Energy Security Issues – India

by

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I. INTRODUCTION

Energy is the basic building block for socio-economic development. Future economic growth crucially depends on the long-term availability of energy in increasing quantities from sources that are accessible, easily available, socially acceptable and environmental friendly.

If one looks at the pattern of energy production in India, coal and oil accounts for 52 per cent and 33 per cent respectively with natural gas, hydro and nuclear contributing to the balance. Nearly 62 percent of power generation is from coal fired thermal power plants and 70 per cent of the coal produced every year in India has been used for thermal generation.

The primary energy requirement is expected to be 455 million metric ton of oil equivalent (MMTOE) in 2001-02 and is projected to be 556.2 MMTOE and 722.3 MMTOE in the terminal years of the Tenth (2006-07) and Eleventh (2011-12) Five Year Plans respectively. However due to an anticipated decline of energy intensity, the actual demand may be 5 – 10 percent below the estimated figures. The recommended fuel mix for the Tenth and Eleventh Plan Period is given in the table below.

Table 1: *Recommended Fuel Mix for India*

Primary Fuel	**2001-02 % (anticipated)**	**2006-07 %**		**2011-12 %**	
		W.G.	S.C.	W.G.	S.C.
Coal & Lignite	**36.1**	35.9	**36.0**	38.4	**36.0**
Oil	**23.4**	26.1	**23.5**	25.7	**23.0**
Gas	**7.2**	7.4	**7.0**	7.7	**7.5**
Hydro Power	**1.7**	2.3	**3.0**	2.6	**3.5**
Nuclear Power	**0.9**	1.1	**1.5**	1.9	**2.5**
Wind Power	**0.1**	0.1	**0.1**	0.1	**0.1**
Traditional Fuels	**30.6**	27.1	**28.9**	23.6	**27.4**
	100.0	100.0	**100.0**	100.0	**100.0**

Source: Planning Commission (W.G. – Working Group S.C. – Steering Committee)

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Energy consumption in India is expected to have more than doubled by 2020 to meet development aspirations. Like many other developing countries, India also is a net importer of energy. 70 per cent of crude requirements are being met through import primarily from the Middle East. The import of crude oil is estimated to increase from the present level of about 85 MMT per annum (PA) to 151 MMTPA during the 10^{th} plan period. The demand for gas is also growing at a faster rate.

Due to geo-political tensions oil prices are highly volatile. The inelasticity of oil demand and the rising oil import bill has been the focus of serious concern due to the pressure it places on scarce foreign exchange resources and also because it is largely responsible for energy supply shortages. During the first oil embargo, India's import bill rose by over 50 per cent, while the adverse impact of the 1990-91 Gulf War, which caused a huge Balance of Payment (BOP) deficit and pushed up the inflation to a all-time high of 13 per cent, slowed down the economic growth of India.

Providing electricity to all citizens on the planet is a global concern. India with a low per capita consumption is striving to provide the targeted mission of 'Power for All' by 2012. This would entail a large sale energy capacity expansion. Increasing local and global concerns would drive India to explore avenues to achieve this goal in an environmentally responsible manner. The issues related to national energy security, which were earlier looked at as a BOP crisis due to a rising oil import bill, need to be visualized in a comprehensive manner.

Energy security can be defined in terms of the physical availability of supplies to satisfy demand at a given price. The security problem therefore involves a supply risk and a price risk governed by internal and external consequences. Long-term supply security requires a delicate balance between indigenous and external energy sources along with technologies in order to minimize the risks. Energy security in India should also be linked with affordability issues as the 'energy burden' for low-income households could obstruct the stream of development of our country. Government should carefully select the 'right energy mix' relying on a well-diversified portfolio of domestic or imported or regionally traded sources of energy in order to minimize energy price volatility and to supply energy at affordable prices.

The paper has been organized in the following manner. **Section II** highlights various issues related to internal energy security, while **Section III** discuss energy security concerns affected by external consequences. Finally, **Section IV** concludes the paper.

