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ENERGY DIGEST

Economy • Energy • Environment

Vol. I, No. 2, January, 2010

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Regulatory Process in Downstream Hydrocarbon Sector in India

A journey towards sustainability...

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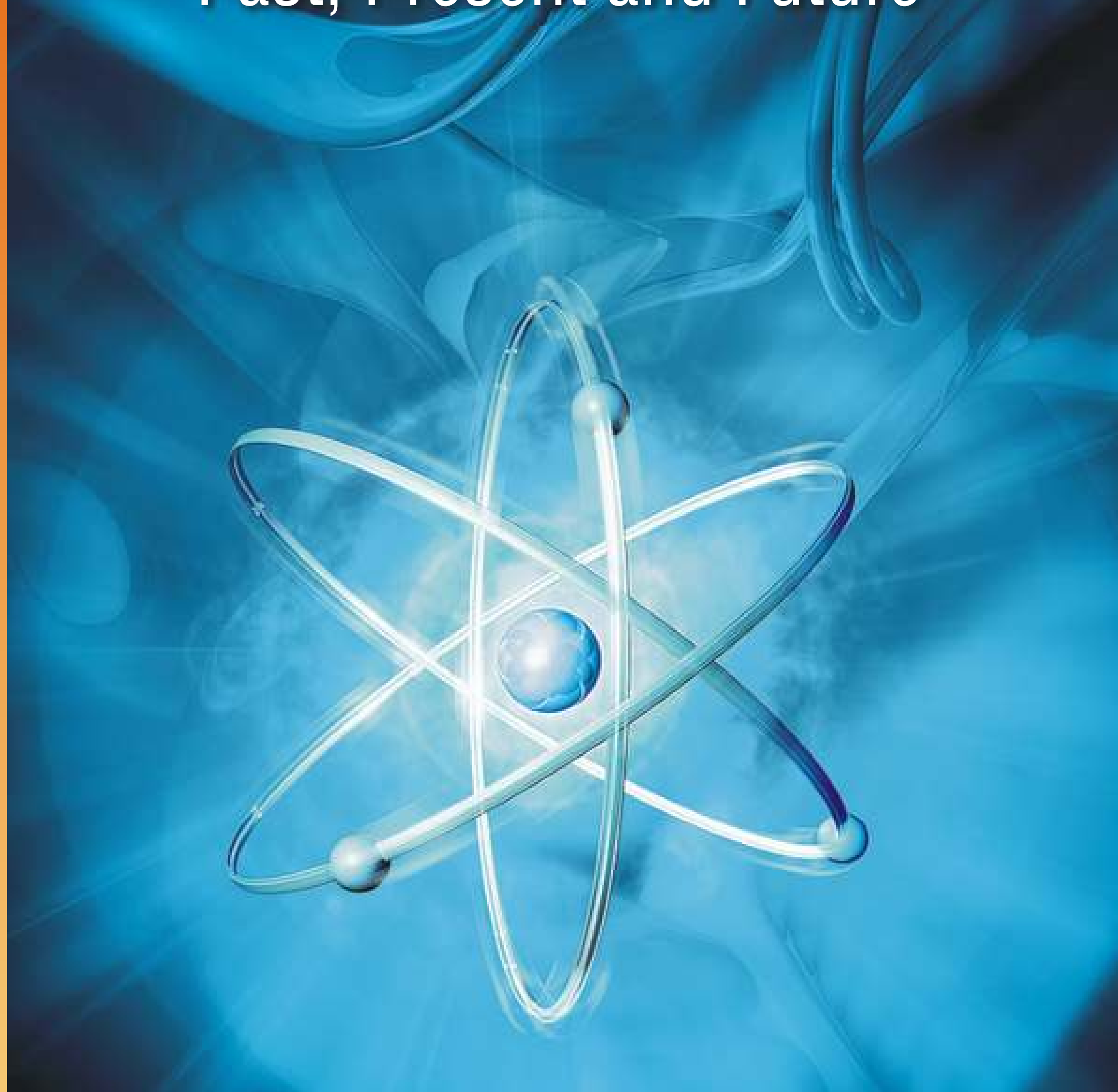
Past, Present and Future



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EDITOR :
A.M.K. Sinha
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ASSOCIATE EDITOR:
S.K. Sarangi
General Manager

ASSISTANT EDITORS:
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From the Editor's Pen

Since the last edition of the Energy Digest, a lot has happened on the Economy, Energy & Environment landscape. The prospects of the world economy have started looking up; the economic crisis has not turned out to be as severe as it was thought to be. The Indian economy, which from the beginning had exhibited resilience due to its limited exposure to the malignant financial assets, now has demonstrated even faster growth, much higher than expectation. However, fiscal imbalances in the country along with the deterioration on the agricultural front & flaring up of inflation, especially food price inflation continue to be areas of concern. After experiencing a marginal dip in September 2009, backed by improving prospects of the world economy, projections for positive demand growth and depreciation of dollar, crude oil prices have firmed up again, despite inventories being at their historic highs. The much awaited Copenhagen UN Climate Change Conference, ended recently, but agreement on the next climate change regime remains elusive still.

The renewed interest & expectations from nuclear power as a means of addressing energy security & climate change has heralded a world wide nuclear renaissance. The article 'Nuclear Power in India- Past, Present and Future' puts forth the strengths of the Indian nuclear power programme developed over the years and its future growth potential & plans in the new era where India's long international nuclear isolation has ended.

In the context of privatization of the Indian oil & gas sector, the importance of an independent regulator is well recognized. The article 'Regulatory Process in the Downstream Hydrocarbon Sector in India' traces the history of government policy intervention in the downstream oil & gas sector and discusses the role of the Petroleum & Natural Gas Regulatory Board and the challenges it faces in the present context.

The potential of hydrogen as a fuel presently remains untapped. Countries across the globe are running programmes for development of hydrogen as a fuel in transport and power generation sectors. India too is actively undertaking Research, Development & Deployment in the area. The article 'Fuelling the Future with Hydrogen' discusses the technical and policy aspects of developing hydrogen as the fuel for future and also brings forth the efforts being taken by IndianOil's R&D Centre for developing hydrogen as a transport fuel.

Sustainable development approach is gaining significant attention by businesses today. The article 'A journey towards sustainability…' discusses this approach from the perspective of intergenerational equity.

We request you to send in your feedback, suggestions and articles to enrich the future editions of the journal.

Wishing a very Happy New Year 2010.

(A.M.K Sinha)

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(Send in your contributions and suggestion to singhjessica@iocl.co.in)

Nuclear Power in India - Past, Present and Future

Sudhinder Thakur

The Indian nuclear power programme has reached a state of commercial maturity in all aspects of nuclear power, associated fuel cycle and supplying electricity at competitive prices. It is now poised for a large expansion. The fruition of international cooperation initiatives have opened up possibilities of large capacity addition through foreign cooperation. The challenges of large capacity addition - infrastructure for supply chain, human resources, investments etc. are being addressed in an integrated manner. Various business models, including partnerships with large public sector energy majors in the first instance, are being explored to realize the large capacity addition planned.

The science of nuclear fission was developed in the late nineteenth century. During the World War II, application of nuclear fission was focused largely to military applications. After the war, scientists realised the potential of the tremendous heat produced by fission for peaceful purposes like electricity generation. Thus began the work on controlled fission in USA, UK, and USSR. Commercial nuclear power production started in the late fifties and several designs have been evolved since then. Today, there are 436 nuclear power reactors with capacity of 370 GW in 30 countries generating about 15% of the world's electricity. In addition, 53 nuclear power reactors are under construction at present.

Foundations of Nuclear Power in India

Dr. Homi Jehangir Bhabha was the visionary who conceptualised the Indian Nuclear Programme and along with a handful of scientists initiated the nuclear science research in India in March 1944. Dr. Bhabha approached Sir Dorabji Tata Trust for starting nuclear research in India leading to the establishment of Tata Institute of Fundamental Research. The Atomic Energy Act was passed after India attained independence in 1947 and the Atomic Energy Commission constituted in 1948. The Department of Atomic Energy was established in 1954. India is thus one of the few countries where the origin of nuclear power is in civilian rather than military applications.

Comprehensive Research and Development facilities were established in the country covering the broad spectrum of nuclear energy and its diverse applications even before the conception of the power programme. Institutions for exploration of atomic minerals, mining, industrial facilities for fuel fabrication, manufacture of nuclear components and heavy water production, nuclear control and instrumentation were also set up. The commencement of drilling for uranium in 1951, setting up research reactors; CIRUS in 1960 & APSARA in 1956, manufacture of first uranium fuel bundle in 1968, setting up of Plutonium Plant in 1963 and establishment of the BARC Training School in 1957, almost a decade ahead of setting up the first commercial reactors is testimony of the resolve on self reliance. These and many other similar activities have significantly contributed in achieving nuclear infrastructure in the country.

The author is Executive Director (CP&CC), Nuclear Power Corporation of India Limited (sthakur@npcil.co.in)

A three-stage sequential nuclear power programme based on the indigenous nuclear resource profile of limited uranium and abundant thorium resources was unveiled in 1954 to "tap the power of the atom" for economic development.

- The first stage comprised of Pressurised Heavy Water Reactors (PHWRs) based on natural uranium,
- The second stage of Fast Breeder Reactors (FBRs) using spent fuel of the first stage and
- Thorium based systems in the third stage, involving reprocessing of spent fuel, in a closed fuel cycle.

This programme, based on self-reliance and indigenous resources, continues to be the main strategy for nuclear power development in the country even today. This programme is unique since it takes advantage of our limited Uranium resource through multiplier effect and use of abundant Thorium.

Potential Of Nuclear Power in India

The potential of nuclear resources in India is shown below:

	Amount	Electricity Potential GWe-yr
Uranium-Metal	61,000 -T	
- In PHWR		328
- Fast Breeders		42,231
Thorium Metal (In Beeders)	225,000-T	155,502

In comparison, the potential of indigenous coal is about 10,000 GWe-yr. Indian scenario in terms of nuclear resources as well as its nuclear power programme is unique. India has very limited uranium reserve which can cater to 10,000 MW installed capacity based on PHWR technology. India, however, has a huge reserve of thorium, which is not a fissile material, but fortunately a fertile material. In order to make use of thorium in nuclear reactor for power generation it has to be first converted into fissile material. Limited uranium reserve in the country and aiming at maximum utilization of uranium energy potential and to ultimately provide large capacity base utilizing thorium, India opted a unique three stage nuclear power programme based on closed nuclear fuel cycle. India is the only country which started its nuclear power programme based on closed fuel cycle. Closed fuel cycle based three stage nuclear power programme provides multiplier effect in the nuclear power plant through fuel breeding. The closed fuel cycle programme also minimizes the volume of final waste, easing the waste disposal.

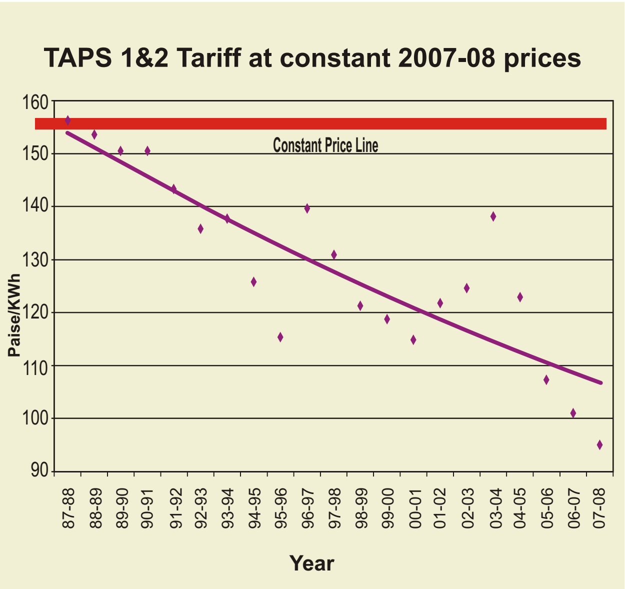
Contribution of Nuclear Power in India

The contribution of nuclear power in the country's total electricity generation has remained around 3% over the years since its introduction in the year 1969. It has thus kept pace with the overall growth of power sector. The near stagnant share has been on account of the time taken for the development of technologies involved in the three-stage programme and their linkages. India did not have the benefits of shared R&D like some of the developed countries and had to develop all the technologies on its own. The international co-operation has only been available to India on and off.

