Inevitability of Nuclear Power in the Asian Region

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Abstract

The Asian region, most populous and fastest growing in terms of economic growth, has countries with lowest per capita energy/electricity consumption. Barring the Middle East, the rest of the region is, by and large, modest in conventional energy resources. This is also a region where large sections of population suffer from income inequality and inadequate economic development. Economic growth and quality of life of a population depend heavily on per capita availability of energy/electricity, and thus there is an urgent need to increase the per capita electricity production/consumption in the region. Unlike in the past, it is the Asian region that is poised to dwarf the today's developed world in new capacity addition in the coming years. This fact alone asks for sensible choices to be made. Also, the Asian region is quite vulnerable to the effects of climate change, given the geography and population distribution. Today, governments must seriously consider the environmental impact of electricity generation, in order to help mitigate global warming and its consequences. Nuclear power, being environmentally benign, affords sustainability at the very outset. But that's not all. The other compelling reasons in favour of nuclear power are its compact nature as a source of energy and the promise of long-term energy security. Nuclear power is, therefore, inevitable for the region. Recognising this, the rapidly developing countries in the region – such as India and China – are pursuing ambitious nuclear power programmes, while several other countries in the region are also planning to embark on the nuclear power route for electricity generation.

As nuclear power is inherently technology-intensive, there is a need for greater cooperation, to reach out to countries that presently do not have the technology base for starting nuclear power programmes on their own. Even in the countries with established commercial nuclear power programmes, there is a need to reach out to the people to demonstrate the merits, safety aspects and economic competitiveness of nuclear power, and also the role of nuclear power in the preservation of the environment. The imperatives of the current scenario warrant building confidence among the people regarding nuclear power through sharing of credible information on all its aspects to remove misconceptions. This paper describes the current scenario, key issues, challenges and possible ways to address them. The paper also briefly describes the Indian nuclear power programme for being the second-most aggressive player in the nuclear arena in this region, after China.

1.0 Introduction

The Asian continent is the largest in the world in terms of both area, (about 45 million square kilometers) and population, estimated at 4121 million (2009), of the total world population of 6829 million, constituting about 60%. It is geographically diverse and has distinct geographical regions like South Asia (Indian Subcontinent), East Asia, Southeast Asia, Middle East, Central Asia and Eurasia (area under Russian Federation). In general, the Middle East and Eurasia are referred to separately, while the Asian region predominantly refers to the remaining areas of the continent.

It has the two biggest countries in terms of population, China and India, which constitute about 37% of the world population. A large population of the region has a very low per capita income of about $3000 (PPP). In view of this, many of the counties in the Asian region rank very low on the human development index (HDI). However, the development goals of the countries in the region need them to be on a path of rapid economic growth. The various policies of most nations of the region are directed at ensuring a fast economic growth rate to achieve their development goals.

China and India are the world's second- and third-largest economies in Purchasing Power Parity (PPP) terms. They are also among the fastest-growing economies, growing at around 7 to 10% every year. The other economies in East and Southeast Asia are also growing equally at rapid rates.

Setting up infrastructure, particularly which of energy/electricity is one of main requirements for ensuring sustained economic growth in the region.

2.0 Present Energy/Electricity Scenario in the Asian Region

The energy/electricity consumption patterns vary across the Asian region depending on the spectrum of economy and the models specific to each of the country, the current policies, demographic pattern as well as industrial and agriculture base, etc. While the electricity consumption in developed nations of the region, such as Japan (8475 kWh) and Korea (8502 kWh), is high, being close to European countries, it is quite low in the range of 80 to 700 kWh in countries of South Asia. About 22% of the population (900 million people of the 4121 million) in the region does not have access to electricity. Of these, the majority, about 700 million are located in South Asia. The graphs below show the range of per capita energy and electricity consumption in some of the Asian countries:

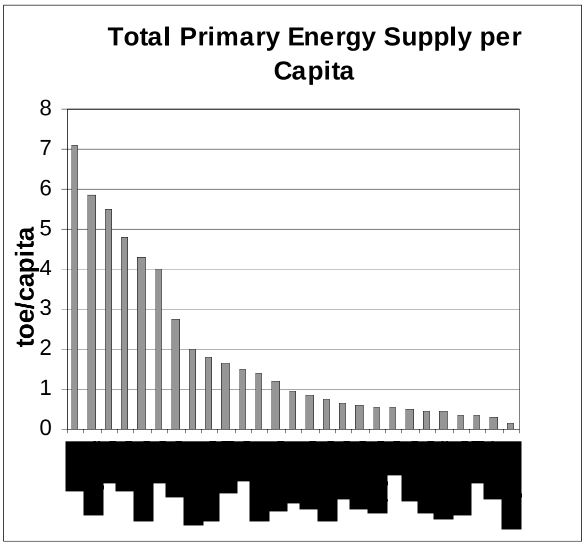
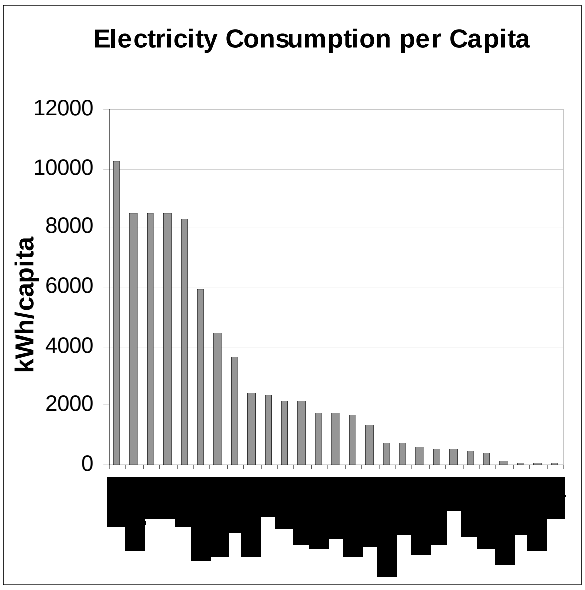


