on 10, December 2007 that found statistical relations between proximity to German nuclear power reactors and incidents of cancer in children. The study conducted under the Institute of Medical Biometry, Epidemiology, and Information Science (IMBEI) calculated for the period 1980-2003 cancer risk of 0.2% for children living within a five kilometres radius of 16 German nuclear power plants. On a statistical basis, that higher risk accounted for 29 of 13, 373 total cancers detected in Germany in children under the age of five during the period of study. However, the authors specified they did not identify a causal relationship between power plants and cancer (Hibbs 2009a: 7).

Maria Blettner, Imbei director with Peter Kaatsch, head of Germany's national register for childhood cancer concluded their study by saying that because the additional exposure from routine operation of power reactors dwarfed by normal background radiation levels. Therefore, based on current scientific knowledge, emissions from the reactors could not explain the correlation between higher cancer incidence and proximity to the reactors. The correlation could be incidental. The Chairman of SSK, Wolfgang-Ulrich Mueller, a scientist at the Institute for Medical Radiation Biology at the University of Essen also discounted radiation as the cause for cancers. He said that the extra exposures at issue are less than exposures from long distance commercial air flights.

Soon after the study was released, the results were highly politicised by both pro-nuclear and anti-nuclear German political parties. The pro-nuclear Christian Democrats accused Wolfram Koenig, former Green State Regulatory official who is president of the Federal Radiation Protection Agency (BFS) as misrepresenting the conclusions of the study, which the former denied. The BFS who funded the study in their report released on 10 December 2007 stated that as opposed to the authors of the study, the BSF-appointed advisers were convinced that radiation emissions from the reactor cannot excluded as the explanation for the correlation. Because of the exceptionally high radiation risk for cancer as well as the incomplete knowledge about the effect on the body of incorporated radio nuclides. The antinuclear Greens and Social Democrats reacted to the study by demanding that Germany must accelerate the pace of its nuclear phase-out and enact radiation exposures limits closer to Zero. However, Gabriel was careful not to cause any political upheaval between pro-nuclear and antinuclear coalition and ordered a probe by SSK before reaching any conclusions on the matter.

In 2008, the French authorities drawing the experience from Chernobyl accident tries to develop a formal strategy for managing the consequences of a serious radiological accident in cooperation with other national or international organizations. The French Nuclear Safety Authority (ASN) chairs the interministerial, interdisciplinary committee known as Codirpa. It commissioned in 2005, to examine what would be involved in managing the long-term consequences of accidents in nuclear power plants (MacLachlan 2008:11). Earlier, the efforts up to that period had focussed only on short-term crisis management of nuclear accidents, but experience taught that decisions made during the crisis period could have consequences over decades. At the Paris Conference sponsored by ASN in December 6-7, 2007 the ASN Chairman emphasised the possibility of serious accidents with long-term consequences.

The Chernobyl episode has greatly influenced nuclear energy debate in both Germany and France, nevertheless, contrary to many experts general assumption, the Chernobyl incidents shows that contamination is long lasting in certain circumstances, such as cesium-137 could remain in soil and plants for decades. In Chernobyl contaminated areas, there are food restrictions for example, even after 22-years of Chernobyl fall-out, restrictions still placed on consumption of reindeer meat, financial compensation measures also still apply to individual settled in closed areas. However, Codirpa initial investigations show that focus on two scenarios which are were very different from Chernobyl-level catastrophe that could lead to long term consequences at the French nuclear power plant:

- The first, assumed to develop quickly, involving ruptures of a steam generator tube combined with highly contaminated primary coolant.

- The second, a slower development-envisages a loss of coolant accident leading to partial core melt.

The preliminary ideas that emerge from initial study of the issue in France was the need to establish reference dose levels on the basis of predetermined exposure scenarios because there won't be time during a crisis to clearly measure doses. The other was "zoning" the contaminated territories according to the level of contamination, both to facilitate agriculture countermeasures and to avoid accumulation of mountains of radioactive wastes that characterized the Chernobyl accident's management. Further, the need is to pre qualify laboratories that could be entrusted with measuring radioactivity that could be entrusted with measuring the level of radioactivity levels after an accident, in order to make sure sufficient measurements would be available n which to base decisions (MachLachlan 2008: 11-13).