The work on first nuclear power station at Tarapur, Maharashtra (TAPS 1&2) was started in 1964 on the basis of a turnkey contract with General Electric Company of the USA. Two Boiling Water Reactors of 210 MW each were set up essentially to introduce nuclear power and demonstrate the suitability of Indian grid to accommodate then, high capacity nuclear power reactors. This venture provided experience in setting up and operation of nuclear power stations. Both reactors commenced commercial operation in October 1969 and the completion of these reactors in five years remains a record in India. The nominal rating of these reactors was subsequently revised to 160 MW due to isolation of secondary steam generators. Both reactors have completed 40 years of operation and are performing very well. These are perhaps the only reactors of its vintage in operation. These reactors have undergone periodical safety reviews and upgrades as necessary over the years.

NUCLEAR POWER IN INDIA- PAST, PRESENT AND FUTURE

TAPS-1&2 started selling electricity at 6 Paise/ kWh in 1969 and current tariff is about Rs. 1/ KWh. The tariff of TAPS-1&2 at constant prices demonstrates long term competitiveness, a characteristic of nuclear power.



In parallel to the setting up of TAPS-1&2 as a turn key contract, two PHWRs at Rawatbhata, Rajasthan (RAPS 1&2) were also set up in collaboration with Atomic Energy of Canada Limited. While most of the reactor equipment for the first unit came from Canada, those for the second unit were fabricated in India. The first unit was commissioned in the year 1971. The Canadian co-operation was discontinued in 1974 and then Indian scientists & technologists successfully completed the project with indigenous efforts. Reactors, since then have been regularly commissioned. Ten PHWRs of 220 MW and two of 540 MW have been set up, progressively with safety features that are internationally contemporary. Thus the nuclear technology has been kept alive all along and India is one of the few countries where infrastructure need not be put in place once again in the global nuclear renaissance being witnessed.

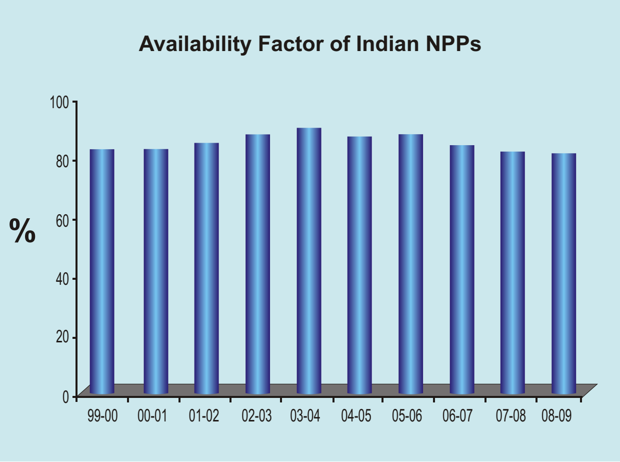
Present Status of Nuclear Power in India

There are seventeen reactors in operation at present. The table below gives the reactor location, type, capacity, and date of commercial operation:

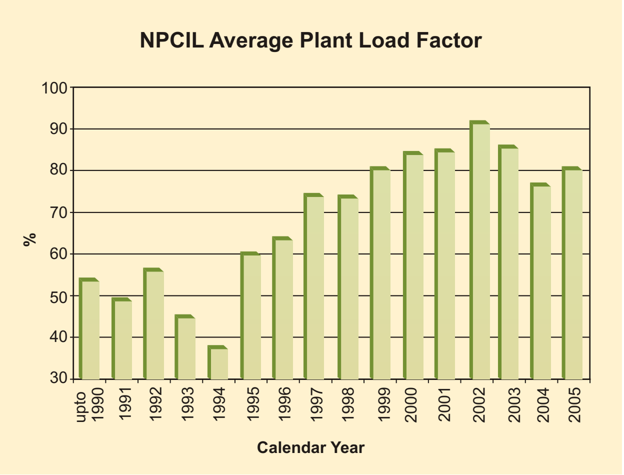
Unit-Location	Reactor Type	Present Capacity (MWe)	Date of commencing Commercial Operation
TAPS-1 Tarapur, Maharashtra	BWR	160	28-Oct-1969
TAPS-2 Tarapur, Maharashtra	BWR	160	28-Oct-1969
RAPS-1 Rawatbhata, Rajasthan	PHWR	100	16-Dec-1973
RAPS-2 Rawatbhata, Rajasthan	PHWR	200	01-Apr-1981
MAPS-1 Kalpakkam, Tamilnadu	PHWR	170	27-Jan-1984
MAPS-2 Kalpakkam, Tamilnadu	PHWR	220	21-Mar-1986
NAPS-1 Narora, Uttar Pradesh	PHWR	220	01-Jan-1991
NAPS-2 Narora, Uttar Pradesh	PHWR	220	01-Jul-1992
KAPS-1 Kakrapar, Gujarat	PHWR	220	06-May-1993
KAPS-2 Kakrapar, Gujarat	PHWR	220	01-Sep-1995
KAIGA-2, Kaiga, Karnataka	PHWR	220	16-Mar-2000
RAPS-3 Rawatbhata, Rajasthan	PHWR	220	01-Jun-2000
KAIGA-1Kaiga, Karnataka	PHWR	220	16-Nov-2000
RAPS-4 Rawatbhata, Rajasthan	PHWR	220	23-Dec-2000
TAPS-4 Tarapur, Maharashtra	PHWR	540	12-Sep-2005
TAPS-3 Tarapur, Maharashtra	PHWR	540	18-Aug-2006
KAIGA-4, Kaiga, Karnataka	PHWR	220	06-May-2007
Total		4120	

Operational Performance

The operational and safety performance of the reactors under operation has been excellent. Indian nuclear power plants are being operated at high Availability

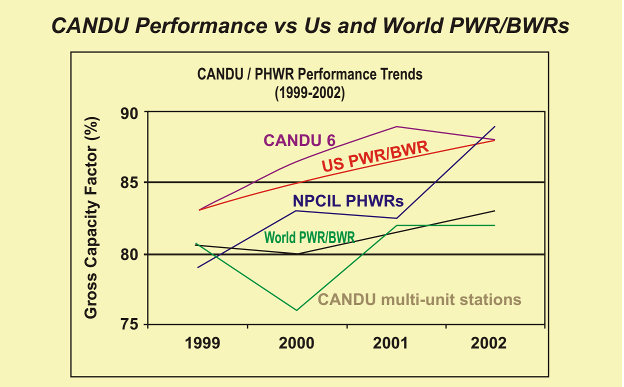


Factor of about 90% consistently for many years now. Many of the units have had continuous runs of more than a year, with Kaiga-2 having set a record on continuous run of 529 days.



The operation Plant Load Factors of 90% over time has been demonstrated. The planned outage durations have also been reduced considerably.

Indian nuclear power plants were rated among the best performing, in an analysis of the performance of reactors world wide during the period 1999-2002, published in COGNIZANT, the monthly magazine of COG.



"At the end of 2002 average annual CANDU/PHWR performance continued to show a gradual improvement, lead by the units of NPCIL (India)........"

"The NPCIL PHWRs showed a major improvement in GCF in 2002, exceeding US light water reactor performance by almost 1%............." -Brian Mac Tavish, President, COG

(Source: COGnizant, Vol.8, Feb. 2003)

Indian nuclear power plants have an excellent safety record with over 305 reactor-years of safe, accident free operation. The doses to the occupational workers and the environment have been well with in the safe limits set by the regulatory authority (Atomic Energy Regulatory Board) and international standards in this regard.

All Indian nuclear power plants are ISO 14001 compliant for Environment Management System. Environment Stewardship programmes with local partnerships have been initiated. Several neighbourhood development programmes also have been taken up.

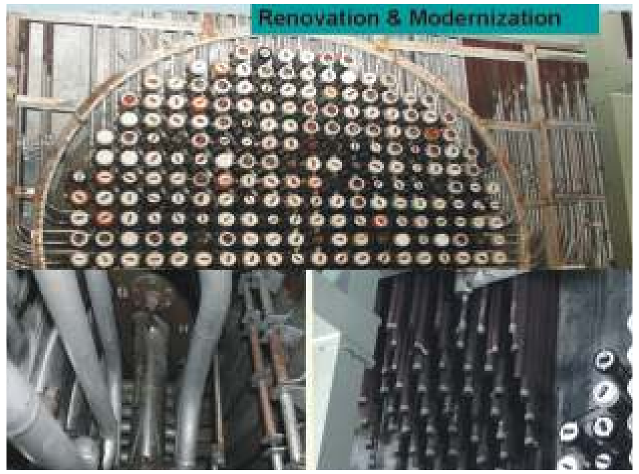
International Peer Reviews

Nuclear Power Corporation of India Limited (NPCIL), which is operating nuclear plants in India, is a member of the World Association of Nuclear Operators (WANO). CMD NPCIL is the current President of the WANO. All the Indian nuclear power stations have been peer reviewed by experts from WANO and found to be adopting the best practices internationally followed. The Performance Indicators (PI) for operating performance and safety of all reactors are published annually by WANO. The median of NPCIL is better than that of the world median for many of the PIs. The PIs of NPCIL have shown a consistently improving trend over the last many years. NPCIL station personnel have also participated in global peer review missions.

Renovation, Modernization & Life Extension

Remotely handled tools and techniques for inspection and repair in the high activity areas of the 'reactor core' have been developed indigenously. Renovation and Modernization of reactors have been carried out to make them state-of-the-art in terms of performance and safety.

En masse Coolant Channel Replacement (EMCCR) has been carried out in RAPS-2, MAPS 1&2, NAPS 1&2 and is underway in KAPS-1. En-masse Feeder Replacement (EMFR) was carried out for the first time in the world in a PHWR at MAPS-1. Subsequently, EMFR has been carried out at RAPS-2 and NAPS 1&2 and is underway at KAPS-1.



Other key 'in core' achievements include an innovative sparger in MAPS 1&2 to restore the unit to its full capacity and repair of Over Pressure Relief Device (OPED) in RAPS-1.

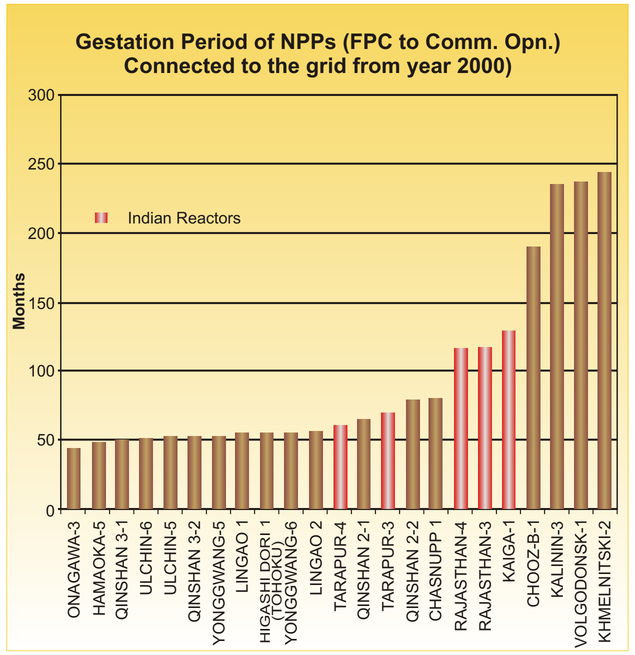
Ageing Management and Life extension of older reactors is carried out to extend their economic life and enhance safety. The health assessment of Tarapur Units 1&2 has been carried out using the latest and advanced techniques. Based on these studies and the needed upgrades, the plant life has been extended. TAPS 1&2 today are operating at a high capacity factor even after 40 years of their commercial operation.

540 MW PHWR design was evolved by scaling up the design of 220 MW reactors. Two reactors with a capacity of 540 MW have been set up at Tarapur, Maharashtra and are in operation since 2005/2006.

