CHAPTER 3

NUCLEAR ENERGY SECTOR

3.1 OVERVIEW:-

Operating and under construction nuclear plants are briefed here to give a glimpse of the international and national nuclear sector. Development of Indian nuclear industries and present scenario of Indian nuclear sector are also briefed in the chapter.

3.2 INTERNATIONAL NUCLEAR SECTOR:-

The total world primary energy demand grew by 26% from 2000 to 2010 and, it is projected to grow less by 2020. Projected growth is 45% under current policies by 2035, and 33% under a restrained scenario. Currently about two billion people do not have access to electricity and it is a highest priority to address this issue. (International Atomic Energy, 2009)

Nuclear power generation had share in 2011 about 11.6% of world electricity (22,202 TWh). As per World Energy Outlook 2013 world electricity generation increases from 22.1 PWh as on 2011 to 37.1 PWh in 2035. It is projected that there will be 66% increase in nuclear contribution 2011-2035. (International Atomic Energy, 2014)

31 countries have nuclear plants to produce electricity. 436 Nuclear reactors are in operation and 63 reactors are under construction in the world. The world scenario is tabulated in table 3.1:

Table No.-3.1:- Global Nuclear Energy Reactor Under O&C

No. of countries	In operation		Under construction	
	Number	Net output MW	Number	Net output MW
31	436	370,494	63	60,057

(Source : IAEA web page and IAEA reports), IAEA(2009,2012, 2013)

Nuclear electricity production and share from 1985 to 2013 in the world is tabulated in Annexure-I. (International Atomic Energy ,2014).

3.3 INDIAN NUCLEAR SECTOR:-

Electricity demand in India is increasing rapidly day to day. 1052 billion kilowatt hours was produced in 2011 which was more than triple the 1990 output. It represented only some 750 kWh per capita for the year. Gross generation of electricity in India comprises 836 TWh from fossil fuels, 131 TWh from hydro sector, 33 TWh from nuclear sector, and 53 TWh from other renewable sectors. Coal provides about 68% of the electricity generation at present, but reserves are limited. Gas contribution is 15% and hydro contribution is 12%. It is expected that the per capita electricity consumption would be doubled by 2020, with 6.3% annual growth. It will be reached to 5000-6000 kWh by 2050. There is an acute demand for more and more reliable power supplies. One-third of the population is not connected to any grid. International Atomic Energy (2013).