Fig. 1 Per Capita Primary Energy Supply



Source: Key World Energy Statistics 2009, IEA

Fig. 2. Per Capita Primary Electricity Consumption

The other significant feature of the energy supply pattern in the countries of the region is a large contribution of non-commercial energy – in the form of firewood, agricultural and farm residue, etc. The main sources of commercial energy in the region are coal (41%) and Oil (28%).

The overall import dependency of the region is significant, particularly for oil, at about 57% (2005). The dependency on imports for oil in India is about 75%. Energy security in the region is one of the concerns in the region and there is an imminent need to address this, which could be achieved by deploying sustainable sources of energy. This has resulted in nuclear power getting serious attention and consideration as one of the preferred options among the other energy sources in the region.

2.1 Demand Projections:

The demand for primary energy in the region is projected to grow at about 2.4% per year, with electricity demand growing at 3.5% per year. China (45.5%) and India (17.2%) are expected to constitute about two-thirds of the region's electricity generation by the year 2030.

In India, the projections of energy and electricity up to 2032 have been made in Integrated Energy Policy (2005) and these are based on falling elasticity rates with assumed GDP growth rates of 8% and 9%. The average growth rate of primary commercial energy and electricity are estimated to be 5% and 7% respectively. The projected energy and electricity requirements by the year 2032 are 1531 mtoe and 1823 mtoe for 8% and 9% growth rates respectively. The corresponding electricity requirements are estimated at 3880 and 4806 Terawatt-hours (billon kWh), which translates to installed capacities of 778 GW and 960 GW by 2032 respectively.

There are several studies made on China's demand projections over varying time frames. The IEA World Energy Outlook 2007 study projects China's total energy requirement by 2030 at 3819 mtoe in one of the scenarios. The study projects China's electricity requirement in 2030 at 8472 billion kWh. The corresponding installed capacity for an average growth rate of 7.5% is estimated about 1775 GW by 2030.

2.2 Energy Resources – Current Position

The energy resources in the regions are distributed most unevenly. Coal is the main source of commercial energy in the region, available in China, India, Indonesia and some other countries. The oil and gas resources are available in Central Asia and Southeast Asia. However, the region is a net importer of oil.

The increased demand over the next two decades will increase the import dependency, apart from increase in exploitation of these resources from within the region.

Hydro power and renewable energy has significant potential in some countries of the region. However, the share of these sources in the total primary energy demand is likely to remain low.

At present, nuclear power is limited to a few countries in the region in Japan, South Korea, China, India, Pakistan and Taiwan. However, projections show a manifold increase of nuclear power in China and India and other countries has planned to start the same . The non-renewable resource profiles for countries of the region that have substantial reserves are given below:

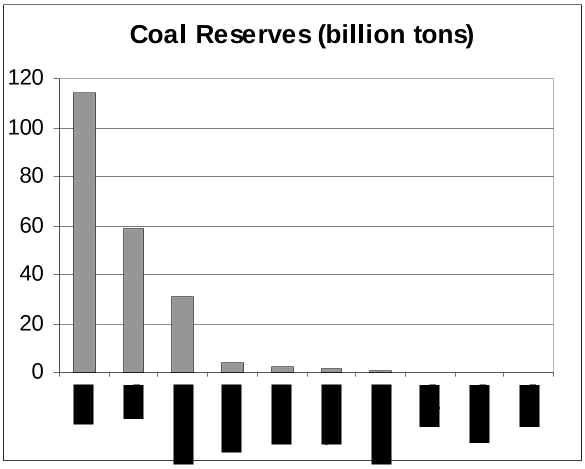


Fig. 3 Coal reserves in countries of Asian Region

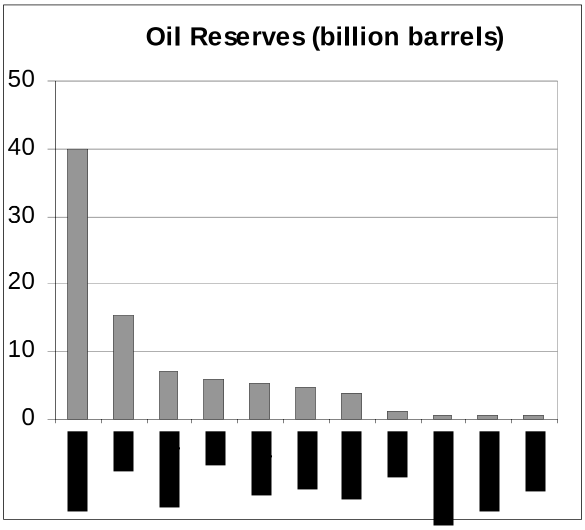


Fig. 4 Oil reserves in countries of Asian Region

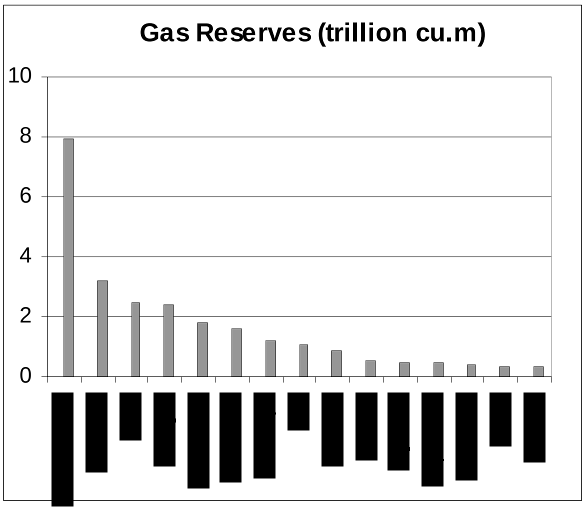


Fig. 5 Gas reserves in countries of Asian Region
Source: BP Statistical Review 2009

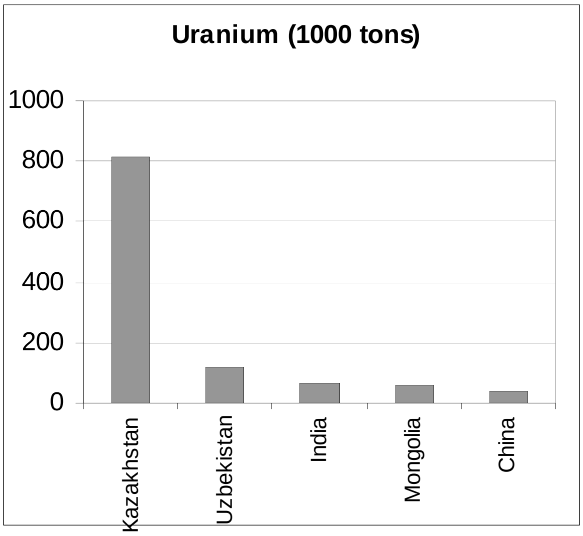


Fig. 6 Uranium reserves in countries of Asian Region
Source: WNA

The resource profiles of two of the most populous nations, China and India, and their reserves-to-production ratio at the end of 2008 are given below:

Table 1 : China & India Fossil Fuel Reserves

Resource	China		India	
	Reserves	R/P Ratio	Reserves	R/P Ratio
Coal (billion tons)	115	41	59	115
Oil (billion barrels)	15	11	5.8	21
Gas (trillion cu.m)	2.46	32	1.09	36

Source: BP Statistical review 2009

Although China has large resources, the rapid rate of exploitation has rendered it a net importer of energy. Its import dependency grew from -4.1% in 1990 to 7.2% in 2006.
Similarly, India's rate of production of coal is growing at about 5%, at which rate the mineable resource of coal could be exhausted in about 40 years. Thus the two countries have limitations on fossil fuels that can be economically mined beyond the medium term.

2.3 Sustainability Issues:

2.3.1 Energy Security

The addition of capacity in the region is projected to be largely commensurate with the economic growth. As each kWh generated from fossil fuel emits about a kg of Carbon dioxide(direct emission) therefore there would be large greenhouse gas (GHG) emissions associated with it if the entire demand is to be met using the conventional resources Also ,the fossil reserves in the region are assessed to be limited and likely to be exhausted in another 60 to 70 years, raising issues of sustainability of the energy sources, availability of resources, long-term energy security, impact on the environment as well as the added cost of mitigation measures that would be needed to be undertaken.

2.3.2 CO_2 emissions and Climate Change Concerns

The rate of growth of CO_2 emissions in the Asian region is estimated to be about 2.3% per year up to 2030, as coal, predominantly, is likely to drive the energy sector in the region in the period.

The Asian region is most vulnerable to the effects of climate change in future because of its geography, population distribution and occupations of the inhabitants, primarily agrarian economies.

In Asia, climate change as a result of global warming could result in crop losses, water scarcity, loss of forest cover and forced migration on a massive scale, among several other drastic consequences. Increase in sea levels as a result of melting of polar ice sheets could lead to loss of coastal ecosystems, with millions living along the coastlines risking flooding. Several low-lying islands and the Asian mega-deltas – Sunderbans (Ganga-Brahmaputra) in India and Bangladesh, Yellow river and Yangste deltas in China, Mekong and Red river deltas in Southeast Asia , Irravady delta in Myanmar and the mega cities like Mumbai are expected to be submerged, at least partly. It is also likely to have adverse effects on human health and compound further the stresses on the environment.

However, provision of energy is critical to achieving the development goals of nations in the region.

Thus both from the point of long-term resource availability and concerns of climate change, nuclear power is inevitable for the region. Nuclear power offers the most potent and lowest-cost option for mitigating climate change.