Construction

The gestation period of nuclear power plants have been reduced substantially. Tarapur unit-4 reactor was made critical within five years; a benchmark considering it was a first of its kind reactor. This has been possible by adoption of advanced project management practices, construction and erection technologies in significant measure by the Indian industry, which executed large supply cum erection packages to the exacting standards of nuclear industry.

Designs for 700 MW PHWRs have been developed and all future PHWRs are planned to be of this size.



Government has approved setting up four 700 MW PHWRs at Gujarat and Rajasthan in October 2009.

Construction - Second Stage of the Programme

The second stage of Fast Breeder Reactors provides the multiplier effect by breeding. Large capacity augmentation (potential of about 500,000 MW as regards fuel) can be achieved in this stage. The technology for the second stage and its fuel cycle has been developed. A 40 MWt Fast Breeder Test Reactor is in operation since 1985. The feed back from this reactor provided very useful design inputs for the 500 MW FBR, the construction of which started in October 2004. This signified launch of the second stage of the nuclear power programme. All critical components for this reactor have

been indigenously designed and manufactured. This reactor is scheduled to be operational in the year 2011.

The reactors under construction, location, capacity and expected commencement of commercial operation are shown in the table below:

Project/ Location	Capacity (MWe) & Type	Expected Commercial Operation
Kaiga Atomic Power Project Units -3&4, Kaiga, Karnataka	2X220 PHWRs	Unit-4 2010
Kudankulam Nuclear Power Project Units -1&2 Kudankulam, Tamilnadu	2X1000 LWRs	Unit-1 2010 Unit-2 2010
Rajasthan Atomic Power Project Units-5&6 Rawatbhata, Rajasthan	2X220 PHWRs	Unit-5 2009 Unit-6 2010
Prototype Fast Breeder Reactor (PFBR) Kalpakkam, Tamilnadu	1X500 FBR	2011

The development work on the third stage systems is in progress. An Advanced Heavy Water Reactor (AHWR) to demonstrate direct use of thorium has been developed. Construction of the reactor is proposed to be started in the near future.

Strengths & Opportunities of Indian Nuclear Power Programme

The strengths of Indian nuclear power programme are its technology base and trained manpower. Competencies in manufacture of critical nuclear components, complex back-end fuel cycle technologies like reprocessing, waste management, fuel fabrication and an industry that can take up large package contracts are the other strengths. The position of India in Small and Medium Reactors is unique, it is the only country operating and constructing reactors of 220/540/700 MW size. It has export potential of these reactors to countries with smaller electricity grids or countries wanting to enter nuclear power with modest investments. There is also a cost advantage, given our low costs for nuclear equipment, goods and services. India can become the center for manufacturing and export of equipment for the global nuclear renaissance.

International Cooperation Initiatives:

International cooperation in nuclear power ceased in 1974 and an international technology denial regime followed. Efforts to seek international cooperation for setting up of additionalities to the indigenous programme for faster capacity addition in the eighties resulted in an agreement being signed with the erstwhile USSR to set up two Light Water Reactors of 1000 MW at Kudankulam. These reactors are now under construction, being set up in technical cooperation with the Russian Federation.

Considering the potential of nuclear energy in meeting the country's needs, the Government of India has taken initiatives for civilian nuclear energy cooperation. The joint statement of 18th July, 2005 between the Prime Minister and the US President was the first step. It recognized India's technological prowess, wide ranging capabilities in the nuclear sector including the entire fuel cycle and a responsible non-proliferation record.

Consequent to the conclusion of the India specific safeguards agreement with International Atomic Energy Agency (IAEA) and clearance of the Nuclear Suppliers Group, several bilateral agreements between Indian and other countries (France, the USA, Russian Federation, Kazakhsthan, Korea, Mongolia, Argentina, Namibia) have been concluded. Fuel supply contracts for reactors to be put under safeguards in accordance with the separation plan were concluded with AREVA of France and TVEL of Russian Federation. Imported fuel has been used in RAPS-2 which has commenced operation after en mass feeder replacement from Sept. 1, 2009. Unit 5 of RAPS using imported fuel has also achieved its first criticality on Nov. 24, 2009 and is poised for synchronization to the grid in December 2009.

Setting up of Additionalities to the Indigenous Programme

Several MOUs have been signed with vendors like AREVA, France, General Electric Hitachi (GEH) & Westinghouse Electric Company (WEC) of the USA, KEPCO of Korea for setting up large capacity Light Water Reactors in India based on foreign cooperation. The process of engagement to arrive at commercial contracts is on.

These reactors are to be set up as additionalities to the indigenous programme. The additionalities, being independent, both in terms of technology and fuel, can be used to add capacity quickly. This can add capacity in the near term, thus enabling meeting the near term demand. In the long term, the spent fuel from the additionalities can be reprocessed and used to further enhance the capacity of FBRs.

Future Plans for Nuclear Power

The current nuclear power capacity of 4120 MW will reach 7280 MW by the completion of projects under construction progressively by 2012.

India is poised to implement a large nuclear power capacity addition plan comprising of about 7,000 MW PHWRs, 40,000 MW of LWRs based on international cooperation and about 3000 MW of Mixed Oxide (MOX) fuel based FBRs in the period upto 2032. The plan is to reach a nuclear power capacity of about 60,000 MW by 2032 as envisaged in the National Energy Policy. Beyond 2032, large capacity buildup based on new, FBRs fuelled by metallic fuel is planned. Thorium is planned to be gradually introduced when a sufficient capacity of FBRs is in operation and corresponding technologies are ready for commercial deployment.

In this regard, the financial sanction has already been accorded for KAPP 3&4 (2 X 700 MW) and RAPP 7&8 (2 X 700 MW) projects to be set up at Kakrapar in Gujarat and Rawatbhata in Rajasthan, respectively. The work on pre-project activities of these projects is nearing completion and the construction is planned to start in 2010.

The 40 GW of LWRs capacity comprising of about 10000 MW each of the four state-of-the-art Generation III+ Light Water Reactors, - VVERs of Atom Stroy Export (ASE) of the Russian Federation, EPRs of AREVA, France, ABWRs of General Electric Hitachi (GEH), USA, and AP-1000 of Westinghouse Electric Company (WEC), USA, are planned in the first instance. These reactors will be fuelled by imported fuel and will be under IAEA safeguards.

These LWRs are envisaged to be set up at coastal sites comprising large atomic parks, each of 8,000 to 10,000 MW capacity. Nuclear reactors of each technology, as mentioned above, will be set up in convoy mode of two reactors each at a site. As the work on one twin unit begins to taper off, the work on the next twin units will be started.

Key Challenges in capacity addition

The technologies for the indigenous PHWRs, MOX fuel based FBRs and LWRs and their fuel cycle are well established. The main challenges in adding such capacities are the availability of infrastructure for supply-chain and project execution, sites, fuel, human resources and investments.

Addressing the Challenges

Sites

Pro active action by the Government has resulted in coastal sites for 40,000 MW of LWR capacity and inland sites for PHWRs being identified and their 'in principle' approval.

Supply Chain

Considering the limited global manufacturing capacity for nuclear grade forgings and other materials, and the overbooking of existing facilities due to the nuclear renaissance, actions are being taken to set up such integrated facilities within the country. An

NUCLEAR POWER IN INDIA- PAST, PRESENT AND FUTURE

Integrated Forging Facility is planned to be set up by NPCIL in partnership with Indian industry. Similar actions by way of arriving at MOUs with BHEL for the conventional island of 700 MW PHWRs have been taken by NPCIL.

Human Resources

The operation additional manpower requirement of about 20000 is planned to be met by a combination of redeployment of existing experienced personnel, induction of fresh trainees and lateral induction from industry. In respect of large contractor manpower, initiatives on setting up/adoption of polytechnics/ industrial training institutes/tying up with academic institutes, with the industry for Induction and training etc. are planned to develop a large work force from the surrounding areas of the nuclear power plants.

Investments

The projects are planned to be funded by a debt: equity ratio of 70:30. The equity requirements in respect of the PHWR and LWR projects are planned to be raised from internal and extra-budgetary resources (IEBR) of NPCIL and equity by the partners. The debt in respect of PHWRs is planned to be sourced from domestic borrowings. In respect of the LWRs, the debt is planned to be sourced from the vendor country government loans, borrowings from foreign/ multilateral lending agencies, domestic borrowings, etc.

Business Models and Implementation Strategies

Various business models - NPCIL/BHAVINI-owned, joint ventures, etc. are being explored under the existing legal framework, to ensure adequate investments. As per the existing legal framework, only NPCIL and BHAVINI are authorized to set up nuclear power stations. Other companies can be minority partners in Joint Ventures with NPCIL and these JVs can also set up nuclear power plants.

The large expansion planned in such a short period of time invariably needs more players. It is in this context, NPCIL has signed MOUs with NTPC and IOCL. The partnership of NPCIL with these large public sector energy majors could lead to synergy of their strengths and development of a successful public sector partnership model for implementation of future nuclear power programme. The above would also pave the way for other players to enter nuclear power when demanded by the power programme and policy of the Government.

FUELLING THE FUTURE WITH HYDROGEN

Fuelling the Future with HYDROGEN

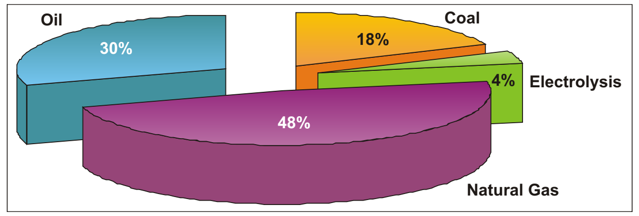
Dr. R.K. Malhotra

Presently, the potential of hydrogen as an energy carrier remains untapped. Countries across the globe are running programmes to develop technologies for using hydrogen in transport and power generation sectors. Efforts in research development and deployment are required in each stage of hydrogen value chain from production, storage, supply & distribution to application. In India, a road map has been developed and research efforts are continuing for the development of this sector.

INTRODUCTION

It has been demonstrated for over a century now that hydrogen is going to be the ultimate fuel of the future, especially when it is produced from the abundantly available renewable sources of energy like solar, wind, geothermal, hydro etc. In the context of energy systems, hydrogen is an energy carrier (a means of storing and transporting energy), similar to electricity rather than the fossil fuels that we extract from the earth's crust. Energy carriers like electricity and hydrogen are produced from primary energy sources using conversion technologies. The conversion technologies are energy intensive processes and therefore for sustainability, it is imperative to understand the energy harvesting methodologies to be utilized for producing hydrogen.

Globally, at present about 42 million metric tonne (MMT) i.e. 500 billion m3/year of hydrogen is produced annually, mainly for captive use for producing fertilizers and by petroleum refineries for processing of inferior quality crude oils and for improving fuel quality. This hydrogen is predominantly produced from feedstock like oil and natural gas (78% put together), coal (18%) while electrolysis of water using electricity from various sources share a meager percentage (4%).



Share of different feed-stocks for Hydrogen Production globally [1]

Presently, hydrogen production in India is estimated to be 3.15 million metric tonne (MMT), of which 2.32 MMT is produced by fertilizer plants, 0.47 MMT is produced by petroleum refineries and 0.36 MMT by chlor-alkali industry as by-product hydrogen. Some limited hydrogen is also produced through electrolysis. Hydrogen produced by fertilizer plants and refineries is primarily used for captive purpose. Hydrogen is also used by vegetable oil industry, chemical industry, as a cooling media of electric generators and in the household & medicine industry as hydrogen peroxide [2,3].

WORLD-WIDE PROGRAMS FOR PROMOTING HYDROGEN AS A FUEL

Ambitious plans and the action programmes have been chalked out by the developed nations as well as the emerging economies for promoting the use of hydrogen in the transport sector [4].

USA

The US-Department of Energy formulated National Hydrogen Energy Roadmap during the year 2002 outlining the key issues and challenges in hydrogen energy development and suggested suitable guidelines for the government and industry for expanding the use of hydrogen based energy. Based on this roadmap, the Government announced two initiatives "Freedom Fuel" & "Freedom CAR" for reducing America's demand of petroleum by over 11 million barrels per day by 2040.