The principal recommendations of the Codirpa's Working Group in the Paris Conference were as follows:

- Setting of pre-established criteria for deciding on evacuation, lifting of sheltering orders, and return of evacuees, it also recommended that each potentially affected community establish a plan for reducing radioactive contamination in built-up areas.
- Zoning scheme for animal feed and foodstuffs. All food from a defined "food prohibition zone" would be declared non-consumable, whatever its contamination, products from a "food surveillance zone" that exceed normal contamination limits could be consumed only under certain conditions.
- Measures for taking a census of contamination populations and establishing centres for public information, and suggested authorities begin planning for such census activities in a 10-kilometer radius around each "major nuclear installations" in France (MacLachlan 2008: 11-13).

Another group studying post accident indemnification suggested that a "single counter or clearing house must be established in the wake of in the wake of a nuclear accident to which all claims would be addressed". Other Groups who studied post-accident waste management and organization of public authorities to manage a radiological crisis proposed that an initial "transition" phase of a few days to a few months would follow the initial crisis phase and be concerned with cleanup of contaminated zones lifting of immediate protective measures, and preparations for long-term action. The following "long term consequences management" phase could last for years. In addition, they also further suggest ways to involve stakeholders in the post-accident management.

In the present context, in France, nuclear energy development continues to gain support with the federal government as compared to the environmental and health lobbies. The problem is that non-use of nuclear energy could cause excessive fossil fuels, moreover the countries lacked of renewable resources and the strive for a stable and secure source of energy supply make the countries to opt for nuclear energy, besides, the power costs projections seem to favour nuclear energy versus all other base load options. Therefore, the recent developments in January 2009 of the France government decisions to built EPR as well as President Sarkozy announcement on the possibility of building another reactor after Penly-3 the possibility developing nuclear reactors after Penly-3 make it clear that France would continue to harness its peaceful nuclear energy options.

In Germany, the recent financial crisis has motivated the reactors owners to seek for extension of the lifetimes of their 17-operating units. The Supreme Court has, however, rejected their appeals by RWE and Vattenhall to permit transfer of allotted reactor lifetime from the shutdown Muelheim-Kaerlich to the Biblis-A and Brunsbuettel nuclear units. However, Reactor owners hope that voters overturn the government in the elections this September. Current polls suggest that pro nuclear parties might get support to form a new coalition without Germany's three anti-nuclear parties. The elections are expected to be close. Political observer says that the anti-nuclear parties' participation in the new government would make unlikely a suspension of the phase-out or the reversal of the current government's rejection of transfer petition. The success of pro-nuclear parties in Hesse in January 18, 2009 could be the first step towards halting Germany phase-out. Moreover, the two German political parties, pro-nuclear democrats FDP and CDU scored a clear feature

Hesse state parliamentary election. The first favoured continued operation of two pressurised water reactors at Biblis. At the same time, political observers have warned against extrapolating for the coming elections. Chancellor Angela Merkel has meanwhile agreed to suspend debate on phase-out as per argument till next coalition.

Therefore, this study concludes that, in the present context, by looking at both the domestic and international developments, France is likely to keep its nuclear energy options given its limited renewable energy resources, need for cheap and clean resources of energy supported political consensus to keep its nuclear options despite some anti-nuclear protest. On the other hand, in Germany, on the possibilities of reversal in the phase-out programme, reasons given include such as possibility of energy scarcity, the need for non-carbon emission sources of energy. Also, the emergence of developing countries such as India and China with their rapidly increasing energy consumption has brought more competition for energy resources. However the ultimate decision-making would lies in the hands of political parties forming the next German government.

REFERENCES

Armand, Louis (1956), "Atomic Energy and the Future of Europe," *Foreign Affairs,* 34 (4): 655-664.

Aron, Raymond (1957)" Historical Sketch of the Great Debate," Daniel Lerner and Raymond Aron (eds.) *France Defeats EDC,* New York: Frederick A. Praeger.

Baev, Pavel K. (2007),"Russia Aspires to the Status of 'Energy Superpower'," *Strategic Analysis,* 31 (3): 447-465.

Baring, Arnulf (ed) (1994), *Germany's New Position in Europe: Problems and Perspectives,* Oxford: Berg Publishers

Beck, Peter (1994), *Prospects and Strategies for Nuclear Power: Global Boon or Dangerous Diversion,* London: Royal Institute of international Affairs.