II ISSUES RELATED TO INTERNAL ENERGY SECURITY

2.a Reform & restructuring the energy sector to develop globally competitive, efficient and environmentally compatible operations

In the pre-reform period, the commercial energy sector was totally regulated by the government. The economic reform and liberalization, in the post 90's, has gradually welcomed private sector participation in the coal, oil, gas, and electricity sectors in India.

Energy prices in India have been under an administered regime and subsidies are being provided to meet certain socio-economic needs of the public, which has led to distortion and inefficiency in the use of different sources of energy. Recently, government has taken serious steps to deregulate energy prices.

The prices of all grades of coal have already been deregulated. Oil companies are allowed to set prices depending upon market conditions. In the electricity sector, most of the State Electricity Boards (SEBs) have started taking reform measures and regulatory commissions have been set up to determine tariffs based on economic rationale.

Establishment of market determined prices for energy is critical if financing is to be made available to maintain facilities, establish new capacity in the energy sector and to support effective transport mechanisms to move energy to users in a sustainable manner. Macroeconomic policies like environmentally harmful subsidies result in over-utilization of natural resources. Energy subsidies in India, which approximate 1 percent of national income, lead to energy intensive economic structures and technologies; and wasteful management practices. In the petroleum sector, subsidized prices of diesel and kerosene encourage fuel adulteration and diesel power generation, which ultimately contribute to environmental pollution besides increasing import dependence. A study by the International Energy Agency (IEA) revealed that reducing price subsidies in India would reduce primary energy consumption by 13 percent, increase GDP through higher economic efficiency by 1 per cent, lower CO_2 emissions by 16 per cent and produce domestic environmental benefits including lower local air pollution.

2.a.1 Comprehensive integrated energy planning taking into account the role of hydrocarbons

Since the energy sector in India is handled by several ministries, there is a need for coordination and integration among them. Reform in the power sector, for example, is suffering from the lack of progress in coal reforms while coal movement suffers from the lack of tariff rationalization in the railways.

For smooth operation of the energy sector, there should be a well-established institutional framework consisting of regulatory agencies, the rules and regulations of the sector and policy guidelines. The regulatory agency should have international experience, political independence, accountability, autonomy and expertise on technology, economics, law and accounting.

In the future, electricity generation will be increasingly from gas and liquid fuels. In such a scenario, a single regulatory authority for electricity, oil, gas and coal sectors has to be seen or the role of regulators acting in unison / supplementing each other needs to be looked into.

2.a.2 Adoption of clean coal technologies & utilization of lower-cost imported coal for coastal power plants.

The Indian power sector is facing challenges and despite significant growth in generation over the years, it has been suffering from shortage and supply constraints. According to Central Electricity Authority (CEA) estimates, the demand for power is expected to double in the next 10-12 years.

Since India has a vast coal reserve, it is expected that power generation from coal will continue to maintain its share in the future. But in order to achieve higher thermodynamic efficiency while minimizing environmental impact and cost effective utilization of high ash Indian coal, emphasis should be placed on coal beneficiation, pit head power generation, heat rate improvement programs in the power plants, fly ash management, carbon sequestration through afforestation programs and scaling up of power plants. In the long run, the technological options would be super and ultra-super critical combustion technologies, integrated gasification combined cycles (IGCC), fluidized bed combustion and underground coal gasification. There should also be sufficient R&D efforts for the development of technologies like integrated gasification humid air turbines, integrated gasification molten carbonate fuel cells, development of hot gas cleanup systems, high temperature air pre-heaters, new material for ultra-supercritical boiler etc. The "Flexibility Mechanisms," like the Clean Development Mechanism included in the Kyoto Protocol, can be used to finance such projects.

Since coal prices in the international market are relatively stable and coal is well dispersed around the world—unlike oil which is concentrated in the Middle East and Russia and subjected to unpredictable price volatility, it would make sense for India to import coal with well drawn out long term contracts for power plants located in the coastal regions.