The author is : Executive Director (R&D), Indian Oil Corporation Limited (malhotrark@iocl.co.in)

Canada

In-line with the US initiatives, the Canadian Government has launched a series of projects to demonstrate hydrogen as a fuel for both stationary and mobile applications.

- Hydrogen Highway

  Targeted for full implementation by the 2010 Olympic and Paralympic Winter Games in Vancouver/ Whistler. A wide variety of transportation, stationary, portable and micropower applications will utilize the hydrogen-fuelling infrastructure.

- Hydrogen Village

  The Hydrogen Village is the dynamic and synergistic deployment of hydrogen and fuel cell technologies driven by an end-user community in the Greater Toronto Area. As a large-scale demonstration project, it will be a 'touch and feel' platform for academic programs, skills graining, codes and standards development and for the advancement of public awareness and acceptance.

- Vancouver Fuel Cell Vehicle Program (VFCVP)

  The Vancouver Fuel Cell Vehicle Program will test and demonstrate fleet of fuel cell vehicles to gather valuable information on performance, durability, and reliability that can be applied towards the evolution of fuel cell vehicles to the commercial marketplace in the transition to a hydrogen economy.

Germany

- CUTE (Clean Urban Transport for Europe)

  A European Union project initiative to test 47 fuel cell buses each in ten cities in Europe. The aim of the project is to demonstrate the feasibility of an innovative, highly energy efficient, clean urban public transport system. This demonstration will encompass the operation of purposely designed fuel cell powered, low-noise buses in 10 European cities.

- Hydrogen and refueling infrastructure and fuel cell bus routes in Stuttgart The steam reformer is designed for small production quantities and can be operated flexibly from 40 to 100% of its nominal load. This technology and design of a compact steam reformer built on skids paves the way for a decentralized hydrogen supply concept in the future.

- Clean Energy Partnership Programme (CEPP)

  The Clean Energy Partnership Programme, a consortium comprising nine corporate partners and the Federal Government, is securing Germany's leading role in hydrogen technology. As a part of this programme, hydrogen filling stations have been commissioned in Berlin and will be fuelling different fuel cells vehicles.

France

CityCell (Paris) is a project initiated by the Govt. of France which aims to demonstrate fuel cell (FC) hybrid vehicles having 80 kW Li-ion battery system, onboard compressed hydrogen storage and electrical power train to operate in the inner-city environments of Torino, Berlin, Madrid and Paris.

China

China has embarked upon a determined National Mission for the development of hydrogen economy [5]. The phase-wise mission has 3 segments:

- R&D and Demonstration Programmes by 2020 - will focus on the research, development and demonstration both in the transport and power generation sector
- Market Entry Phase from 2020 to 2050 - will depend on the desires of the customer, environmental policies, operating costs and performance of hydrogen energy systems
- Hydrogen Economy Phase beyond 2050

The delineation of the energy policies and targets set across the world for instigating hydrogen based systems do take into consideration, the challenges associated for the synergic development & integration of the complete hydrogen process chain in a cost effective manner. Key research areas have been identified focusing on production, delivery, storage, applications and safety in most of the plans.

HYDROGEN PRODUCTION METHODS

(i) From Natural Gas

Natural gas is currently the most economical and used source for producing hydrogen in view of its availability, ease of handling and its high hydrogen to carbon ratio. Natural gas can be converted to hydrogen by number of processes including steam reforming (Steam Methane Reforming - SMR), Partial Oxidation & Autothermal Reforming [6]. Steam reforming involves the endothermic conversion of methane and water vapour into hydrogen and carbon monoxide (a). The process typically occurs at temperatures of 700 to 850 °C and pressures of 3 to 25 bar. The product gas contains approximately 12% CO, which can be converted to CO_2 and H_2 through water-gas shift reaction (b).

$CH_4 + H_2O + heat \rightarrow CO + 3H_2$ (a)

$CO + H_2O \rightarrow CO_2 + H_2 + heat$ (b)

Hydrogen can also be produced from fuels including naphtha, gasoline and ethanol via Steam Reforming Process. The process requires two additional reactors, i.e for desulphurization of liquid fuels (HDS unit) and a pre-reformer for converting the liquid fuels into natural gas.

Partial oxidation of natural gas is the process whereby hydrogen is produced through the partial combustion of methane with oxygen gas to yield carbon monoxide and hydrogen (c). In this process, heat is produced in an exothermic reaction, and hence a more compact reactor design is possible as there is no need for any external heating of the reactor. The CO produced is further converted to H_2 as described in equation (b).

$CH_4 + 1/2O_2 \rightarrow CO + 2H_2 + heat$ (c)

Autothermal reforming is a combination of both steam reforming (a) and partial oxidation reaction as described in equation (c). The total reaction is exothermic, and so it releases heat. The outlet temperature from the reactor is in the range of 950 to 1100 °C, and the gas pressure can be as high as 100 bar.

(ii) From Coal

Hydrogen can be produced from coal through a variety of gasification processes (e.g. fixed bed, fluidised bed or entrained flow). In practice, high-temperature entrained flow processes have maximum carbon to gas conversion ratio, thus avoiding the formation of significant amounts of char, tars and phenols. A typical reaction for the process is given in equation (d), in which carbon is converted to carbon monoxide and hydrogen.

$C(s) + H_2O + heat \rightarrow CO + H_2$ (d)

Since this reaction is endothermic, additional heat is required, as with methane reforming. The CO is further converted to CO_2 and H_2 through the water-gas shift reaction, described in equation (b). Hydrogen production from coal is commercially mature, but it is more complex than the production of hydrogen from natural gas. The cost of the resulting hydrogen is also higher.

(iii) Biomass Gasification

In a country like India, which has a vast availability of biomass sources, this renewable source of energy can be utilized to produce hydrogen through gasification route. The product of the reaction is a syngas which can be converted to hydrogen through water-shift gas reaction. Because the syngas is cleaned before combustion, the criteria air pollutants generated from the gasification route are far less as compared to other routes. Therefore, apart from being a renewable source, utilization of biomass can result in mitigation of carbon footprints and can earn carbon credits while creating the employment opportunities for rural India.

(iv) By Splitting of Water

Hydrogen can be produced by splitting of water through

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various processes which includes water electrolysis, photo-electrolysis, photo-biological production and high-temperature water decomposition.

(a) Electrolytic Processes

Electrolytic processes use electricity to split water into hydrogen and oxygen in a unit called an electrolyzer. Like fuel cells, electrolyzers consist of an anode and a cathode separated by an electrolyte. Electrolysis is compatible with existing fossil fuel technologies and future power generation technologies using renewable sources of energy like solar, biomass, hydro, wind, tidal, wave, geothermal, etc.

Most of the water electrolysis technologies to date have used acidic or alkaline electrolyte systems for hydrogen generation. Typical system efficiencies quoted are in the 55-75% range with most commercial systems having efficiencies below 65%. The current density is typically around 0.3-0.4 A/cm^2 and there are technical difficulties in maintaining the electrolyte balance and keeping hydrogen and oxygen separated. The electrolysis technology based on polymer electrolyte membranes (PEMs) is an all solid state system with no corrosive electrolyte or electrolyte recycling. It can produce very high purity H_2 (>99.999%) with water and electricity as the only inputs. The major R&D challenge for the future is to design and manufacture electrolyser equipment at lower costs with higher energy efficiency and larger turn-down ratios for countering the demand variations.

(b) Photolytic Processes

Photolytic processes use light energy to split water into hydrogen and oxygen. These processes are in the very early stages of research but offer long-term potential for sustainable hydrogen production with low environmental impact.

- **Photobiological Water Splitting**

In this process, hydrogen is produced from water using sunlight and specialized microorganisms including green algae and cyanobacteria. Just as plants produce oxygen during photosynthesis, these microbes consume water and produce hydrogen as a byproduct of their natural metabolic processes. **Photobiological water splitting is a long-term technology.**

Photosynthesis: $2H_2O \rightarrow 4H^+ + 4e^- + O_2$ (e)

Hydrogen Production: $4H^+ + 4e^- \rightarrow 2H_2$ (f)

Currently, the microbes split water at rates too low to be used for efficient commercial hydrogen production. Research is underway to modify the microorganisms as well as to identify other naturally occurring microbes that can produce hydrogen at higher rates. These processes require genetic engineering to achieve significant levels of H_2 production and a lot of R&D is needed to demonstrate the feasibility.

- **Photoelectrochemical Water Splitting**

In this process, hydrogen is produced from water using sunlight and photo-electrochemical materials-specialized semiconductors that absorb sunlight and use the light energy to dissociate water molecules into hydrogen and oxygen. Currently, there are materials that can split water efficiently and others that are durable, but to produce hydrogen for widespread use, a material must be developed that is both efficient and durable. A solid inorganic oxide electrode is used to absorb photons and provide oxygen and electrons. The electrons flow through the external circuit to a metal electrode and hydrogen is liberated at this electrode. Some of the inorganic oxides are $KTaO_3$, TiO_2, Fe_2O_3 etc. When successful this promises to directly provide low cost hydrogen from solar energy. The cost challenge is similar to that for electricity produced from Solar cells.

- **High Temperature Water Splitting**

High-temperature water splitting, a longer-term technology which is in an early stage of development, uses very high temperatures to drive a series of chemical reactions that produce hydrogen from water. The chemicals are reused within each cycle, creating a closed loop that consumes only water and produces hydrogen and oxygen. However, these technologies are unlikely to be commercial before 2020.

- **High-Temperature Water Splitting Using Solar Concentrators**

Dissociation of water using solar energy is an attractive option as the production of hydrogen takes place without any emission of GHG. However, there are many challenges associated with the use of solar energy. The intermittent nature of sunshine is one of them. A backup system is required for periods when sunshine is not available. Decrease in the module size and cost because of this is an issue. Another challenge is to ensure that no toxic material is discharged during the fabrication and over the complete life cycle of solar cell A solar concentrator uses mirrors and a reflective or refractive lens to capture and focus sunlight to produce temperatures up to 2,500°C.

- **High-Temperature Water Splitting Using Nuclear Energy**

Hydrogen can be produced from current nuclear reactors using electrolysis of water. More efficient hydrogen production may be attained by thermochemical splitting of water or electrolysis of high-temperature steam. Another possibility is the use of nuclear energy as the source of heat for steam methane reforming (SMR). The water-splitting approach releases no carbon dioxide. Efficient water-splitting processes and nuclear-SMR all require temperatures well above 700°C. Current water-cooled reactors produce temperatures under 350°C and cannot be used for efficient hydrogen production. Advanced reactors, such as gas-cooled reactors, can achieve the required high temperatures.

A nuclear reactor produces heat that can drive a series of chemical reactions to create hydrogen by splitting water and recycling the chemical. High temperature water splitting reaction using Sulfur-Iodine Thermochemical Cycle is one of them. Sulfuric acid, when heated to about 850°C, decomposes to water, oxygen and sulfur dioxide. The oxygen is removed, the sulfur dioxide and water are cooled, and the sulfur dioxide reacts with water and iodine to form sulfuric acid and hydrogen iodide. The sulfuric acid is separated and removed; the remaining hydrogen iodide is heated to 300°C, where it breaks down into hydrogen and iodine. The net result is hydrogen and oxygen, produced from water-the sulfuric acid and iodine are recycled and used to repeat the process [7].

HYDROGEN STORAGE TECHNIQUES

(i) Gaseous Form

The most common method to store hydrogen in gaseous form is in steel tanks, although lightweight composite tanks designed to endure higher pressures are also becoming more and more common.

Gaseous hydrogen cooled to near cryogenic temperatures, is another alternative that can be used to increase the volumetric energy density of gaseous hydrogen. A more novel method to store hydrogen gas at high pressures is to use glass microspheres. The basic concept for how glass microspheres can be used to store hydrogen gas onboard a vehicle can be described by three steps: charging, filling and discharging. First, hollow glass spheres are filled with H_2 at high pressure (350-700 bar) and high temperature (300°C) by permeation in a high-pressure vessel. Next, the microspheres are cooled down to room temperature and transferred to the low-pressure vehicle tank. Finally, the microspheres are heated to 200-300 °C for controlled release of H_2 to run the vehicle [8].