3.0 Nuclear Power in Asia – Current Scenario and Future Prospects

Nuclear power is inherently technology-intensive, requires a developed industry, trained and qualified human resources, appropriate and a certain minimum required technology base and resources to be deployed in a country aspiring to deploy nuclear power. Due to historical reasons including their colonial past, with the exception of Japan, the countries in Asia did not have such a base till they attained independence in the twentieth century. Some of the countries developed their nuclear power programme subsequently.

Thus, today a limited number of countries in the region have nuclear power programmes. The domestic share of nuclear power in the countries of the Asian region is shown below:

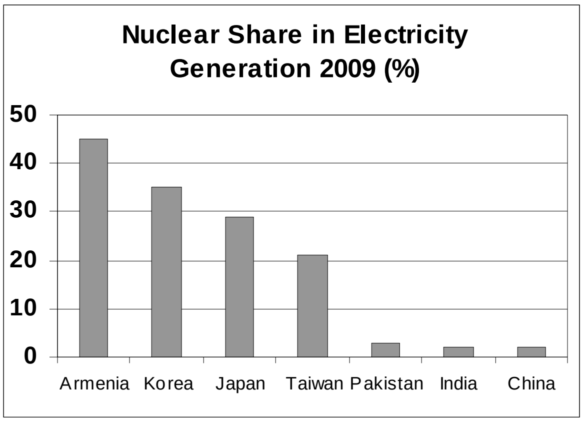


Fig. 7 Nuclear Share in countries of Asian Region

The details of the Asian countries with nuclear power programmes as of August,2010 are given below:

Table 2 Nuclear Reactors in countries of Asian Region

Country	Reactors in Operation		Reactors under Construction		Reactors Planned/ Proposed
	No.	Capacity net (MW)	No.	Capacity net (MW)	
Japan	54	46623	2	2650	13
Korea	20	17705	6	6520	6
China	12	9438	23	23620	153
Taiwan	6	4980	2	2600	
India	19	4189	4	2506	60
Armenia	1	375			1
Pakistan	2	425	1	300	4

Source: PRIS, IAEA and WNA

In addition , other countries including Vietnam, Indonesia, Thailand, Malaysia, Sri Lanka, Philippines, Mongolia, Kazakhstan, etc., have plans to deploy nuclear power in future. However, China and India have ambitious plans for nuclear power capacity addition. While India targets reaching a nuclear power capacity of 63 GW by the year 2032, China's plans are to reach about 200 GW of nuclear power capacity by 2030. The IAEA estimates that the Asian region will have a nuclear power capacity of about 270 GW of its projection out of the global nuclear power capacity projections of 748 GW by 2030.

India has made notable strides in nuclear power development and deployement of commercial nuclear power during last four decades, registering over 320 reactor-years of safe ,reliable and accident free nuclear power plants operation. In view of its comprehensive capabilities in the nuclear sector ,India is recognized as a country with advance nuclear technology. Thus, India is seen to be playing an important role in rapid growth of nuclear power .

4.0 Nuclear Power Plans & Prospects and Experience in India

4.1 The Indigenous Programme

Indian nuclear power programme the three-stage programme ,the most unique, comprises Pressurised Heavy Water Reactors (PHWR) in the first stage, Fast Breeder Reactors (FBRs) in the second stage, and thorium-based systems in the third stage. It is a sequential programme based on a closed fuel cycle where the spent fuel of one stage is reprocessed to produce fuel for the next stage, it multiplies manifold the energy potential of the fuel and greatly reduces the quantity of waste. essentially aims at optimum utilisation of the country's nuclear resources of limited uranium and abundant thorium. It is thus a single-basket solution for meeting the country's energy needs in a sustainable manner, while also securing its energy future in the long term.

The Indian nuclear power programme and Industry developed in synergy over a period of time to a complete maturity. Recognising the imperatives of the rapid expansion plans, the Indian Industry have been geared up to augment its capability and capacity.

4.2 Status of Industrial Infrastructure

When India gained independence in 1947, the scientific and industrial base in the country was limited. One of the achievements of India's nuclear power programme has been the development of technology and creation of nuclear infrastructure. Nuclear infrastructure in terms of R&D facilities, fuel cycle facilities and industrial units for production of fuel and heavy water was created within the government domain. The public/private industry was also developed, with initial hand-holding, for manufacturing critical nuclear components to exacting standards and executing large-package contracts. This was achieved in the face of international isolation and technology-denial regime. Today, India has achieved commercial maturity of the first stage and launched the second stage in the commercial domain

4.3 Evolution of Nuclear power

The first commercial nuclear power reactors in India, two Boiling Water Reactors (BWRs), were launched in 1964 at Tarapur in Maharashtra on a turnkey basis by GE, USA These reactors started commercial operation in 1969 .The aim of setting up these reactors was essentially for absorption of the technology and to gain experience in the operation of nuclear power plants. Subsequently, two units of PHWRs of first stage of the three stage programme were also launched in technical cooperation with AECL, Canada in 1966 at Rawatbhata in Rajasthan. . The foreign cooperation ended abruptly in 1974 when Canadians withdrew and an international technology-denial regime was enforced. From then on, the PHWR programme progressed on indigenous efforts and since then 15 more PHWRs of indigenous designs have been set up and commercial maturity has been reached. The programme went through phases of indigenisation, standardisation, consolidation, commercialisation, expansion and increase in unit size (economies of scale) during the period.