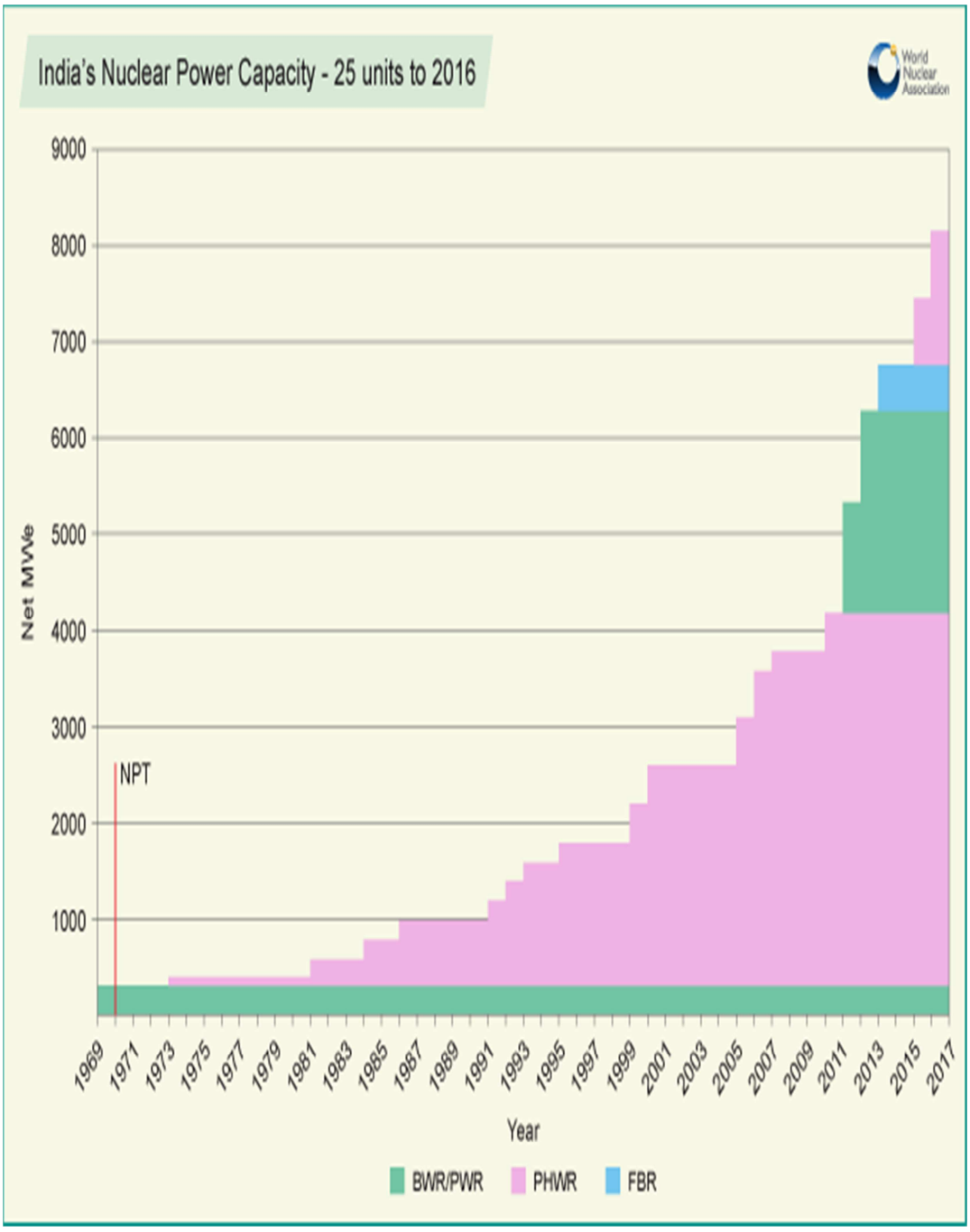
The government's twelfth five-year plan for 2012-17 is targeted to add another 94 GWe over the period. Three quarters of this would be form coal and only 3.4 GWe form nuclear, which includes two imported 1000 MWe units and two indigenous 700 MWe units . By 2032 total installed capacity would be 700 GWe to meet 7-9% GDP growth. International Atomic Energy (2013).

Shortage of fossil fuels is driving the nuclear investment for electricity in India. It is aiming that 25% nuclear contribution will be from nuclear by 2050 . International Atomic Energy (2014).

NPCIL has targeted to achieve 60 GWe form nuclear by 2032, International Atomic Energy (2014).

Indian nuclear energy scenario is presented in Figure no.-3.1.

Figure No.-3.1:- Indian Nuclear Energy Scenario



(Source, WNAO)

3.3.1 INDIAN NUCLEAR SECTOR DEVELOPMENT: - The importance of nuclear energy in India has been recognized at the inception stage of atomic energy programme more than four decades ago. A three-stage nuclear power programme was then framed. The three stages are:

- Operation of Pressurized Heavy Water Reactors (PHWRs) using Natural uranium as fuel.
- Operation of Fast Breeder Reactors (FBRs) utilizing plutonium as base fuel.
- Operation advanced nuclear power systems, Advanced Heavy Water Reactor (AHWR) for utilization of Indian thorium for yielding an efficient production of plutonium. Plutonium is the fissile material needed to fuel further growth in nuclear power sector.

Nuclear power for civil use ie. electricity generation, medical use, industrial use is well established in India. Indian civil nuclear strategy/ policy has been directed towards complete independence in the nuclear fuel cycle. It is necessary because India is excluded from the 1970 Nuclear Non-Proliferation Treaty (NPT) due to it acquiring nuclear weapons capability after 1970. (As per NPT those five countries doing so before 1970, were accorded the status of Nuclear Weapons States).