(ii) Liquid Form

(a) Liquid Hydrogen - Cryogenic hydrogen, usually simply referred to as liquid hydrogen (LH_2), has a density of 70.8 kg/m^3 at normal boiling point (-253 °C). (Critical pressure is 13 bar and critical temperature is -240 °C.) The theoretical gravimetric density of LH_2 is 100%, but only 20 wt. % H_2 of this can be achieved in practical hydrogen systems today.

On a volumetric basis, the respective values for liquid and gaseous storage systems are 80 kg/m^3 and 30 kg/m^3. This means that liquid hydrogen has a much better energy density than the pressurized gas solutions mentioned above. However, it is important to recall that about 30-40% of the energy is lost when LH_2 is produced. The other main disadvantage with LH_2 is the boil-off loss during dormancy, plus the fact that super-insulated cryogenic containers are needed [9].

(b) Liquid Solutions - Borohydride ($NaBH_4$) solutions can be used as a liquid storage medium for hydrogen. The catalytic hydrolysis reaction is:

$NaBH_4$ (l) + $2H_2O$ (l) ' $4H_2$ (g) + $NaBO_2$ (s) (ideal reaction) Eqn. g

The theoretical maximum hydrogen energy storage density for this reaction is 10.9 wt.% H_2, the ideal reaction being $4H_2/(NaBH_4 + 2H_2O)$.

The main advantage with using $NaBH_4$ solutions is that it allows for safe and controllable onboard generation of H_2. The main disadvantage is that the reaction product $NaBO_2$ must be regenerated back to $NaBH_4$ off-board.

(iii) Solid Form

Hydrogen can be stored at high densities as reversible metal hydrides or adsorbed on carbon structures. When the hydrogen is needed, it can be released from these materials under certain temperature and pressure conditions. Complex-based reversible hydrides such as alanates have recently demonstrated improved weight performance over metal hydrides along with modest temperatures for hydrogen recovery. The most promising carbon materials for hydrogen storage at this time appear to be carbon nanotubes.

Chemical hydrides are emerging as another alternative to direct hydrogen storage. The chemical hydrides considered for storage applications are a class of compounds that can be stored in solution as an alkaline liquid.

Since the hydrogen is chemically bound in the compound and released by a catalyzed process, chemical hydrides present an inherently safer option than the storage of volatile and flammable fuel, be it hydrogen, gasoline, methanol, etc. The challenges associated with chemical hydrides include lowering the cost of the chemical hydride process, increasing overall "well to wheels" energy efficiency, and development of infrastructure to support the production, delivery, and recycling of the chemical hydrides for transportation and other uses.

HYDROGEN TRANSPORTATION / DELIVERY TECHNIQUES

A key element of the overall hydrogen energy infrastructure is the delivery system that transports hydrogen from its point of production to an end-use device. Delivery system requirements necessarily vary with the production method and end-use application. At present, hydrogen is produced in limited number of plants/refineries and is used for making chemicals or upgrading fuels. Across the world, it is currently transported by pipeline or by road via cylinders, tube trailers, and cryogenic tankers. Current delivery systems will need to expand significantly to deliver hydrogen to all regions of the country in a safe and affordable manner. Distributed hydrogen production is likely to play a significant role, but alternative delivery systems tailored to consumer applications (such as the transport of hydrogen in safe, solid metal alloy hydrides, carbon nanomaterials, and other chemical forms) need to be developed to transport hydrogen to end-use sites on need basis [6]

Pipelines are an effective way of transporting fuels but in case of hydrogen, the size of the pipeline and the operating pressure play a significant role because the cost economics directly depends upon these parameters. Also, overcoming the challenges of

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hydrogen embrittlement in the pipelines requires breakthroughs in the metallurgical science. De-centralized hydrogen production and transportation seems to be a cost effective solution incase limited area has to be covered. The choice of the transportation system will really be governed by the market penetration and demand of hydrogen as a fuel.

Improvements are also needed in areas such as hydrogen detectors; odorization; materials selection of seals, and valves; and transportation containers for hydrogen. Technology validation has to address research and development needs for fueling components such as high pressure, breakaway hoses; hydrogen sensors; compressors; on-site hydrogen generation systems. Researchers need to test the feasibility of delivery methods from centralized and distributed hydrogen production plants as well as compressors, storage systems, and other components integrated into complete delivery systems.

INDIAN SCENARIO

Recognizing the importance of hydrogen as an energy carrier for the future, the Ministry of New and Renewable Energy, as the nodal Ministry for this sector, has formulated a Research, Development and Demonstration Programme on Hydrogen Energy and Fuel Cell Technologies to lead India to the year 2020.

In order to accelerate research and technology development in this sector, the Ministry set up **National Hydrogen Energy Board** (NHEB) in October, 2003, under the Chairmanship of Minister for New and Renewable Energy with representation from concerned Ministries/Departments, industry and industry associations, eminent experts and public figures. A **National Hydrogen Energy Road Map** (NHERM) was prepared by a Steering Group set up by the NHEB and was approved in the year 2006.

The National Hydrogen Energy Road Map identified research, development and demonstration efforts to be undertaken in the country for bridging the technological gaps in different areas of hydrogen energy, including production, storage, transportation and delivery, applications, safety, codes and standards and capacity building for the period up to 2020. The Road Map emphasizes on development of the total hydrogen energy system, which includes all the above components of hydrogen energy sector. Keeping in view the present status of development of hydrogen energy, the National Hydrogen Energy Road Map has recommended two major initiatives for promoting the use of hydrogen as a fuel for Green Transportation (Green Initiative for Future Transportation-GIFT) and Green Power Generation (Green Initiative for Power Generation-GIP) [3].

The Road Map envisages that there would be about one million hydrogen fuelled vehicles and aggregate power generating capacity of 1000 MW based on hydrogen in the country by 2020. For these applications, hydrogen production facilities with a total capacity of 1.1 MMT/year will have to be set up in the country, involving huge investment. The Road Map projected a total investment of Rs. 24,000 crores for creating infrastructure for production, transportation and supply of hydrogen. The transport sector is expected to create the main demand for hydrogen, though hydrogen based stationary power generation using fuel cells and internal combustion engines would also be another potential application that would require hydrogen.

In the Indian context, a schematic showing processes for production of hydrogen for meeting its requirement for immediate supplies, medium and long-term supplies using different primary energy sources for transport sector, power generation and also for process industries like fertilizers and petroleum refining is shown in following figure. Besides, hydrogen produced from SMR, by-product hydrogen available from chlor-alkali industry could be used for meeting requirement of hydrogen for vehicles.

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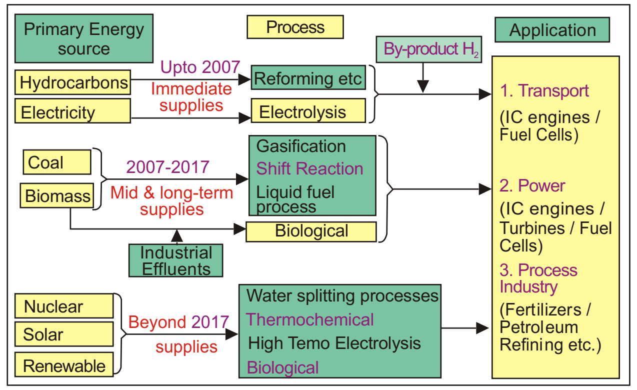

Hydrogen Production Routes [3]

HYDROGEN VEHICLES IN INDIA

R&D for development of hydrogen fuelled vehicles is of relatively recent origin in India. Banaras Hindu University (BHU), Varanasi has modified petrol driven motorcycle to operate with hydrogen as fuel, which is stored in solid state metal hydride powder. IITs are continuing their research in developing the I.C engines based on hydrogen and also in using hydrogen for stationary applications. Several Automobile manufacturers exhibited their hydrogen fuelled three wheelers in the recently concluded World Hydrogen Technologies Convention - 2009.

Indian Oil's Research & Development centre after being nominated as the nodal agency in the petroleum sector to undertake research in the area of hydrogen as a transport fuel has taken several initiatives, to tap the immense opportunities which hydrogen offers. With the fuel cell technology still in the lap, it was decided to initiate research program on use of hydrogen along with CNG in I.C. engine powered vehicles. Considering the existing Natural Gas infrastructure in India, this route of using hydrogen blended with CNG seemed feasible and attractive in the short-term, due to the associated advantages in terms of investment required, technology available and use of the existing experience with CNG applications in automotive vehicles

The very first hydrogen & HCNG dispensing station in India was set up at IndianOil R&D Centre, Faridabad in the year 2005. The station is capable of dispensing H2-CNG blends varying from 5 to 50% H2 in CNG at 250 bar pressure.

India's 1st HCNG Dispensing Station

Further, Indian Oil joined hands with Society of Indian Automobile Manufacturers (SIAM) to develop, test and demonstrate range of vehicles running on hydrogen-CNG blends.

Experimental studies with hydrogen/CNG-blended fuel in the existing CNG vehicles, vehicles of different makes and sizes e.g. 3-wheelers, mini buses, passenger car with different H2-CNG blends have revealed that 18% HCNG blend appears to be a optimum as far as emission benefits and vehicle power are concerned. The further plan is to optimize the engines for 18% HCNG blend before carrying out extensive field trials on road.

To extend the supply of hydrogen blended fuel, Indian Oil in support from Ministry of New & Renewable Energy (MNRE) has set-up India's 1st commercial Hydrogen-CNG dispensing station at Dwarka, Delhi.

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Test vehicles running on HCNG fuel

ISSUES

National Hydrogen Energy Roadmap envisaged the targets for both transport sector as well as power sector but did not delineate from where will this hydrogen come from and at what cost? Production of hydrogen through electrolysis is always going to be a costlier affair as it uses electricity which is another form of energy carrier. Hydrocarbons will never be the strong contenders for producing hydrogen on economic basis as it will only make the transport fuels more expensive and we will have continued dependence on fossil fuel

Hydrogen & HCNG dispensing station at Dwarka, Delhi

sources. However, the driving force for producing hydrogen from such sources and still using for transportation purposes would be the local pollution which can reduce by mixing hydrogen in CNG or running vehicles on neat hydrogen. Further, the future developments in fuel cells, which will be much more energy efficient and environmentally benign need to be watched as they may bring in hydrogen transition sooner than expected. Simultaneously future developments with regard to production of hydrogen from renewable sources need to be aggressively researched as then only we will have full freedom from fossil fuels and also carbon free environment. We cannot rest thinking that hydrogen economy is far-off as the environmental issues will haunt us even more vigorously in time to come and push us to carbon free fuels.

There are no safety codes and standards available for hydrogen fuel. However, upto 20% hydrogen blended in CNG has been declared as a CNG equivalent fuel and existing cylinders can be used for filling upto 20% HCNG, but to fulfill the set targets it is imperative to define transportation, handling, dispensing and general safety guidelines for hydrogen at the earliest.

An energy company like IndianOil has to not only prepare for the challenges which such transition would bring in but work aggressively and research all aspects of hydrogen e.g. production, storage, supply & distribution and application of hydrogen ahead of others.

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Regulatory Process in Downstream Hydrocarbon Sector in India

R.K. Samtani & S.K. Sarangi

Government interventions assume an important role in the development of oil & gas sector, in view of the economics of this sector and its criticality as a key energy services provider. The sector was nationalized by the mid 1970s and this was followed by the establishment of the Administered Pricing Mechanism (APM). With the change in the economic environment in the 1990s and beginning of economic reform process in the country, the sector was gradually opened and phased programme for APM dismantling was announced. In this changed scenario, the role of the Government as a regulator has assumed importance. In view of this, the Petroleum & Natural Gas Regulatory Board was established in 2007 to protect the interests of consumers, create a level playing field, promote competitiveness, efficiency, and maintain quality of services and safety.