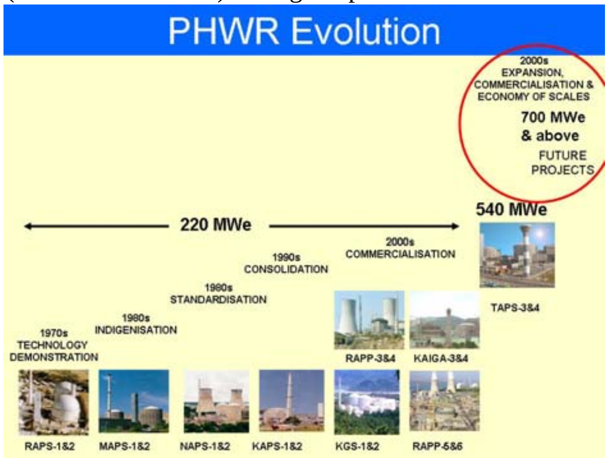


Fig. 8 PHWR Evolution in India

The other unique aspect of the Indian nuclear power programme has been that it has been based on small and medium-sized reactors. This was because of the small grid sizes of the regional grids that existed in the earlier days of the launch of the nuclear power programme. India today is the only country with a live small-reactor technology. Its PHWRs of 220-MW, 540-MW and 700-MW design are licensed and are in operation/under construction.

4.4 Performance:

The performance of Indian nuclear power reactors over 320 reactor-years of operation has been comparable to international benchmarks with high availability factors of 90% and above, excellent safety and reliability in operations. All aspects of PHWR technology has been developed and implemented successfully despite the international technology denial regime. Some of the performance indicators of Indian nuclear power stations and projects are given as under,

GenerationPerformance

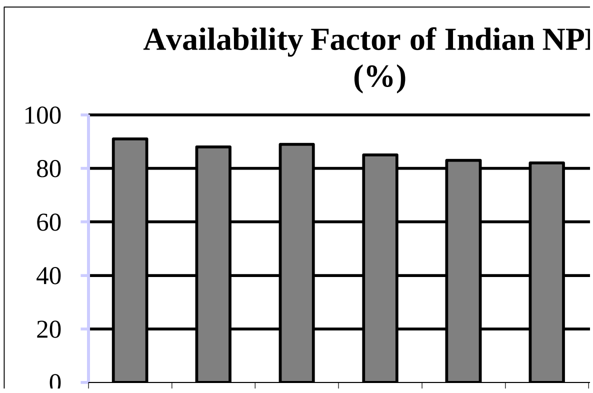


Fig. 9 Availability Factor of Indian Reactors

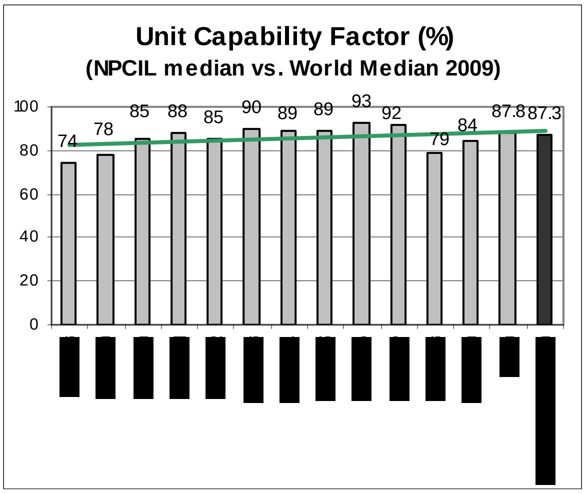


Fig. 10 Unit Capability Factor Indian Reactors vs. World Median

Safety Performance

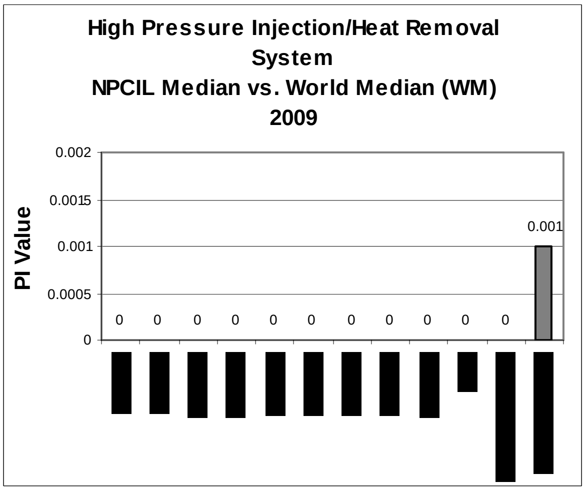


Fig 11 High Pressure Injection System

Fig 12 Emergency AC Power System

Project construction:

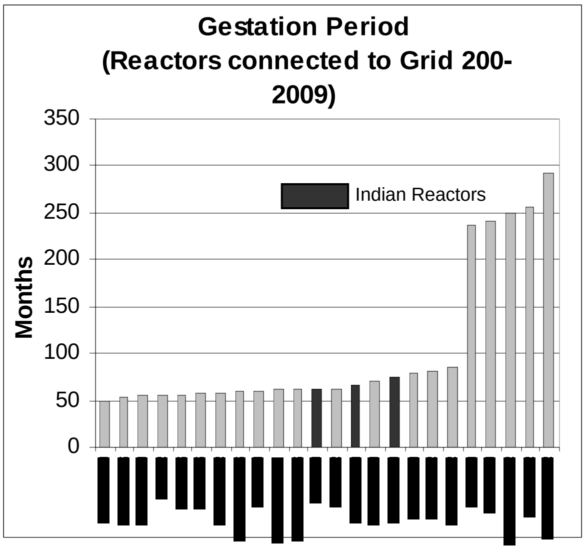


Fig. 13 Gestation Period of Reactors

4.5 Tariffs and Economics

The tariffs of nuclear power in India have been competitive to other electricity generating technologies. The current tariffs range from 20 $/MWh to 60 $/MWh. The average tariff over the last three years has been about 45 $/MWh. Nuclear power plants are capital intensive and it is the capital cost that decides the economics of nuclear power. The overnight costs of the 700-MW Indian nuclear power plants that have just been launched are estimated to be about 1300 $/kWe each (at 2009 prices), with the completion cost (by 2016) works out to about 1650 $/kWe.

4.6 Current Status

Currently, as of 2010, there are 19 nuclear power reactors in operation with a gross capacity of 4560 MW and 4 reactors with a capacity of 2720 at an advanced stage of construction. Four indigenous-design 700-MW PHWRs with a capacity of 2800 MW have been launched, two reactors of 700 MW at each of the existing sites, Kakrapar in Gujarat state and Rawatbhata in Rajasthan state respectively.

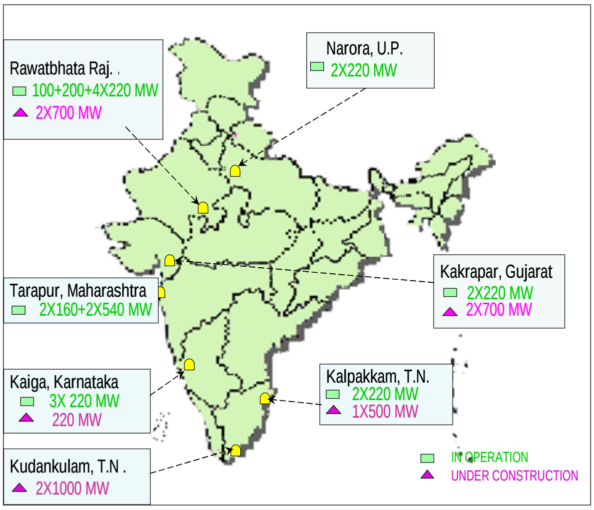


Fig 14 Current Status of Nuclear Power Plants in India

4.7 Opportunities ahead from International Cooperation

The clearance of nuclear commerce with India by the Nuclear Suppliers Group (NSG) in 2008 brought to fruition the efforts of the country to access international cooperation in nuclear energy. This enables India to import fuel and set up large-capacity Light Water Reactors based on technical cooperation, to meet the country's growing energy needs. It also enables India to export reactors, equipment and components as well as services to the global nuclear energy market.

4.7.1 Export Potential

A 220-MW single-unit design for export has been evolved. Nuclear Power Corporation of India Limited (NPCIL), the Indian industry and the units of the DAE for fuel and heavy water are fully geared for manufacturing the equipment, components and providing services for export of this reactor. This is a very safe, proven and cost-effective option for countries with small grids planning to start their nuclear power programmes.
In addition, India will also be ready soon to export SMRs of 540 MW and 700-MW sizes tailor-made to local conditions to countries needing such reactors.

4.8 Future Plans

India has ambitious nuclear power expansion plans to reach 63000 MW by the year 2032 by setting up nuclear reactors based on both indigenous technologies of PHWRs and FBRs and large size LWRs based on international cooperation. The roadmap to realize the vision of reaching 63000 MW as brought out in Integrated policy of India in next two decades has been drawn up. It envisages 40000 MW from LWRs based on international cooperation, 14000 MW indigenous PHWRs (including 7000 MW based on Recycled Uranium) and the remaining through Fast Breeder Reactors.

5.0 Meeting the challenges in Nuclear Power Expansion in Asia

The prospects for growth and expansion of nuclear power depend on several challenges being met. Few important one are:

5.1 Establishing acceptable infrastructure in countries introducing nuclear power

The implementation of an appropriate infrastructure to address all relevant issues for the introduction and rapid expansion of nuclear power is of key importance, especially for countries planning a first nuclear power plant. Infrastructure comprises the governmental, legal, regulatory, managerial, technological, human, and other resources support for the nuclear programme throughout its life cycle. It covers a wide range of issues – from physical delivery of electricity, the transport of the material and supplies to the site, the site itself, and special facilities for handling the radioactive waste material, to the legislative and regulatory framework and the necessary human and financial resources. In short, infrastructure, as used in this context, includes all activities and arrangements that are needed to set up and operate a nuclear programme.
Governmental organisations, utilities, industrial organisations and regulatory bodies in a country adopting or expanding a nuclear power programme all play a role in the establishment of a national nuclear infrastructure. Exporting governments and suppliers may also contribute, as stakeholders, in understanding the adequacy of a national infrastructure before supplying nuclear equipment and material. The development of the competence of these organisations is a key aspect that needs to be established at the beginning of the preparations for a nuclear power programme.
The buildup of all elements of a national nuclear infrastructure need to be thoroughly planned. It is, however, not essential to have the whole infrastructure established before the preparation for a nuclear power programme starts, since the infrastructure can (and ought to) be developed in a phased manner consistent with the development of the programme.