2.a.3 Enhancement of strategic oil reserve through accelerated exploration and increased domestic oil supply

Keeping in view India's energy security, the long-term exploration and production policies to enhance hydrocarbon reserves and increase domestic production should be as follows:

i. Explorations in new frontier areas like deep water and other geologically and logistically difficult areas.

ii. Creation of a policy environment for developing a vibrant, thriving and world-class exploration and production industry which can mobilize and infuse technology and capital and can stand on its own in the process of globalization for energy security to the country.

iii. Development of new oil fields and additional development of existing oil fields.

iv. Implementation of Improved Oil Recovery (IOR) or Enhanced Oil Recovery (EOR) schemes.

v. Implementation of specialized technologies, continued technology acquisition and absorption along with development of indigenous R&D.

vi. Maintenance of reservoir health and better reservoir delineation.

vii. Increased private participation through putting the New Exploration Licensing Policy (NELP) into operation.

viii. One hundred percent exploration coverage of the Indian sedimentary basins by 2025.

ix. Continuation of the supportive role of the government in exploration, particularly for high-risk ventures.

One of the landmarks in liberalization in the petroleum sector is the encouragement of participation of foreign and Indian companies in the exploration and development activities to supplement the efforts of national oil companies. New Exploration Licensing Policy has been put into operation through NELP-I, II & III production sharing contracts and NELP-IV is expected soon.

To upgrade the quality and volume of seismic data, the Government also announced bidding rounds for speculative surveys. After the seismic work is completed, the blocks are to be offered for exploration. The data acquired by the seismic companies can be sold in India and abroad.

2.a.4 Achieving 90 percent self-sufficiency of middle distillates with appropriate mix from national oil companies, private Indian players and foreign companies

In line with international trends, it is estimated that the share of middle distillates, which constitutes a large part of the total demand, would further increase from 59 to 64.6 percent by 2025.

Based on considerations of national oil security, stability of supply and development of the economy, it is felt that India should set up refining capacity to meet a substantial part of its domestic demand. It is desirable that the quantum of refining capacity set up should be sufficient to meet at least 90 percent of the country's demand for middle distillates, which are the main product group. It is expected that due to technological progress, the yield of middle distillates will be substantially more than the current yield.

While the decision to invest in refining capacity would be left to the investors, it is recommended that if in future, the investment in refining capacity falls below the desired level, the Government should intervene to take remedial steps by providing fresh incentives to this sector.

2.a.5 Conditional marketing rights for transportation fuels to companies who invest in exploration and production, refining, pipelines or terminals

As the objective of dismantling of the Administered Price Mechanism (APM) is to remove the existing controls and usher in a free market, this should be done at the earliest to encourage internal competition.

After the dismantling of the APM, limiting the competition to the existing marketing companies may not be conducive to development of a true free market environment, as has been seen in other countries that have deregulated without entry of new players.

Entry of new players in the marketing sector may be required to ensure a truly competitive scenario. While foreign participation in the marketing sector is felt necessary for fostering greater competition, the access to the marketing sector, which is a more profitable retail oriented business, should be given to only those players who have a commitment to the overall development of the country's hydrocarbon sector.

In addition, in order to ensure incremental investment in building the much needed marketing infrastructure, all new entrants should set up their own distribution network for marketing and not encroach on the infrastructure of the existing marketing companies.

The existing Public Sector Undertakings (PSUs) should be given full operating freedom in establishing and maintaining their marketing networks.

2.a.6 Operational flexibility to refineries in crude sourcing and risk management through hedging

The Government should allow every refinery the flexibility to source its own crude, as well as the ability to manage the business risk by using commodity hedges and other risk management techniques. Indian refinery companies should explore the possibility of investing in crude production assets overseas. This would help Indian companies tie up secured crude supplies and also enable them to become strong, integrated, globally competitive entities.

To encourage foreign participation in the sector, the Government could also consider increasing the ceiling on foreign direct investment in the refinery sector.

In order to provide a level playing field for the Public Sector Undertaking (PSU) refineries, they should be given flexibility in making decisions on all commercial aspects without the risk of external scrutiny as per the prevailing norms of corporate governance as applicable to any private enterprise.