Historical back ground

At the time of independence the consumption of petroleum products was 2.72 million tonnes per annum against the refining capacity of 0.25 million tonnes per annum and the import dependence was about 91%. In the early 1950s pricing was based on a system of Valued Stock Account (VSA). Under this system, the basic selling prices of major petroleum products were determined as the sum of f.o.b. Ras Tanura price, ocean eight , insurance, ocean loss, import duty, interest and other charges as well as 10 % remuneration. However, the government decided to abandon this system of pricing as it was based on assumed costs rather than actual costs. Consequently, Oil Price Enquiry Committee(OPEC) was set up in 1960, under the chairmanship of Mr. K R Damle. The committee recommended that ceiling selling prices for bulk refined products should follow the import parity principle. By the 1970s it was felt that the refining capacity of the country was adequate to meet the needs thus the dependence on imports of petroleum products was less. It was also felt that the west Asian product prices, which were the basis for determining the import parity prices, did not necessarily reflect the cost pattern and operations of Indian refiners.

Till the mid - 1970s, the Indian Petroleum Industry was operating as a free market with many of the multinational oil companies like Shell, Caltex, Esso, etc, having a significant presence. Nationalization of the oil industry resulted in the private players being bought out by the government. Since then, 'public sector undertakings' (PSUs) have played a dominant role in this sector. In all PSUs, the government of India holds 51 percent or more of the paid up share capital.

The Administered pricing Mechanism, (APM) was introduced in 1977 and was later modified by the Oil Cost Review Committee (OCRC) in 1984. The Oil Co-ordination Committee (OCC) was set up in 1975 to manage oil pool Accounts and to co-ordinate supply & other matters of oil sector and act as central planning agency for the Government.

The author are : R.K. Samtani, DGM (on deputation to PNGRB) (samtani_ramesh@yahoo.com)
: S.K. Sarangi, General Manager (CP&ES), CO, IOCL (sarangisk@iocl.co.in)

The APM essentially constituted a cost - plus pricing regime wherein costs were reimbursed as per standards laid out with respect to throughputs, yield patterns, fuel and loss, operating cost, capital employed, etc. Companies were allowed a 12% post - tax return on their net - worth and reimbursed their borrowing costs. The APM was aimed at ensuring continuous availability of petroleum products to consumers at fairly stable process and crude to refiners, while ensuring the socio - economic objectives of the Government.

The need for deregulation

In the 1990s, various factors contributed significantly in initiating and carrying forward the process of reforms:

- Demand for oil and gas was expected to grow at the rate of 6-7 % per annum. This demand could be met either by increasing domestic production or through imports. Domestic production could be increased if substantial domestic and foreign investments were made in this sector, hence requiring an investor - friendly environment. " There had been serious unintended effects of the APM. Oil pricing had been divorced from underlying economic realities. The prices of sensitive products were not reflective of the economic cost of these products. Subsidies and cross - subsidies resulted in a wide distortion of consumer prices and led to a wasteful use of energy. The APM provided little incentive for improving productivity or efficiency as returns were guaranteed on the capital employed. Competition was stifled with marketing companies acting as mere distribution companies.
- Over the decades of the 1980's and 1990's, import of petroleum products soared ten - fold from over 2.2 million tonnes in 1975 to nearly 18 million tonnes in 1995. Given the high levels of import in the Indian economy, the APM, which insulated the country from global markets, had lost its utility. Further, it was estimated that during the Ninth Plan Period, an investment of about Rs. 1,24,000 crores would be required to create the necessary infrastructure to meet the demand of petroleum products in the country. It was recognized that such a scale of investment was not possible by the Government or the public sector oil companies. Participation of private capital from both domestic and international sources was considered imperative. The APM, divorced from economic realities, was not attractive to private investors.
- The oil pool deficits increased to about Rs 18200 crore in 1997.

Initiatives by the Government in the Reform Period

In 1995, the Ministry of Petroleum and Natural Gas (MoPN&G) set up the Oil Industry Restructuring Group ('R' Group) to come up with a time bound program for reforms in the petroleum sector. The phasing of reforms as envisaged by the R Group was as follows:-

- Phase I (1996 - 98): rationalization of retention margin; deregulation of natural gas pricing; decimalization of furnace oil and bitumen; partial deregulation of the marketing sector with freedom to appoint dealers and distributors; removal of the subsidy on HSD and reduction of the subsidy on kerosene, LPG and input for fertilizers.
- Phase II (1998 - 2000) : pricing of indigenous crude on the basis of average FOB price of imported crudes; rationalization of royalty and cess; further deregulation of the marketing sector; further reduction of subsidy on kerosene, LPG and input for fertilizers.
- Phase III (2000 - 02) : decimalization of ATF, HSD, MS.

As a follow up, to the 'R' group recommendations, the Government had appointed an Expert Technical Group (ETG), an inter - ministerial committee, which was required to examine various scenarios reflecting the impact of different levels of duty structures on various sectors.

The ETG recommended a time - bound programme of reforms to move towards a market driven pricing mechanism for petroleum products in the country. Following the ETG's recommendations, the Government(Ministry of Petroleum & Natural Gas, Resolution dated 21st November, 1997) decided on several initiatives as summarized below :-

1. The cost plus formula for pricing of indigenous crude was withdrawn by linking the price receivable by oil producers to a phased import parity scheme.

2. Retention pricing system for refineries was abolished and refinery gate prices were linked to import parity except for controlled products, namely, Motor Sprit (MS), High Speed Diesel (HSD), LPG and Aviation Turbine Fuel (ATF). Refinery gate prices for controlled products were fixed on an adjusted parity basis.

3. Ex - storage point prices of HSD were fixed at import parity with immediate effect, while consumer prices of other controlled products were linked to a phased import parity. Prices of other petroleum products were decontrolled.

4. Imports and exports of all petroleum products except crude, natural gas liquids (NGL), ATF, MS and HSD were decanalised. Sourcing and imports of crude by private and joint sector refineries was allowed.

5. Phased rationalization of duties on crude and petroleum products was announced.

6. Conditional marketing rights for transportation fuels, namely MS, HSD and ATF subject to investments of Rs. 2000 crores in refining or infrastructure in oil and gas sector or a minimum crude production of 3 million tonnes per annum were announced.

7. Establishment of a regulatory framework to oversee the functioning of and enforcing a competitive frame work in the hydrocarbons sector was suggested.

Besides this, initiatives for opening the sector to private players on selective basis were started in mid 1980s. Private participation in the refining sector in the form of joint ventures with public sector was announced in 1986. Subsequently, MRPL was set up in 1987.

The marketing of lubricant - based stocks was allowed in 1992. The government had allowed parallel marketing of LPG (liquefied petroleum gas) and SKO (superior kerosene oil) in 1993, under which the import of these products were decanalised and private parties were allowed to import and market them at market determined prices.

In addition, the refining sector was delicensed in 1998. Further, while naphtha exports were decanalised with effect from June 1998, Furnace Oil (FO) imports were decanalised under the provisions of the Export - Import policy in July 1998. Freight under - recoveries on HSD to the extent of 20% were passed on in the selling prices in January 1999.

In 2000, refining sector was opened up for foreign investment with the government allowing FDI at 100% equity in refining sector. Since then, the sector has been further opened up and FDI is also permitted in pipelines and marketing and E&P segments.

The government planned to move from administered Pricing Mechanism (APM) to Market Determined Pricing Mechanism (MDPM). With the declared objective of moving towards market determined prices for petroleum products, Government announced the dismantling of the Administered Pricing Mechanism (APM) effective from 1.4.2002. However, it was decided to continue to subsidize PDS kerosene and domestic LPG on the ground that these were fuels of mass consumption largely consumed by "economically weaker sections of society". The subsidy on these two products was to be continued on a flat rate basis financed from the budget and was to be phased out in three to five years. The Oil Marketing Companies (OMCs) were to adjust the retail selling prices of these products in line with international prices during this period, however, this part was not

implemented. In compliance with Government directions, the OMCs did not make the necessary adjustment in prices of PDS kerosene and domestic LPG with international prices commensurately, resulting in losses on account of these two products. In October 2003, Government decided that the OMCs would make good about a third of the losses on these two products from the surpluses generated by them on petrol and diesel while the balance losses would be shared equally by the upstream companies (ONGC/OIL/GAIL) and the OMCs.

This *burden sharing arrangement* began to collapse in the face of unprecedented, sharp and spiraling increase in international oil prices, particularly since late 2003, combined with sharp week-to-week and even day-to-day volatility. The impact of this global price trend on the domestic situation has been two fold. First, the burden of subsidy on PDS kerosene and domestic LPG ballooned to unprecedented levels. Second, Government took back control of price setting for petrol and diesel, and restrained the 'pass-through' of the international prices to domestic consumers.

The Government on 26th October 2005 set up a committee under the Chairmanship of Dr. C. Rangarajan, (Chairman, PM's Economic Advisory Council) to look into the various aspects of pricing and taxation of petroleum products with a view to stabilizing/ rationalizing their prices, keeping in view the financial position of the oil companies, conserving petroleum products, and establishing a transparent mechanism for autonomous adjustment of prices by the oil companies.

Need for a Regulatory Authority

An independent and accountable regulatory framework is a specific response to the general mantra of promoting economic growth. Given the fact that most of the infrastructure services are inherently non-competitive, establishing a transparent and coherent regulatory regime can attract necessary investments to meet the demand supply gap and unlock the economic growth potential. An independent regulator is needed to enhance transparency and protect the interests of consumers apart from achieving other important objectives such as promoting competitiveness and efficiency, maintaining quality of services, safety and so on.

Overall, the need for an empowered, independent regulator is to ensure:

- a level playing field for public and private sectors players;
- a clear framework of operating rules and regulations, as ambiguity hampers investment;
- economic efficiencies and customer service;
- smooth and fair transition of competition;
- enforcement of an affiliate code;
- non-discriminatory open access.

A Much Awaited Regulatory Regime

The Petroleum Regulatory Board Bill was first introduced in the Lok Sabha on May 06, 2002, and was then referred to a Group of Ministers, which, in turn, referred it to the Parliamentary Standing Committee on Petroleum and Chemicals for examination on May 17, 2002.The report of the Committee was presented to the Lok Sabha on May 08, 2003, that suggested nearly 26 amendments. After incorporating those amendments, the Bill was then renamed as the PNGRB Bill, 2003. However, the Bill lapsed on account of the dissolution of the 13th Lok Sabha, in terms of Article 107(5) of the Constitution. The Petroleum Ministry reintroduced the Bill in the Rajya Sabha on December 21, 2005. This bill was tabled in Lok Sabha on 21st March 2006 and got the consent of President of India on 31st March 2006. It became an Act on 2nd April 2006(19 of 2006). The Act was notified by the Government on 1st October 2007.

The India Hydrocarbon Vision 2025 suggested opening up the hydrocarbon market so that there is free and fair competition, between public sector enterprises, private companies and other international players. In addition,

REGULATORY PROCESS IN DOWNSTREAM HYDROCARBON SECTOR IN INDIA

it was suggested to restructure the oil sector PSUs with the objective of enhancing shareholder value and disinvest in a phased manner. The vision also emphasized on the need for developing regulatory and legislative framework and setting up independent regulators for both the upstream & downstream sectors.

The Minister for Petroleum and Natural Gas introduced in the 13th Lok Sabha, "The Petroleum Regulatory Board Bill, 2002" on 6th May, 2002. On the 17th May, 2002, the Bill was referred to the Parliamentary Standing Committee on Petroleum and Chemicals for examination and report. The Committee presented its report to the Lok Sabha about a year later, on the 8th May, 2003, recommending that the Bill be passed, subject to their recommendations and observations. The official amendments, as proposed by the Committee, were introduced in the 14th session of the 13th Lok Sabha in December, 2003. However, the Bill could not be taken up for consideration by the 13th Lok Sabha, and it lapsed.

The Parliamentary Standing Committee made 49 recommendations. The Government accepted 47 of the 49 recommendations by making appropriate modifications in the Bill in respect of 26 recommendations and incorporating 21 recommendations in the rules/regulations which would be framed by the Government and Regulatory Board. With respect to the remaining two recommendations relating to declaring storage facilities, hydrant systems at airports, etc., as common carriers, the Bill introduced in the House on 21st December, 2005 sought to empower the Board to register entities which propose to establish storage facilities for petroleum, petroleum products and natural gas beyond a certain capacity. The Ministry generally agreed with the recommendations of the entire Committee.