5.2 Achieving and retaining the public confidence in nuclear power

The public perception of nuclear power is focused on concerns over safety, proliferation and waste management. After the Three Mile Island and Chernobyl nuclear accidents, the public became concerned not only about the dangers of radiation to people and the environment, but also about the speed and accuracy of available information. Also, concerns about proliferation and nuclear terrorism continue to play a role in the public perception of nuclear power.

Public perception is also dependent on many factors specific to a given society, such as the local energy-supply position, national experience with nuclear power and national perceptions of environmental considerations. The changing public perception of nuclear power is partly due to the realisation of the fact that nuclear energy can make valuable contribution towards reducing global warming. Experience with successful decommissioning and waste management may also increase public confidence. Open communication with all stakeholders (decision makers, public, media, etc.) on all of the issues surrounding nuclear power (benefits, risks, commitments and obligations) is essential in order to build and maintain trust and confidence in a nuclear power programme.

5.3 Developing and retaining the necessary Human resource competencies

The availability of human resources is a critical challenge to the expansion and growth of nuclear power. It is a challenge for the nuclear industry to recruit and train a large number of qualified individuals just to replace those highly experienced individuals who are retiring. Additional human resources will be needed to support the planned expansion or implementation of new nuclear power programmes.

For those countries initiating a nuclear programme, one proven way to obtain the competence needed, for those who will operate and maintain the first plants, is through gaining experience in existing facilities using similar technologies. It is through this practical training and experience that both competencies and safety culture needed in the nuclear power industry are transferred.

With the large number of retirements coming at around the same time as that of the planned expansions, having sufficient human resources with suitable experience to carry out these tasks can be a significant challenge.

The buildup of a nuclear workforce should be thoroughly planned. However, it is not essential to have the whole workforce established before construction has started, since the years that it takes to build a plant can provide the time to train most of the non-nuclear specialist portions of this work force.

5.4 Continued efforts in achieving Safety and Reliability on the existing and future NPPs

Safety and reliability are fundamental to an effective nuclear power programme. There is a need to maintain diligence and vigilance with regard to the operation of, and also preparation for, the introduction of nuclear power plants. Any incident or accident in operating nuclear power plants, significant project delay, or reduction of standards, either in the countries operating nuclear power plants, or in those countries introducing nuclear power in the future, may have a very significant effect on the expansion of nuclear energy.

5.5 Improving Economic competitiveness

Nuclear power plants are more capital intensive than other large-scale power generation plants. In the overall cost of nuclear electricity generation, the cost of capital is offset by lower and more stable fuel costs during operation. The competitiveness of nuclear power is sensitive to construction time, cost of materials, the time in regulatory process and the effectiveness of financing schemes. These needs to be optimised by innovative approaches and reduction in gestation periods.

Nuclear power's external advantage of very low GHG emissions has, at the moment, little economic value for investors, but that could change if nuclear power were able to be included in mechanisms that place restrictions or taxes on such emissions. The economic competitiveness of nuclear power would be improved in the near term if nuclear were eligible for worldwide carbon trading schemes associated with the reduction of GHG emissions.

Efforts to reduce construction costs and times will thus be important. Consideration in expansion of nuclear power

5.6 Successful management of spent fuel and radioactive waste

The management of new or additional spent nuclear fuel and radioactive waste needs to be considered when planning for the expansion or introduction of nuclear power and a policy and strategy for its implementation and funding need to be developed.

The spent fuel and radioactive waste can be safely stored for a long time from a technical point of view. This can be helpful in a scenario, say, when a country may require a decision on a permanent waste solution before deciding to expand the use of nuclear power. The disposal of low- and intermediate-level waste (LILW) is a mature technology; nevertheless, experience shows that difficulties with public acceptance can be encountered in the construction of an LILW disposal facility.

Spent nuclear fuel is either reprocessed for reuse or regarded as waste depending on economic conditions. Reprocessing separates plutonium and uranium from the waste for recycling as MOX fuel. The remaining high-level waste (HLW) needs safe disposal. At present, only a few countries have decided against reprocessing because of economic as well as proliferation or environmental concerns relating to the separation of plutonium. In these countries, the fuel is planned to be disposed of in a geological disposal facility following approximately 30-40 years of interim storage (in once-through fuel cycle). Recently, many countries have shown interest in the closed fuel cycle for sustainability reasons (better utilisation of resources). India, since the beginning, has adopted a three-stage programme based on the closed fuel cycle concept. The Indian nuclear power programme, based on this philosophy, has demonstrated it to be robust, is well on course for several decades now and is poised to achieve the next bunch of targets as planned.

5.7 Maintaining confidence in nuclear nonproliferation and nuclear security

The civil nuclear power plants in themselves do not pose an increased proliferation risk. However, the dissemination of nuclear technology and the existence of international terrorism can raise perception of an increased risk. Growth in nuclear power would require additional safeguard activities.