CIA (1956) Central Intelligence Agency, "The French Nuclear Weapons Program", s13 November, URL: http://www.foia.cia.gov/wizards/osi_pdf/the_french_nu.pdf.

Cohen, Kenneth (1959), "Euratom", *The Journal of Industrial Economics,* 7 (2): 79-86.

Conradt, David P. (1996), *"The German Polity", Sixth Edition,* New York: Longman Publishers USA.

Davis and Mary Byrd (2001), "Nuclear France: materials and sites" [Online: web] Accessed 3 April, 2009 URL: http://www.francenuc.org/en_sites/cen_chinon_e.htm

Drake, Helen (2005), "Perspectives on French relations with the European Union: an Introduction", in Helen Drake (eds.)*French Relations with the European Union,* Oxon: Routledge.

Duffey, R.B, (2005), "Sustainable Futures Using Nuclear Energy", *Progress in Nuclear Energy* 47 (1-4), 535-43).

EEF (2007) European Energy Forum," Treaty establishing the European Atomic Energy Community (Euratom)", URL:http://www.europeanenergyforum.eu/background-and-references/background-and-reference-documents/treaty-establishing-the-european-atomic-energy-community-eurato.

EIA (2008), Energy Information Administration, "Energy Profile of Germany", The Encyclopaedia of Earth, 5 June, URL:http://www.eoearth.org/article//Energy_profile_

Elliott, Dave et.al. (1978), *The Politics of Nuclear Power,* London: Pluto Press Ltd.

ENA (2007), European Navigator, "Euratom and France's military plans", 8 March, URL: http://www.ena.lu/euratom_frances_military_plans-020102554.html.

ENA (2007), European Navigator, "Treaty Establishing Euratom". 9 April, URL: http://www.ena.lu/treaty_establishing_euratom-020102564.html.

EOE (2008), The Encyclopaedia of Earth, "Energy profile of Germany", 5 June, URL: http://www.eoearth.org/article/Energy_profile_of_Germany.

EPIC (2007), European Parliament Industry Committee, "EU will need conventional energy resources for some time" The European Weekly New Europe, 747, 15 September URL: http://www.neurope.eu/articles/77833.php.

Fiore, K., (2006), "Nuclear Energy and sustainability: understanding ITER", *Energy Policy* 34 (17): 3334-3341.

Foley, Gerald and Ariane van Buren ((1978), *Nuclear or Not? Choices for our energy future,* London: Heinemann Educational Ltd.

France, Nicky (2008), "Operational research models and methods in the energy sector- Introduction to the special issue", *Energy Policy*, 36(2008): 2293-2295.

Frederic Joliet-Curie (1949), "La Premiere Pile Atomique Francaise," *La Pensee*, March-April (23):3-7. .

Frey, Karlsten (2006), *India's Nuclear Bomb and National Security*, New York: Routledge

Gilpin, Robert G. (1992), *France in the Age of the Scientific State*, New Jersey: Princeton University Press.

Gofman, John W. and Arthur R. Tamplin (1971), *Poisoned Power: The Case against Nuclear Power Plants,* London: Chatto & Windus.

Gueron, Jules (1968), "Une geographie cordial de l'Europe atomique," *Les problemes de L'Europe*, 4 (42): 29-30.

Hafele, Wolfe (1981), *Energy in a Finite World: A Global Systems Analysis*, London: Ballinger Publishing Company.

Henderson, Harry (2000), *Nuclear Power: A Reference Handbook,* California: ABC-CLIO, Inc.

Heuser, Beatrice (1997), *NATO, Britain, France and the FRG Nuclear Strategies and Forces for Europe, 1949-2000,* Great Britain: Macmillan Press Ltd.

Heuser, Beatrice (1998), *Nuclear Mentalities? Strategies and Beliefs in Britain, France and the FRG,* Great Britain: Macmillan Press Ltd.

Heilbron, John L. (1986)," *The Dilemmas of an Upright Man: Max Planck as spokesman for German Science*", Berkeley: University of California.

Hibbs, Mark (2009a), "German political deal postpones decision on safety rules until 2011", *Nucleonics Week*, New York, 11 June 2009.

Hibbs, Mark (2009b), "BMU: continue phase out, replace reactors with efficiency, renewables", Nucleonics Week, New York, 19 February 2009.

