Center for Study of Science, Technology & Policy

CSTEP Policy Brief On Nuclear Power

PREFACE

CSTEP's research appointment is with a select set of technologies. Not technologies per se; goodness knows there are enough science and technology journals, conferences and workshops to promote their findings, but on the consequences of technologies to society through economic growth and human welfare. CSTEP will frequently release summaries of such studies. Such policy briefs are not research papers or even opinion pieces; but a succinct review of the state of the art and of options such technologies provide to society.

The object of the policy briefs is not to present one set of recommendations or another. Instead, they cite a number of options for the policy makers to consider. Some may even envisage drastic policy changes and may even prove difficult to implement.

The first policy brief is on Nuclear Power. This study has become relevant because of our society's concern on growing CO2 emissions and of countries' pursuit for energy security. I am grateful to Dr. Anshu Bharadwaj, Prof S Rajagopal and Shri L V Krishnan, for authoring the first policy brief. In the coming months we hope to publish similar briefs on topics spanning solar power, bio-fuels, batteries, infrastructure and disaster management.

Dr V S Arunachalam
Chairman, CSTEP

CSTEP RESEARCH AREAS

ENERGY AND ENVIRONMENT

SECURITY

NEXT GENERATION INFRASTRUCTURE

INFORMATION AND COMMUNICATIONS TECHNOLOGY

This policy brief is part of the CSTEP research brief series. CSTEP policy briefs are succinct reviews of state of the art technologies and the options they provide to society.

Center for Study of Science, Technology and Policy

CAIR Building
Ali Askar Road
Raj Bhavan Circle
High Grounds
Bangalore - 560 001
Tel: +91 (80) 4249-0000
Fax: +91 (80) 2237-2619
Email: admin@cstep.in

Center for Study of Science, Technology & Policy

CSTEP Policy Brief 1

Nuclear Power (PB-1:21.7.09)

CSTEP RESEARCH AREAS

ENERGY AND ENVIRONMENT

SECURITY

NEXT GENERATION INFRASTRUCTURE

INFORMATION AND COMMUNICATIONS TECHNOLOGY

This policy brief is part of the CSTEP research brief series. CSTEP policy briefs are succinct reviews of state of the art technologies and the options they provide to society.

Center for Study of Science, Technology and Policy

CAIR Building
Ali Askar Road
Raj Bhavan Circle
High Grounds
Bangalore - 560 001
Tel: +91 (80) 4249-0000
Fax: +91 (80) 2237-2619
Email: admin@cstep.in

Introduction

India's nuclear power program formulated by Bhabha in 1960s consisted of three phases. The first phase envisaged setting up of 10,000 MW of Pressurized Heavy Water Reactors (PHWR) using indigenously available natural uranium. Fast Breeder Reactors (FBR) using a mixture of plutonium (recovered from spent fuel of PHWR) and depleted uranium came next. The third phase reactors would use plutonium to convert thorium into good nuclear fuel. This was considered a viable for energy security since thorium is available in plenty in India.

While India has done well to develop the technology for the first two phases (Figure 1), for various reasons, actual power generation remains far below the initial targets and contributes about 3% to the nation's electricity. The nuclear world has now dismantled the controls and embargo on India that impeded growth for 5-6 decades. This provides a huge opportunity for rapid nuclear expansion which is vital for India's energy security and low carbon growth (1, 2)

The question is how do we achieve a rapid growth in nuclear power? How do we leverage the benefits of the nuclear deal with the indigenous program? This brief examines a few options for the near and long run to achieve a rapid growth in nuclear power.

Spent Fuel Reprocessing

FBRs are the backbone of the three phase program and this requires sufficient capacity to reprocess spent fuel for recovering plutonium. Present capacity of 200 Tons per annum is inadequate to meet the fuel requirements of the four 500 MW FBRs planned by 2020. Further, the reprocessing capacity would have to be capable of handling at least about 1600 Tons per annum of spent fuel from PHWRs and 500 Tons per annum from Light Water Reactors (LWR) on completion of the planned thermal reactors (Figure 1) (2). Three possible ways of achieving this are:

1. Indigenous reprocessing plants.
2. International reprocessing facility in India.
3. Arrangements to get spent fuel reprocessed abroad.

What are the prospects for each of the above? India has designed built and operated reprocessing plants over several decades and is self-reliant in the technology. Therefore, building new and larger plants indigenously should not face any technical challenges, but each plant requires at least 7 – 8 years for construction and commissioning.