Vulnerability of material in transit is one aspect that may require additional measures if the volume of reactor fuel shipments increases.

5.8 Achieving, for the long term, effective and sustainable use of resources

The estimates of global uranium resources published by the OECD/NEA and the IAEA in 2008 show identified conventional uranium resources of 5.5 million tones (MtU). This corresponds to almost 100 years of consumption at the present level. Although this figure is high compared with other mineral resources, the important challenge is to improve the utlilisation of the uranium resources, i.e., to increase energy output per tonne of uranium mined. In parallel, it can be expected that increased exploration will increase uranium resources.

Certain improvements (up to doubling the energy output) in the present generation of reactors can be achieved by reducing the fraction of uranium-235 in enrichment plant tails, re-using uranium and plutonium extracted form spent fuel, and increasing fuel burnup.

One of the measures to improve the effective use of available resources would be the introduction of fast reactors and associated fuel cycles. With multiple recycling, the energy output per tonne of uranium can be increased by as much as 60 times compared with the present generation of LWRs. Innovative reactors that use thorium fuel may also be commercially developed, thus increasing the world’s usable sources of nuclear fuel.

In addition to using uranium and thorium resources efficiently, an effective use of structural materials such as steel is also an important aim. Several design concepts of evolutionary reactors provide technical solutions that, directly or indirectly, ensure material savings for economic competitiveness.

Among the solutions are: longer design life; increasing thermal efficiency of the power conversion cycle, reduction of steel consumption, and compact plant layouts. In a longer-term perspective, the recycling of radioactive structural materials arising from decommissioned nuclear reactors may also contribute to the effective use of resources.

6.0 Cooperation in Nuclear Power

As discussed earlier, nuclear power is highly technology- and capital-intensive. Thus, initiating a nuclear power programme in a country that does not have one requires a huge effort in terms of resources and time.

Considering the need for energy and the inevitability of nuclear power, nuclear power needs to be extended to several countries in the region that do not have nuclear power at present. This requires cooperation at the global, regional and bilateral levels between countries/agencies. There is a need for larger cooperation between countries in this regard in sharing technology and providing necessary resources.

The proliferation risks associated with nuclear power make it inevitable that the cooperation has to be in accordance with the IAEA safeguards mechanism, with monitoring of all nuclear activities.

As most of the countries in the Asian region have smaller demand and smaller electricity grids (except those that already have nuclear power programmes), SMRs would be the most suitable for starting nuclear power programmes. India, as the country with live small-reactor technology and expertise in all aspects of fuel cycle, with a fully developed industry, would be in a position to address this aspiration of these countries. The added advantage of the cost of goods and services produced in India would also make it an attractive proposition.

7.0 Social Outreach of Nuclear Power

Nuclear power, apart from contributing to the GDP by adding capacity that provides the multiplier effect in the economy, has several socio-economic spin-offs. Some of them include economic growth and increase in opportunities around nuclear power plant sites, improvement in infrastructure, improvement in the environmental conditions, etc. The nuclear power utilities also take up various benefactive programmes for the community around the nuclear power plant sites as part of their corporate social responsibility.

There is however, a lesser realisation of these benefits by the community at large and particularly before the start of construction of nuclear power plant. There are also many unfounded apprehensions and misconceptions about nuclear power in the minds of the people.

There is therefore a need to have a structured and sustained public awareness campaign to provide authentic and credible information to the community at large and people in the vicinity of the plants, in particular. There is also a need to reach out to the community and help them meet their needs as a part of corporate social responsibility.

7.1 Need for Inclusion

Considering the inevitability of nuclear power expansion in the region, where there is pressure on land and other resources needed for setting up nuclear power plants, it is important to take the community along to ensure availability of these resources for setting up nuclear power plants.

While nuclear power brings about development in terms of power capacity and increases the economic activity around the nuclear power plant sites, it is important that the development also include the local people, peculiarly those directly affected – like ones who are resettled, or whose land is acquired, or those communities like tribals, etc., whose way of life is altered by the setting up of nuclear projects. Apart from ensuring that the development process is inclusive, there is a need to ensure that the communities at large also perceive it in that manner.

7.2 Ensuring Inclusion

There can be no single or easy method to ensure such inclusion; nonetheless, a broad set of initiatives could certainly be taken. These could include ensuring adequate compensation (where applicable), providing them a stake in the project, ensuring their incomes by providing assured direct/indirect employment, generating opportunities for them by providing them necessary facilities, providing them the benefits of the project (electricity) and a share in profits through the life of the plant, establishing local infrastructure for these groups/sharing the plant infrastructure with them, etc.

While the exact initiatives for inclusion would vary from project to project, the need is to ensure sensitivity of the project owners and operators to the need for inclusion and continuous innovation in this regard.

8.0 Conclusion

Given the large population, the development objectives and limited availability of resources and climatic concerns caused by emissions of green house gases from the use of fossil fuels , nuclear power is inevitable for the Asian region. India and China, the two large countries in the region, already have large nuclear expansion plans. There is a need for mutual cooperation among friendly countries of the region for further expansion of nuclear power. India, with its experience, alive small-reactor technology, and cost advantage, is in a position to take a lead in this regard.

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