India's nuclear power program has proceeded without fuel or technological assistance from other countries. As the result, power reactors to the mid-1990s had some of the world's lowest capacity factors, reflecting the technical difficulties of the country's isolation. But further rose impressively from 60% in 1995 to 85% in 2001-02. Again in 2008-10 the load factors dropped because of shortage of uranium fuel.

India's nuclear energy got self-sufficiency right from uranium exploration, mining, fuel fabrication, heavy water production, reactor

design &construction, operation, to reprocessing and waste management. India has also developed technology to utilize its abundant resources of thorium as a nuclear fuel for electricity generation.

The Atomic Energy Establishment was set up at Trombay, near Mumbai, in 1957 and ten years later, it was renamed as Bhabha Atomic Research Centre (BARC) in the memory of father of Indian Nuclear Programme and first director BARC & Chairman, Atomic Energy Commission. Canada's Douglas Point reactor was built as a collaborative venture between Atomic Energy of Canada Ltd (AECL) and NPCIL. This was the first Pressurized Heavy Water Reactor (PHWR) and design was finalized in 1964 to establish at Kota, Rajasthan. It was commissioned in 1972. The same design was duplicated in subsequent indigenous PHWR development.

The Indian Atomic Energy Commission (AEC) having two departments, Department of Atomic Energy and Atomic Energy Regulatory Board. This is the main policy & execution body in nuclear field. The Nuclear Power Corporation of India Ltd (NPCIL) and Bharatiya Nabhikiya Vidyut Nigam Limited (BHAVANI) are responsible for design, construction, commissioning and operation of thermal nuclear power plants in India. Bhabha Atomic Research Centre (BARC) and Indira Gandhi Centre for Atomic Research (IGCAR) are responsible of reprocessing & waste management activities. India is aiming to involve other public sector and private corporations in future nuclear power expansion Department of Atomic Energy,2012, 2014), (NPCIL, 2014).

3.3.2 INDIAN NUCLEAR PROJECTS: - 21 Nuclear reactors of different technology are in operational and 7 reactors are under construction in India. NPCIL & BHAVINI, PSUs of Government of India, are responsible for design & operation of power generation . BARC and IGCAR are responsible for reprocessing & waste management

activities. ECIL & HWB are supporting organizations along with some private firm like L&T, Godrej, Blachandnager Industries etc.

Reprocessing & waste management projects/ plants are associated facility to complete the total nuclear energy cycle.

Indian nuclear reactors under operation are listed in Table-No. 3.2 & Indian reactors under construction are listed in Table No.-3.3:

Table No.-3.2 :- Indian Nuclear Energy Reactor Under Operation

Reactor	MWe net, each	Commercial operation
Tarapur 1 & 2 (Maharashtra)	150	1969
Kaiga 1 & 2 (Karnataka)	202	1999-2000
Kaiga 3 & 4 (Karnataka)	202	2007, 2012
Kakrapar 1 & 2 (Gujarat)	202	1993-1995
Madras 1 & 2 (Tamil Nadu)	202	1984-1986
Narora 1 & 2 (Uttar Pradesh)	202	1991-1992
Rajasthan 1 (Rajasthan)	90	1973
Rajasthan 2 (Rajasthan)	187	1981
Rajasthan 3 & 4 (Rajasthan)	202	1999-2000

Reactor	MWe net, each	Commercial operation
Rajasthan 5 & 6 (Rajasthan)	202	2010
Tarapur-3 & 4 (Maharashtra)	490	2006, 2005
Kudankulam 1 (Tamil Nadu)	1000	2013
Total (21)	5385	

(Source : DAE and NPCIL web pages and internal reports)

Table No.-3.3: Indian Nuclear Energy Reactor Under Construction

Reactor	MWe	Commercial operation due
Kudankulam -2 (Tamil Nadu)	1000	2015
Kalpakkam- PFBR (Tamil Nadu)	500	2015
Kakrapar -3 (Gujrat)	700	2015
Kakrapar- 4 (Gujrat)	700	2015
Rajasthan -7 (Gujrat)	700	2016
Rajasthan- 8 (Gujrat)	700	2016
Total (6)	4300 MWe	

(Source : DAE and NPCIL web pages and internal reports)