Hodgetts, J.E. (1964), *Administering the Atom for Peace,* New York: Atherton Press.

Hodgson, Peter E. (1999), *Nuclear Power, Energy and the Environment,* London: Imperial College Press.

IAEA (1957), International Atomic Energy Agency, "Atoms for Peace: Address by Mr. Dwight D. Eisenhower, President of the United States of America, to the 470th Plenary Meeting of the United Nations General Assembly, 8 December 1953", 4 March, 2009, URL: http://www.iaea.org/About/history_speech.html.

Jean-Baptiste and Ducroux P. (2003), "Energy Policy and Climate Change", *Energy Policy,* 31 (2003): 155-166.

Kalicki, Jan H. and David L. Goldwyn (2005), *Energy and Security: Towards a New Foreign Policy Strategy,* Washington.D.C: Woodrow Wilson Centre Press.

Kartha, Tara (1998), *French Strategic Doctrine,* New Delhi: Institute for Defence Studies and Analyses.

Kasperson, Roger E. et al. (1987), "The emergence of risk analysis on the international scene" in Roger E. and Jeanne X. Kasperson (eds.) *Nuclear Risk Analysis in Comparative Perspective: The impacts of large-scale risk assessment in five countries,* Boston: Allen & Unwin Inc.

Keiger, J. F. V. (2001), *France and the World since 1870,* London: Arnold.

Kelleher (1990), "The New Germany," *New York Times,* 21 (July): 18

Knapp, Andrew and Vincent Wright (2001), *The Government and Politics of France, Fourth Edition,* London: Routledge.

Lavoy, Peter (2003), "The Enduring Effects of Atom for Peace". Accessed 10 Jan. 2009 URL: http://www.armscontrol.org/act/2003-12/lavoy#notes1.

Lillington, J.N., (2004), *The Future of Nuclear Power,* UK: Elsevier Ltd.

Lochbaum, David A. (1996), *Nuclear Waste Disposal Crisis,* Oklahoma: Pennwell Publishing Company.

Lodgaard, Sverre and Marek Thee (1983), *Nuclear Disengagement in Europe,* London: Taylor & Francis.

MacLachlan (2009), "EDF: Higher capacity factors offset long outages at some units in 2008," *Nucleonics Week,* 50 (5): 1, 11.

MacLachlan, Ann (2009), "Siemens- Rosatom joint venture would compete with Areva", *Nucleonics Week,* New York, 12 March 2009.

Manners, Ian and Richard G. Whitman (2000), *The foreign policies of European Union Member States,* Manchester: Manchester University Press.

Mathijsen, Pierre (1961), "Problems Connected with the Creation of Euratom," *Law and Contemporary Problems,* European Regional Communities, 26 (3): 438-453.

McCarthy, Patrick (2001), *France-Germany in the Twenty-First Century,* New York: Palgrave.

Mendershausen, Horst (1972), "Will West Germany goes Nuclear?", *Orbis,* 10 (2): 411-34.

MIT (2009), Massachusetts Institute of Technology, "The Future of Nuclear Power" 26 July, URL: http://web.mit.edu/nuclearpower/pdf/nuclearpower-summary.pdf.

Moret, Leuren (2005), "Planet Earth as Weapon and Target," *World Affairs,* 9 (4): 64-107.

Morone, Joseph G. and Edward J. Woodhouse (1989), *The Demise of Nuclear Energy? Lessons for Democratic Control of Technology,* New Haven and London: Yale University Press.

Moss, Norman (1981),*The Politics of Uranium,* London: André Deutsch Limited.

Nau, Henry R. (1975), "Collective Responses to R&D Problems in Western Europe: 1955-1958 and 1968-1973", *International Organization,* International Responses to Technology, 29 (3): 617-653.

NIF (2009) Nuclear info.net, "The cost of nuclear Power", 10 June, URL: http://nuclearinfo.net/Nuclearpower/WebHomeCostOfNuclearPower

Palumbo, D. (1987), "Nature and Prospects of the Euratom Fusion Programme", *Philosophical Transactions of the Royal Society of London. Series A, Mathematical and Physical Sciences, the JET Project and the Prospects for Controlled Nuclear Fusion,* 322 (1563): 199-211.

Pande, Savita (1997), *Fissile Material for Nuclear Weapons,* New Delhi: Institute for Defence Studies and Analyses.