2.b Development of regulatory and legislative framework for proper structuring and oil / gas security in India.

The need for regulation can be summarized as follows:

- Ensuring fair competition among all players,
- Monitoring of the availability and price of petroleum and gas products in different regions of the country especially remote areas,
- Managing the strategic minimum reserve of oil products,
- Establishing quality specifications and monitoring compliance,
- Ensuring equitable access to pipelines and monitoring of tariffs, and
- Establishing environmental standards and targets for technological achievements.

The regulatory body has to be sensitive to the needs of the downstream players and also encourage exploration and production in the country. There will be conflicts in the interests of producers and transporters and these have to be resolved. There is also a need for the regulator to facilitate an environment that stimulates investment.

Petroleum Regulatory Board Bill 2002 – proposes a common regulator for petroleum products and natural gas. The petroleum products industry and the natural gas industry in India are at two different stages of development with the former being significantly more mature than the nascent gas industry. Therefore, separate guidelines for the two sectors, particularly with respect to transmission infrastructure and distribution franchises, in the proposed regulatory framework are important. Ideally governed under one umbrella, the structure of the regulatory body could consist of one nodal point each for the upstream, downstream, transportation – pipelines and gas transmission and distribution for better management.

2.c Adequate port & domestic shipping facilities for future oil and gas import

Even if, pipelines will be used in the future to import oil and gas, a substantial portion of these imports will still be dependent on tankers. Unfortunately India's port facilities are inadequate to handle future hydrocarbon imports. At present, India has 11 ports and most of them are in dire need of expansion and modernization. At the same time, the Indian shipping industry is also undersized with only 476 ships for coastal and overseas trade, with a total of 6.88 million Gross Registered Tonnes – less than 1.5 per cent of total world tonnage. Therefore, proper planning and investment are required on a priority basis.

Though the choice of carrier would be determined on the basis of competitiveness, for strategic reasons it is desirable to develop Indian shipping tonnage. For this purpose, domestic oil companies could be encouraged to enter into joint venture agreements with Indian shipping companies.

2.d Substitution from oil to gas

In recent years, natural gas (NG) has emerged as an alternative for oil. With the discoveries of new gas fields, most Asian countries, which are heavily dependent on oil, realize that NG not only diversifies energy sources but also contributes to security of supply. Besides that, gas is a cheap, efficient and environmentally clean source of energy.

The gas industry seeks to play an important role in the growth of the energy sector in India. It is primarily used in gas-based power projects (utility and captive) and also by the fertilizer sector as feedstock in the manufacturing process. Natural gas is being increasingly used as fuel by the transport sector and has major usage in the industrial sector as eco-friendly fuel. At present, gas based power projects account for 11 percent of power generation and are expected to double their share in energy supply by the year 2011-12.

Hydrocarbon Vision- 2025 projects a natural gas demand of 313 million metric standard cubic meters per day (mmscmd) and 391 mmscmd by the years 2011-12 and 2024-25 from the existing demand and supply of 115 mmscmd and 65 mmscmd respectively. However, as per a recent GAIL (Gas Authority of India Limited) estimate, demand for gas will grow in the country from 110 mmscmd in 2001-02 to 145, 225 and 325 mmscmd in 2006-07, 2011-12 and 2019-20 respectively.

Recently, Reliance and Cairn have reported seven trillion cubic feet and one trillion cubic feet of gas finds from two blocks in the Krishna-Godawari basin. A similar gas potential is also expected on the West Coast. This will definitely restructure the future energy mix and provide the energy starved Southern Region of India a much-needed solace. This is also an indicator that opening sectors to the private sector gives results and needs to be pursued with greater vigor. In this context, issues like the provisions to regulate the import of LNG, gas pricing, provision for open access to gas pipeline, and the role of regulators need to be resolved.