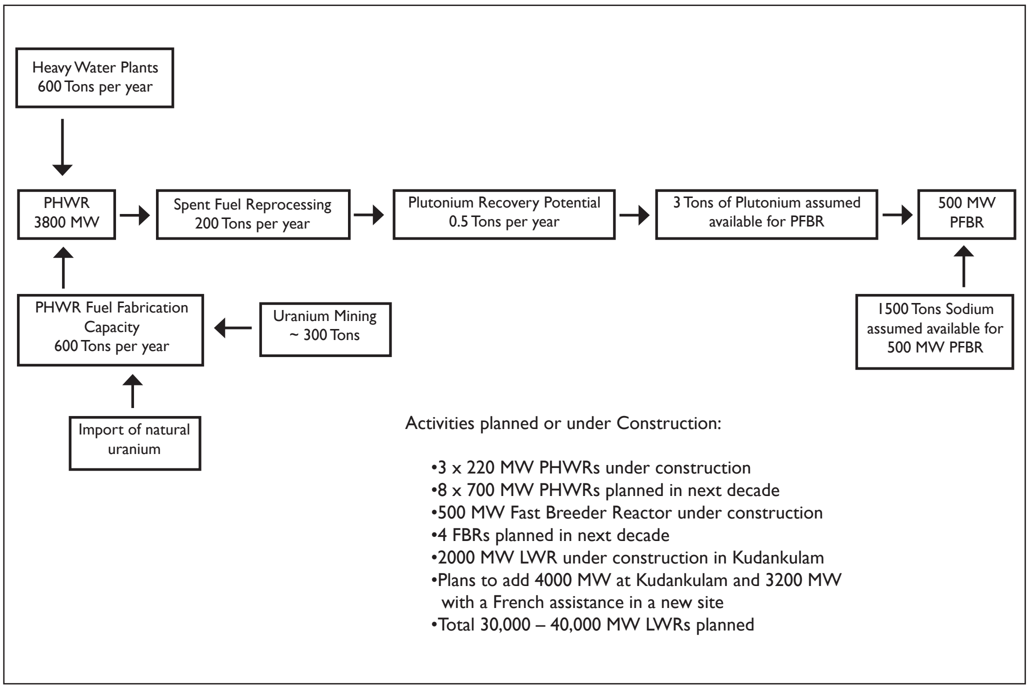

Figure 1: Present nuclear scene in India and activities planned or under construction.

The proposal for international fuel cycle facilities is still in the conceptual stage. Getting spent fuel reprocessed abroad could provide early availability of plutonium for initiating the FBR program. But, it is subject to successful negotiations with the concerned countries. Moreover, recent reports indicate that international collaboration in reprocessing is uncertain and depends on prevailing geo-political circumstances.

Non-availability of adequate plutonium would delay large scale FBR addition. Therefore, the best option for rapid nuclear capacity addition is to accelerate and expand the PHWR and LWR program. The spent fuel from the PHWRs and LWRs that accumulates in the meanwhile could be reprocessed as and when new plants are built with international cooperation or without.

Pressurized Heavy Water Reactors (PHWR)

India has gained considerable experience with the technology, manufacture, fuel fabrication and all aspects of nuclear fuel cycle of PHWRs that operate on natural uranium. Eight reactors, each of 700 MW are planned to be completed by 2020, which will take the PHWR capacity to 10,000 MW. This is the maximum that can be supported by the estimated domestic uranium reserves of about 61,000 Tons. The prospect of importing uranium facilitates building more PHWRs. PHWRs being of indigenous manufacture, their capital cost is lower than that of imported Light Water Reactors (LWRs). The official estimate for the proposed 700 MW reactors is $1700/kW (3) while a recent MIT study estimates the cost of LWRs at $ 4000/kW (4). It is therefore prudent to build more PHWRs beyond the earlier target of 10,000 MW.

Annual uranium requirement to support 10,000 MW is expected to be 1600 tons, far exceeding the present production of about 300 Tons. Clearly, in addition to augmenting domestic mining, international agreements are required for uranium imports. India has already signed agreements with Russia and France for supply of 2,000 Tons and 300 tons of uranium respectively (5). Discussions are also in progress with Kazakhstan and Canada. These efforts should be continued.

Light Water Reactors (LWR)

There is a proposal to add 30,000 – 40,000 MW through large capacity LWRs to enable rapid increase in installed capacity. This option must be pursued vigorously selecting suitable sites in good time, establishing necessary regulatory framework and ensuring a robust fuel supply security. It could also be extended beyond 40,000 MW to facilitate accelerated growth.

Fast Breeder Reactors (FBR)

Design and development of metal fueled FBRs with high breeding capability is vital for accelerated growth of the nuclear program in the long run. It requires development of a new reprocessing technique for high temperature processes associated with recovery of plutonium, fabrication of recycled fuel and waste management. After the completion of the PFBR, the design of a prototype metal fuelled reactor and fuel cycle could be taken up so that it serves as a forerunner for a series of such reactors to follow.

Thorium Options

There are high expectations about utilizing India's abundant thorium resources for energy security. Thorium is not a fissile material and has to be converted to U233, which requires enriched uranium or plutonium. For instance, the 300 MW Advanced Heavy Water Reactor (AHWR) requires a continuous feed of plutonium totaling to 7 Tons over the first 10 years alone. Considering that 6 tons plutonium can support one 1000 MW FBR for its lifetime, plutonium is better used in FBRs and hence large scale thorium use in AHWRs is not advisable at least for a few decades while capacity growth is a main target.

An alternate option for early thorium utilization is to fuel the LWRs with a mixture of LEU and thorium. Thorium gets converted to U233 and generates power in situ without the need for reprocessing. This scheme could be attempted in Kudankulam reactors. Similarly, introduction of thorium with LEU in the PHWRs could also be considered.

Summary

A great opportunity now lies before the country to build a substantial nuclear power program. The focus should be on quick capacity addition by continuing to build more PHWRs beyond 10,000 MW and at least 30,000 MW – 40,000 MW LWRs. Reprocessing capacity addition should also continue. The recent debate about access to reprocessing and enrichment technologies should not be allowed to distract attention from building more LWRs and PHWRs.

References:

1. A. Bharadwaj, Tongia, R., Arunachalam, V.S., Economic and Political Weekly, 1203, March 25, 2006.

2. A. Bharadwaj, Krishnan, L.V., Rajgopal, S., "Nuclear Power in India – The Road Ahead", CSTEP, 2008.

3. Chairman AEC., Indian Academy of Sciences, July 4, 2008.

4. Update of the MIT 2003 Future of Nuclear Power, an Interdisciplinary MIT Study, Massachusetts Institute of Technology.

5. DAE Press Release. See http://www.dae.gov.in/press/press110209.htm