Park, Chris C. (1989), *Chernobyl: The Long Shadow,* New York: Routledge.

Pierre, Andrew J. (1984), *Nuclear Weapons in Europe,* New York: Council on Foreign Relations, Inc.

Paul, T.V. (2000), *Power versus Prudence: Why Nations Forgo Nuclear Weapons,* London: McGill-Queen's University Press.

Proedrou, Filippos (2007), "The EU- Russia Energy Approach under the Prism of Interdependence", European Security, 16 (3-4): 329-355.

Reiche, D. (2006), "Renewable energies in the EU-accession states." *Energy Policy* 34 (2006): 365-375.

Scheinman, Lawrence (1965), *Atomic Energy Policy in France under the Fourth Republic,* New Jersey: Princeton University Press.

Sir Cottrell, Alan (1981), *How Safe is Nuclear Energy?,* London: Heinemann Educational Books Ltd.

Smith, Peter D. (2007) "Doomsday Men: The Real Dr. Strangelove and the Dream of the Super weapon", New York: St. Martin's Press.

Stellfox, David (2009),"EDF to look at building EPRs in Italy; Enel to take stake in Penly-3", *Nucleonics Week,* 50 (6): 1, 9.

Suzuki, Hitoshi (2008), "Trade Unions as a Peace Movement?: The Ideas of Euratom, the European Trade Union Network, and Debates of how to Exclude Nuclear Armament from German Rearmament 1950-1960 ", [Online: web} Accessed 2 June, 2009, http://www.lse.ac.uk/Depts/global/PDFs/Peaceconference/Suzuki.doc

Sweet, William (2006), *Kicking the Carbon Habit: Global Warming and the Case for Renewable and Nuclear Energy,* New York: Columbia University Press.

Takada, Jun (2005), *Nuclear Hazards in the World: Field Studies on Affected Populations and Environments,* Japan: Kodansha Ltd. and Springer-Verlag Berlin Heidelberg.

UN (2000), United Nations Department for Disarmament Affairs, "2005 Review Conference of the Parties to the Treaty on the NON-PROLIFERATION OF NUCLEAR WEAPONS" 11 July, URL: http://www.un.org/events/npt2005/npttreaty.htCanada

Vaillancourt *et al.* (2008), "The role of nuclear energy in long term climate scenarios: An analysis with the World-TIMES model", *Energy Policy,* 36 (2008), 2296-2307.

Van Evera, Stephen (1999), *Cause of War: Power and the Roots of Conflict,* Ithaca, NY: Cornell University Press.

Walsh, John (Oct. 6, 1967), Euratom: After 10 Years, Still Seeking the Way", *Science New Series*, 158 (3757): pp. 95-98.

Walker, Mark (1989), *German National Socialism and the quest for nuclear power 1939-1949,* Cambridge: Cambridge University Press.

Weiss, Leonard (2003)," Atoms for Peace", {Online: web] Accessed 10 Jan. 2009 URL: http://www.mindfully.org/Nucs/2003/Atoms-For-Peace1nov03

Willis, F. Roy (1978), "Origins and Evolution of the European Communities", *Annals of the American Academy of Political and Social Science,* The European Community after Twenty Years, 440: 1-12.

Wilpert, Bernhert and Naosuke Itoigawa (2001), *Safety Culture in Nuclear Power Operations,* London: Taylor & Francis.

Winnacker, Karl and Karl Wirtz (1979), *Nuclear Energy in Germany,* Translated by David Goodman, Illinois: American Nuclear Society.

WNA (2008), World Nuclear Associations," Nuclear Power in Germany", 30 December, URL: http://www.world-nuclear.org/info/inf43.html.

Yergin, Daniel (2006), "Ensuring Energy Security", *Foreign Affairs*, 85(2): 69-82.

Yergin, Daniel (2005), "Energy Security and Markets", in Kalicki, Jan H. and David L. Goldwyn (eds.) *Energy and Security: Towards a New Foreign Policy Strategy,* Washington D.C: Woodrow Wilson Centre Press.

Zonabend, Francoise (1989), *The Nuclear Peninsula,* Translated by J. A. Underwood, Cambridge: Cambridge University Press.

Zwaan, B. C. C. van der (1999), *Nuclear Energy: Promise or Peril?,* in Zwaan et al. (eds.) Singapore: World Scientific Publishing Co. Pte Ltd.