However, the new domestic gas finds or more such discoveries in the future would not in any significant way diminish the prospect of import of piped gas or LNG. Due to limited domestic reserves, the country would have to be dependent on gas imports. The neighboring countries of Bangladesh and Myanmar have large gas reserves beyond their short and medium term domestic requirement and can be explored as alternate sources of gas supply. India has already signed agreements with Qatar and Oman to transport NG over a period of 20 years, beginning in 2001-02. Ample opportunities exist to import gas from Iran and the Caspian region, the details of which are provided in Section 3.e. However, the problem of transit routes and the mode of transport need to be resolved.

2.e Strategic reserve / storage

Strategic stock draw is regarded as a vital element in the emergency preparedness of the International Energy Agency (IEA) countries. According to the International Emergency Program (IEP) norms, net oil importers have a stock-holding obligation equivalent to 90 days of net oil imports in the preceding year. In about one-third of the IEA countries stock draw is considered to be the main response in the early stages of crisis, in the remaining two-thirds of the IEA however, there is a flexibility regarding an early use of stocks depending upon the circumstances of disruption. In Japan, for example, an early use of stocks along with demand restraint measures is considered as an effective response.

India needs roughly 105 million tonnes of oil a year, with only 30 per cent coming from domestic production. At present companies stock crude oil for 23 days (including 11 days of stocks in transit), petrol for 53 days, diesel 43 days, kerosene 51 days, cooking gas 19 days and jet fuel for 88 days.

As mentioned above, in line with the emergency preparedness for the country, building strategic crude oil reserves is a necessity from a security and a strategic point of view. In the event of a disruption in supplies in an uncertain geopolitical environment, the disruption is likely to be minimal when crude import sources have been diversified and an effort has been made to ensure that shipping routes do not pass through conflict zones. However, in today's economic scenario, even with keeping the stocks held by oil companies in mind (which they are free to use for their own requirements), the cost of setting up and maintaining the reserve is rightly justified.

As per the Hydrocarbon Vision 2025 report, the proportion of crude demand being met from indigenous production (30 percent) presently is likely to decline even further. Estimates suggest that by 2010, only about 27 percent of the total demand will be met internally. While oil-importing agencies have tried to insulate future oil imports from the shocks of possible West Asian hostilities, a sizable strategic crude reserve will make the management of supplies much easier in such a scenario. Also, by leveraging the reserves, the economy will be better placed to meet the volatility of crude prices.

The Sundarajan Committee Report of 1995 (**Hydrocarbon Perspective: 2010)** had proposed that as in the case for most countries maintaining strategic reserves, the funding for construction of tankage as well as the cost of carrying inventory should be borne by the government. Various options including long-term leasing of required tankage can be considered to minimize the financial impact of strategic reserves.

The Indian government plans to build and maintain a strategic oil reserve for forty-five days that would hold 15 million tons of crude oil at an estimated cost of Rs. 4350 crore (Rs. 43.5 billion). Indo-U.S. cooperation in this field is being explored. The project can be financed either through budgetary grants from the government or through levying taxes on petroleum products. The locations and financing of the project are yet to be finalized.

2.f. Lack of optimal utilization of economically viable indigenous energy sources

2.f.1 Exploration of new oil and coal fields

Exploration of new oil and gas fields is taking place in the remote far-flung hilly areas of India, most of which are covered by deep forests. Due to lack of socio-economic development of the local people, these locations are often politically sensitive and are prone to law and order problems. These, coupled with environmental activism, make exploration, exploitation and infrastructure development associated with new oil and coal fields a major area of concern - impacting country's energy security.

2.f.2 Hydropower

Hydropower is a clean and economically cheap source of energy, which has the lowest long-term costs amongst all available sources of power. Once hydro plants are up and running, the variable cost is practically nil and limited only to operating and maintenance costs. The character of the cost is non-inflationary in nature, as it does not depend on imported fuel.

Hydro stations are the best choice for meeting peak demand. Hydroelectric projects have long useful life (nearly 50 years), which help in conserving scarce fossil fuel. It is estimated that at least 75 percent of the surface water, which gets drained into the sea without proper utilization can be harnessed to generate energy through hydel projects.