After a very arduous journey spanning over eight years, the Petroleum and Natural Gas Regulatory Board Bill was passed by both the Houses and received Presidential assent and thereafter became an Act on April 3, 2006. The Board was established by the Government on 1st October 2007. This opened a new phase of reform and development for the Indian oil and gas industry.

Establishment of PNGRB

Primarily, the Petroleum & Natural Gas Regulatory Board (PNGRB) was established to foster competition among entities and to lay down, by regulations, technical standards and specifications, including safety standards, in activities relating to petroleum, petroleum products and natural gas, including construction and operation of pipeline and infrastructure projects related to downstream petroleum and natural gas sector.

Apart from the power to register entities, the Board would authorise the entities to lay, build, operate or expand a common carrier or contract carrier or city or local natural gas distribution network. It is also entrusted with the power to declare pipelines as common carriers or contract carriers and further regulate access to such common carriers or contract carriers or city or natural gas distribution networks. With respect to the prices of notified petroleum, petroleum products and natural gas, the Board will not only monitor the prices and take corrective measures to prevent restrictive trade practice by entities but will also ensure correct display of information about the maximum retail prices fixed by entities of such petroleum, petroleum products and natural gas, as may be notified by the Central Government. Besides, PNGRB will secure equitable distribution of petroleum and petroleum products, lay down and enforce retail service obligations for retail outlets and marketing service obligations for entities.

Functions of the Board

The Board shall-

(a) protect the interest of consumers by fostering fair trade and competition amongst the entities;

(b) register entities to-

(i) market notified petroleum and petroleum products and, subject to the contractual obligations of the Central Government, natural gas;

(ii) establish and operate liquefied natural gas terminals;

(iii) establish storage facilities for petroleum, petroleum products or natural gas exceeding such capacity as may be specified by regulations;

(c) authorise entities to-

(i) lay, build, operate or expand a common carrier or contract carrier;

(ii) lay, build, operate or expand city or local natural gas distribution network;

(d) declare pipelines as common carrier or contract carrier;

(e) regulate, by regulations;

(i) access to common carrier or contract carrier so as to ensure fair trade and competition amongst entities and for that purpose specify pipeline access code;

(ii) transportation rates for common carrier or contract carrier;

(iii) access to city or local natural gas distribution network so as to ensure fair trade and competition amongst entities as per pipeline access code;

(f) in respect of notified petroleum, petroleum products and natural gas-

(i) ensure adequate availability;

(ii) ensure display of information about the maximum retail prices fixed by the entity for consumers at retail outlets;

(iii) monitor prices and take corrective measures to prevent restrictive trade practice by the entities;

(iv) secure equitable distribution for petroleum and petroleum products;

(v) provide, by regulations, and enforce, retail service obligations for retail outlets and marketing service obligations for entities;

(vi) monitor transportation rates and take corrective action to prevent restrictive trade practice by the entities;

(g) levy fees and other charges as determined by regulations;

(h) maintain a data bank of information on activities relating to petroleum, petroleum products and natural gas;

(i) lay down, by regulations, the technical standards and specifications including safety standards in activities relating to petroleum, petroleum products and natural gas, including the construction and operation of pipeline and infrastructure projects related to downstream petroleum and natural gas sector;

(j) perform such other functions as may be entrusted to it by the Central Government to carry out the provisions of this Act.

The regulator has an uphill task ahead. Huge investment is required for development of downstream sectors of oil and gas, especially in the latter. Gas market is still evolving and significant gas infrastructure needs to be developed.

The regulatory board has notified the access code for natural gas pipelines which also addresses the issue of inter connectivity of pipelines. Similarly, the 'affiliate code of conduct' for entities engaged in both marketing and transportation of natural gas has also been notified.

The PNGRB has so far issued 21 regulations mainly pertaining to the natural gas pipelines and city or local natural gas distribution networks through the consultative process. The notified regulations mainly include authorizing entities to lay build, operate, or expand natural gas pipelines or city or local natural gas distribution networks, determination of tariff for natural gas pipelines or city or local natural gas distribution network, technical standards and specifications including safety standards for natural gas pipelines or city or local natural gas distribution networks. The notified regulations are available on the website of Petroleum & Natural Gas Regulatory Board, www.pngrb.gov.in. Many more regulations are under various stages of finalization.

A journey towards sustainability...

Barun Barpujari and Sanjoy Kumar Dam

Given the critical importance of maintaining climate and ecosystem stability, sustainable development approach has attained special significance in our business model.

This paper briefly dwells upon some of the tenets that influence the approach from the perspective of an "intergenerational equity".

Introduction

In 1984, the United Nations established an independent group of 22 people drawn from across the world with a view to identify the long term environmental strategies for the international community. The deliberations opened up key debates on several developmental issues and a report was finally published in 1987 (WCED, 1987) widely known as 'Brundtland Report', named after its chair, Gro Harlem Brundtland, the then Prime Minister of Norway. The report for the first time appeared to be formally claiming the concept of 'sustainable development' defining it as 'Development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. One of most widely translated , this report thus entered the international political arena and ignited global development thinking in that direction.

This lucid definition of 'sustainable development' seems to leave a situation of potential conflict between the present and future generations. Questions therefore, arise, what is it that one generation is passing down to the other? Over a period of time, new understandings have emerged on the linkages between environmental resources, its potential conflicts, and the way we do our business. Many challenging notions are therefore, associated with the concepts of 'sustainable development'.

Sustainable framework

The idea of sustainable development is not new, rather it has a substantial history. Various definitions have been accordingly drawn from time to time depending upon the disciplines from which this has been viewed. The challenges of understanding the sustainable development process depend upon new norms of behavior at different levels and in the interests of all concerned. This will in turn encompass all areas of human activities, production, trade, technology, politics and finally mutually supportive actions between individuals and nations. Most definitions of sustainable development finally revolve around three interdependent pillars viz. (i) environmental, (ii) economic and (iii) social. These three pillars can be graphically represented through three interlocking circles as seen in Figure:1 below. The objective of sustainable development is to maximize the goals across all the three systems.

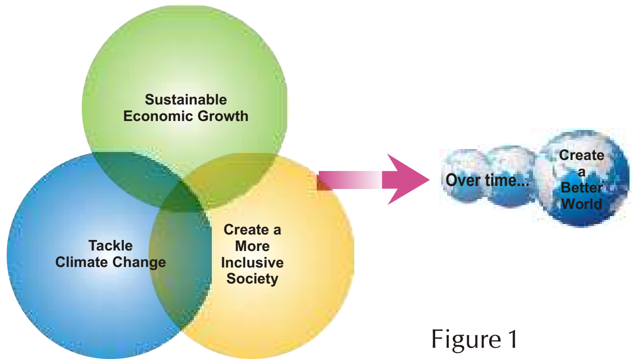

Figure 1
(source: internet)

Environment is the basis of all our economic activities. Besides, being a source of human existence, environment provides us with the raw materials to produce goods and services. Additionally, by acting as a sink, for our wastes, it provides us with the 'life support services' such as maintaining climate and eco system stability. An important motivation for sustainable development, therefore, centers around the fact that present generation has a concomitant duty to ensure that it is not the 'utility' but the 'natural capital' that we need to bequeath to the next generation in ways that would lead us to believe that at least an intergenerational justice has been done.

Therefore, while answering to our earlier question on what we are really passing down to our next generation, we need to ask ourselves whether we are as a corporate or as a society maintaining the environmental quality? Are we meeting the demand of intergenerational justice? It is by now clear that current distribution of wealth, rights and opportunities does not come close to conforming with any reasonable concepts of social justice. The enormity of wealth of the ultra rich is mind-boggling in contrast with the poverty in the developing world.

Business and Sustainability

With the advent of industrialization and economic progress, global ecosystem has been put into enormous strains primarily due to pollutions created out of carbon intensive growth path. The progressive deterioration can be broadly categorized as (i) increasing pollution and waste generation exceeding 'sink' capacities of the planet to absorb or convert them and (ii) growing excessive demand on the natural capital of the planet far beyond its regenerative capacity. Environmental crisis therefore, has attained a serious dimension 'that are nudging humanity towards the outer limits of what the earth can stand' .

Having said so, it is therefore, pertinent to ask where business fits into this? Environmental revolution has been now for almost three decades and it has changed forever how companies do business. In the 1960s and 1970s if companies were in the state of denial regarding their impact on environment, then the series of highly visible ecological problems that followed created a grim reflection of several activities of business calling for strict government regulations. Today's businesses have accepted their responsibilities towards creating a cleaner environment and social justice. In other words, pursuit of profit must go hand in hand while meeting the environmental challenges and social justice. This is what has been often referred to as 'Triple Bottom Line' (Elkington, 1997)- i.e business must consider not only its own economic well being but also its contribution to environmental and social well being.

Corporate environmental agenda is therefore, evolving into a broader sustainable development agenda. Traditionally, businesses have been judged by their financial performance. But increasingly the environmental aspects of business performance has been put under lens and in days to come the social impact of the business will be placed for more closer scrutiny. Business performance will be therefore, judged by their ability to generate profit, contribution to protection of environment and to act in accordance with the demands of social justice. Businesses have to reinforce traditional financial accounting with environmental accounting and social accounting.

Conclusion

There is a growing body of influential literature which suggests that there lies an enormous opportunity when corporates try to green their supply chain and accept the challenge to develop a sustainable global economy. However, when we think about sustainability from the perspective of only pollution control or for that matter as an one-off activity, one may miss the bigger picture. Today's business is increasingly, facing problems which are spilling over the geographical borders and thereby in meeting the needs of today, we are destroying the ability for the future generations to meet their requirements.

A sustainable business practice will therefore, be committed to create a positive impact on the society and environment in which we operate. Corporates will be increasingly focusing upon selling solutions to world's environmental problems.

Envisioning tomorrow's business will therefore, require a very clear understanding of the problems in a globally interdependence overlapping economies.

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The authors are : B. Barpujari, General Manager (CP&ES), CO, IOCL (BARPUJARIB@iocl.co.in)
: S K Dam, Chief Manager (CP&ES), CO, IOCL (DAMSK@iocl.co.in)

A JOURNEY TOWARDS SUSTAINABILITY...

Policy Interventions for Energy Efficiency in Indian Industry

BUREAU OF ENERGY EFFICIENCY

ENERGY USE IN INDIAN INDUSTRY

- Industry accounts for around 25% of the national Gross Domestic Product (GDP), and 44% of commercial energy use in India.
- Since 2000, industrial GDP has been growing on an average of more than 8% per annum, and energy use in industry has been growing at more than 5% per annum.
- In any energy-intensive industry, energy consumed per unit of product typically accounts for double-digits percentage share of the total manufacturing cost. In India, energy costs as a percentage of production cost accounts for 15 per cent in textiles, 25 per cent in pulp and paper, and 40 per cent in glass, ceramics and cement industries.
- Any reduction in specific energy consumption will reduce overall costs significantly, thereby improving overall profit margins.
- The overall energy efficiency investment market size under Energy Service Company (ESCO) system of performance contract in India has been estimated by the Asian Development Bank Study project team (2004) at Rs. 14,000 crore.

AWARENESS FOR ENERGY EFFICIENCY

Earlier, investments in energy efficiency were often relegated to the background, citing amongst others the reason of non-availability of investment funds.However, in recent years awareness on this front has increased with the industry going in for state-of-the-art technologies, which are more energy efficient. Moreover, there have also been numerous in-house efforts such as carrying energy audits, improving systems etc. by industries to become more energy efficient. Nevertheless, the new energy-efficient plants coexist with older, smaller and less efficient plants in the same sector and the least efficient plants use two to six times more energy to manufacture a tonne of the product as compared to the most efficient plant.

POLICY INITIATIVES

Recognizing the formidable challenges of meeting the energy needs and providing adequate and varied energy of desired quality to users in a sustainable manner and at reasonable costs, improving efficiency of conventional and non-conventional energy and its conservation have become important components of energy policy in India.

The Energy Conservation Act, 2001: The Energy Conservation Act, 2001 integrates these elements as a measure of express legal intent and commitment and came into force with effect from 1st March, 2002.