Despite hydroelectric projects being recognized as the most preferred source of electricity, the share of hydroelectricity has been going down. During the first and second five-year plan periods, large hydroelectric projects had received the highest priority because of their range of benefits, including flood prevention, irrigation, and power generation. The slacking of emphasis on such multipurpose projects after the second plan period was due to:

- Interstate disputes,
- Long gestation periods,
- High environmental costs,
- Geological surprises,
- Constructional and operational risks,
- Resettlement problems associated with large hydro projects, and
- Inconsistent SEBs policy on wheeling and banking of captive hydro projects.

Viable hydro potential in India is assessed to be about 84,000 MW at 60 percent load factor (1,48,700 MW installed capacity). In addition, 6780 MW in terms of installed capacity from Small, Mini, and Micro Hydel schemes have been assessed. Besides that, 56 sites for pumped storage schemes with an aggregate installed capacity of 94,000 MW have been identified. So far, only 15 percent of the potential have been harnessed and 7 percent is under various stages of development. Thus, the remaining 78 percent of the potential remains untapped. The utilization of hydropower in India is much lower than in countries like Norway (58 percent), Canada (41 percent) and Brazil (31 percent).

As of April 2001, hydro projects, which are under construction will add 13,155.85 MW within 2011-12 out of which 5960 MW and 5663.85 MW will be contributed by central (NHPC, THDC, NEEPCO) and state agencies respectively. The capacity addition by the private sector during this period will be 1532 MW.

The Ministry of Power (MoP) has taken several steps to accelerate capacity addition from hydroelectric projects. These include:

- Exploitation of untapped hydro potential through basin wise action plans and ranking studies. Preliminary ranking studies of hydroelectric schemes have been completed. Prioritization of identified potential hydroelectric sites in the various river basins based on their attractiveness for implementation is underway. The ranking studies will serve as a guide to the potential developers to choose hydro schemes for implementation.

- Promotion of mini and micro hydel projects.

- Adoption of best practices for project implementation and operation.

- Renovation and modernization of old operating units.

- Tighter monitoring, time bound action plan and budgetary support from the Government for rapid completion of new hydro projects.

- Development of pumped storage schemes.

- Encouragement of private sector investment through a transparent approach for the selection of developers for survey, investigation and project execution

- Dispensation of tariffs and innovative financing mechanism to minimize the risks associated with hydel projects.

Policy Prescriptions for promoting hydro power

- Encouragement of private sector investment in hydel projects through:
  - reduction of procedural delays,
  - a single window clearance of projects, and
  - a regulatory framework that has transparency

- Facilitation of early financial closure of projects through:
  - off-take agreements from transmission/distribution companies and
  - fiscal incentives for potentially unattractive projects.

- Implementation of adequate regulatory mechanisms to resolve Inter-State disputes.

- Application of catchment area treatment and reclamation of degraded land.

- Setting up a timetable for completion of projects and incentive mechanism for early completion of the project.

- Application of remote sensing and various sophisticated geophysical techniques for site selection and for minimizing geological risks.

- Consideration of seasonal inflows of water in preparing the estimates of hydroelectric potential.

2.f.3 Nuclear Power

Development of nuclear power is essential in the context of India's energy security and environmental perspective. Nuclear power plants would be a good option for future base load power generation. Although the present share of nuclear power is only 2.59 per cent (2720 MW) of the total installed capacity, the Vision 2020 of the Department of Atomic Energy envisages a cumulative installed capacity of 20,000 MWe.

In the late 1960s-70s, India decided to opt for nuclear power to meet its growing power demand. The long-term nuclear power program formulated by Dr. Bhabha[1] about four decades ago included the following three stages:

a. Natural uranium fuelled Pressurized Heavy Water Reactors (PHWRS)
b. Fast Breeder Reactors (FBRs) utilizing plutonium based fuel
c. Advanced nuclear power systems for utilization of thorium.

Nuclear power generation in India commenced in 1969 with the commissioning of the Tarapur Atomic Power Station built on a turnkey basis by International General Electric of the USA based on boiling water reactor technology using imported enriched uranium. The first two Indian Pressurized Heavy Water Reactors, for which indigenous uranium is used were built with Canadian assistance. In 1987, the Nuclear Power Corporation of India Limited (NPCIL) was set up to operate and maintain existing power stations and for setting up future projects.