- The Bureau of Energy Efficiency (BEE) was created as the nodal central statutory quasi-regulatory and policy advisory body to assist in developing policies and strategies with a thrust on self-regulation and market principles to achieve the primary objective of reducing energy intensity of the Indian economy.
- The Act empowers the State Governments to facilitate and enforce efficient use of energy and its conservation through their respective State Designated Agencies in consultation with the Bureau of Energy Efficiency.
- The Act has identified 15 large Energy Intensive Industries for energy efficiency improvements. Section 14(e) and 14(g) of the Act, empower the Central Government, on the recommendations of BEE, to prescribe energy consumption norms and standards. The Government in March, 2007, notified units in 9 industrial sectors, namely Aluminum, Cement, Chlor-Alkali, Pulp & Paper, Fertilizers, Power Generation Plant, Steel, and Railways, as Designated Consumers (DCs). These industries have to appoint an energy manager, file energy consumption returns every year and conduct mandatory energy audit. They also will have to adhere to the energy consumption norms specified by the Government.

The National Energy Conservation Awards: This scheme is one of the most innovative schemes introduced by the government more than a decade ago to acknowledge energy conservation efforts of industries and other agencies. The scheme recognizes best practices from large/medium and small scale industries, building sector, zonal railways, the State Designated Agencies (SDAs) and Municipalities. This initiative is a means to institutionalize the energy efficiency movement in the country. The awards are distributed every year on 14th December, which is also observed as the National Energy Conservation Day.

The Integrated Energy Policy: It lays emphasis on energy conservation and efficiency, particularly through Demand Side Measures (DSM) and estimates that 15% saving in energy is possible through such interventions. The Conference of Chief Ministers chaired by the Hon'ble Prime Minister on 28th May, 2007, recognized the significant potential of saving electricity through its efficient use by DSM interventions, such as, bulk procurement and distribution of CFLs, adoption of Energy Conservation Building Code (ECBC), promoting and mandating the use of energy efficient pumps and other energy efficient and appliances.

ENERGY EFFICIENCY & CLIMATE CHANGE

India is faced with the challenge of sustaining its rapid economic growth while dealing with the global threat of climate change. This threat may alter the distribution and quality of India's natural resources and adversely affect the livelihood of its people. With an economy closely tied to its natural resource base and climate-sensitive sectors such as agriculture, water and forestry, India may face a major threat because of the projected changes in climate. Cost- effective energy efficiency and energy conservation measures are of particular importance in this connection.

The National Action Plan on Climate Change released by the Prime Minister on 30th June, 2008, recognizes the need to maintain a high growth rate for increasing living standards of the vast majority of people and reducing their vulnerability to the impacts of climate change. It outlines Eight National Missions, representing multi-pronged, long-term and integrated strategies for achieving key goals in the context of climate change. ***National Mission for Enhanced Energy Efficiency (NMEE)*** is one of these. The ***Perform, Achieve and Trade (PAT)*** scheme is one of the initiatives under the NMEE and is specifically aimed at Industries. It has been conceptualized as a market based mechanism to enhance cost effectiveness of improvements in energy efficiency in energy-intensive large industries and facilities, through certification of energy savings that could be traded. It is based on a strategy that creates demand for energy efficient products, goods and services by

- Spreading awareness about efficacy of these products and services
- Amending government policies
- Programmes to integrate energy efficiency
- Preparing bankable projects to stimulate the process
- Incentivizing cost effective improvements in energy efficiency in energy-intensive industries and facilities, through certification of energy savings that could be traded

The main issues that need to be addressed for institutionalizing the PAT mechanism are as under:

- Methodology for setting Specific Energy Consumption (SEC) norm for each designated consumer in the baseline year and in the target year
- Verification process for SEC of each designated consumer in the baseline year and in the target year by an accredited verification agency
- Issuance process for Energy Savings Certificates (ESCerts) to those designated consumers who exceed their target SEC reduction
- Trading Process for ESCerts
- Compliance and reconciliation process for ESCerts
- Cross sectoral use of ESCerts and their synergy with Renewable Energy Certificates

The Ministry of Power, BEE and other agencies are working on these issues for implementation of the PAT mechanism.

STATISTICS

POL PIPELINES IN INDIA AS ON 01.04.2009*

	Length Kms.	Capacity MMT
PRODUCT PIPELINE		
INDIAN OIL CORPORATION LIMITED		
BARAUNI-PATNA-KANPUR	745	3.50
GUWAHATI-SILIGURI	435	1.40
HALDIA-BARAUNI	525	1.25
HALDIA-MOURIGRAM-RAJBANDH	277	1.35
KOYALI-AHEMDABAD	116	1.10
KOYALI-NAVGAM	78	0.00
KOYALI-VIRAMGAM-SIDHPUR-SANGANER	1056	4.10
MATHURA-DELHI	147	3.70
PANIPAT-AMBALA-JALANDHAR	434	3.50
PANIPAT-DELHI	182	0.00
PANIPAT-BHATINDA	219	1.50
DIGBOI-TINSUKIA	75	1.00
MATHURA-TUNDLA	56	1.20
PANIPAT-REWARI	155	1.50
CHENNAI-TRICHY-MADURAI	683	1.80
KOYALI-DAHEJ	103	2.60
CHENNAI ATF	95	0.18
DDPL (ATF PIPELINE TO BANGALORE INT. AIRPORT)	36	0.66
NNPL (DOCKLINE FROM IBP NARIMANAM TO NAGPATTINAM)	7	0.37
KOYALI-RATLAM	265	2.00
Sub-Total - IOC	**5689**	**32.71**
BHARAT PETROLEUM CORPORATION LIMITED		
MUMBAI-MANMAD	252	5.40
MANMAD-MANGLIYA	358	3.50
MANGLIYA-PIYALA	722	2.20
PIYALA-BIJWASAN	57	0.70
Sub-Total - BPC	**1389**	**11.80**
HINDUSTAN PETROLEUM CORPORATION LIMITED		
MUMBAI-PUNE-SOLAPUR	508	3.67
VIZAG-VIJAYAWADA-SECUNDERABAD	571	5.38
MUNDRA-DELHI	1056	3.84
Sub-Total - HPC	**2135**	**12.89**
PETRONET INDIA LIMITED		
KOCHI-COIMBTORE	292	3.30
MANGALORE-HASAN-BANGALORE	361	2.14
Sub-Total - PIL	**653**	**5.44**
LPG PIPELINES		
INDIAN OIL CORPORATION LIMITED		
PANIPAT-JALANDHAR	274	0.70
Sub-Total - IOC	**274**	**0.70**
GAIL (INDIA) LIMITED		
JAMNAGAR-LONI	1250	2.50
VIZAG-VIJAYWADA-SECUNDERABAD	600	1.33
Sub-Total - GAIL	**1850**	**3.83**
TOTAL PRODUCTS (POL+LPG)	**11990**	**67**
CRUDE PIPELINES		
INDIAN OIL CORPORATION LIMITED		
SALAYA-MATHURA-PANIPAT (INCLDG. LOOP LINES)	1870	21.00
HALDIA-BARAUNI/PARADIP BARAUNI	1302	11.00
MUNDRA-PANIPAT	1194	9.00
Sub-Total - IOC	**4366**	**41.00**

	Length Kms.	Capacity MMT
OIL INDIA LIMITED		
DULIAJAN-DIGBOI-BONGAIGAON-BARAUNI	1405	7.68
Sub-Total - OIL	**1405**	**7.68**
ONGC LIMITED		
30"MUMBAI HIGH-URAN	204	15.63
24"HEERA-URAN	81	11.50
KALOL-NAVAGAM-KOYALI	2022	8.54
MHN-NGM	1078	2.26
CTF, ANKLESHWAR TO KOYALI	1517	2.00
LAKWA-MORAN	210	1.50
GELEKI-JORHAT	679	1.50
NRM TO CPCL	44	0.74
KSP-WGGS TO TPK REFINERY	54	0.08
GMAA EPT TO S. YANAM UNLOADING TERMINAL	14	0.06
Sub-Total - ONGC (Tunck pipelines)	**5903**	**43.81**
TOTAL CRUDE PIPELINES	**11674**	**92.49**
TOTAL (PRODUCTS + CRUDE)	**23664**	**159.86**

Source: Petroleum Pricing & Analysis Cell, Internal Data(IOCL)
**Data IOCL upto 30.11.2009*

Gross Domestic Product at Factor Cost (Constant Price: 1999-2000)

				APRIL-SEPTEMBER	
	2007-08	2008-09	2009-10	2008-09	2009-10
SECTOR	Rs. crore			% year-on-year growth	
agriculture, forestry and fishing	230,457	237,063	241,084	2.9	1.7
mining and quarrying	28,093	29,262	31,808	4.2	8.7
manufacturing	228,611	240,693	255,940	5.3	6.3
electricity, gas and water supply	31,706	32,739	34,971	3.3	6.8
construction	108,854	118,655	126,696	9	6.8
trade, hotels, transport and communication	400,789	450,989	488,412	12.5	8.3
financing, ins., real est. and Business services	220,973	235,641	254,165	6.6	7.9
community, social and personal services	194,711	211,426	232,261	8.6	9.9
GDP at factor cost	1,444,195	1,556,470	1,665,338	7.8	7

Source: Central Statistical Organization

Expenditures of Gross Domestic Product at Market Price (Constant Price: 1999-2000)

	APRIL-SEPTEMBER			
	2008-09	2009-10	2008-09	2009-10
SECTOR	Rs. crore		% share	
Private Final Consumption Expenditure (PFCE)	954,213	988,580	56.7	55.2
Government Final Consumption Expenditure	149,877	176,942	8.9	9.9
Gross Fixed Capital Formation (GFCF)	561,202	593,825	33.3	33.2
Change in Stocks	53,661	42,234	3.2	2.4
Valuables	22,589	21,436	1.3	1.2
Exports	388,851	339,721	23.1	19
LessImports	489,295	363,381	29.1	20.3
Discrepancies	41,777	-9,306	2.5	-0.5
GDP at market prices	1,682,876	1,790,051	100	100

Source: Central Statistical Organization

World: Installed Capacity of Renewable Energy Sources

	Added during 2008	Existing at end of 2008
Electricity	**Giga Watts**	
Large hydropower	25–30	860
Wind power	27	121
Small hydropower	6–8	85
Biomass power	2	52
Solar PV, grid-connected	5.4	13
Geothermal power	0.4	10
Concentrating solar thermal power (CSP)	0.06	0.5
Ocean (tidal) power	~0	0.3
Hot water/heating	**GWth**	
Biomass heating	n/a	~250
Solar collectors for hot water/space heating	19	145
Geothermal heating	n/a	~50
Transport fuels	**(billion liters/year)**	
Ethanol production	17	67
Biodiesel production	3	12

Source : Renewable Global Status Report 2009Update(Ren21)

India: Installed Electricity Generation Capacity of Renewable Energy Sources

Sources / Systems	Achievements during 2009-10 (upto 31.10.2009)	Cumulative Achievements (upto 31.10.2009)
A. Grid-interactive renewable power		
Biomass Power (Agro residues) (in MW)	113.50	816.50
Wind Power (in MW)	649.00	10891.00
Small Hydro Power (up to 25 MW) (in MW)	91.11	2519.88
Cogeneration-bagasse (in MW)	192.00	1241.00
Waste to Energy (in MW)	8.41	67.41
Solar Power (in MW)	3.10	6.00
Sub Total (in MW) (A)	**1057.12**	**15541.79**
B. Off-grid/Distributed Renewable Power (including Captive/CHP plants)		
Biomass Power / Cogen.(non-bagasse) (in MW)	10.60	181.37
Biomass Gasifier (in MWeq.)	2.91	108.37
Waste - to - Energy		
	3.91	37.97
Solar PV Power Plants and Street Lights (in MWeq.)	0.09	2.39
Aero-Generators/Hybrid Systems (in MW)	–	0.89
Sub Total (B) Mweq	**17.506**	**330.99**
Total (A + B) MW	**1074.63**	**15872.78**

MWeq. = Megawatt equivalent; MW = Megawatt
Source: Ministry of New & Renewable Energy

YOUR FEEDBACK

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