Despite the imposition of bans on India after the nuclear tests, followed by technological, commercial, organizational, political and financial challenges, there are reasons to prioritize nuclear power plants:

- In recent years, India's nuclear power plants have been operating at good capacity utilization levels. Plant Load Factors (PLFs) are now close to design levels and these mean costs are close to normative levels.

- In terms of Long Range Marginal Cost (LRMC) advantages, nuclear power is a genuine economic option for power supply at locations far remote from coal reserves, particularly if hydel sources are not available in the vicinity. Cost of nuclear power is comparable with that of coal based power at locations 1000 kilometers away from the coal pit-heads. Reduction in capital costs and improvement in the performance of the nuclear power plants would further reduce the cost of nuclear power.

[1] Dr. Homi Jehangir Bhabha, an eminent nuclear scientist, established India's nuclear research program; a man who throughout his life outlined both the scientific and policy spheres of India's nuclear affairs, first bringing the Indian nuclear program to life and then setting its priorities and direction.

Nuclear potential in India

The present nuclear power program in India is based on natural uranium and indigenous thorium resources. Available reserves of natural uranium can support a program of 10,000 MWe power generation based on PHWR technology. The present estimates show that the known deposits may yield 363,000 tons of thorium oxide, which may produce 900,000 Billion Unit (BU) of electricity when used through breeder reactors. Efforts are underway to produce technological development in fast breeder reactors; enhancement of thorium utilization; engineering development in fuel cycle areas and of thorium-based, advanced heavy water reactors; high temperature reactors employing gaseous or advanced liquid metal alloy coolants; source drive reactors; and the reprocessing of spent fuels.

Barriers in promoting nuclear power in India

- Lack of government initiatives to speed up the electricity sector reform, to attract private sector participation in construction and operation of nuclear power plants;

- Apparently high cost of nuclear power in comparison to the power from other conventional sources; and

- Anti-nuclear lobbing activity.

Policy prescriptions for promoting nuclear power

- Increasing the economic competitiveness of the nuclear power plants through proper R&D, design standardization, management competence, training and regulatory practices;
- Maintaining the highest standards on safety and environment from mining to decommissioning;
- Establishing a watchdog agency independent of the Department of Atomic Energy (DAE)/ Nuclear Power Corporation (NPC) to monitor environmental and safety standards;
- Allowing private sector participation as joint ventures with government in construction and operation of nuclear power plant;
- Changes in existing legislation and allow independent power producers in this field;
- Competitive pricing mechanism in the energy sector;
- Unbundling and privatization of SEBs;
- Lobbying to get nuclear power eligible for green house gas emission reduction and getting sanctions lifted.

2.f.4 Captive Power

Despite restrictive captive power policy in a number of states, the captive capacity in the country has been growing by nearly 8.5 per cent. The captive segment contributed almost

25 per cent of capacity addition and captive power now accounts for at least 35 per cent of the electricity consumed by Indian Industry. The reasons behind the growth of captive power plants include:

- High power tariffs for industrial units,

- Unreliable supply of grid power and voltage fluctuations which can cause damage to sensitive and expensive equipment, and

- Attractive packages offered by equipment manufacturers to captive consumers, which include low-cost financing, operation and maintenance agreement, etc.

Although in the last couple of years, the Ministry of Power has sent clear and strong signals towards the development of captive power to bridge the future demand-supply gap, attitude of some of the SEBs towards captive power is restrictive because:

- SEBs are concerned about the over-supply and declining power shortages in some states and they have the fear that there would be no takers for their relatively high cost surplus power.
- Industrial consumers are the SEB's best-paying customers. Loss of industrial consumers would force SEBs to reduce subsidies and raise tariffs for agriculture and domestic consumers.

The main hindrances of captive power are uncertainty regarding the availability of fuel, lack of evacuation facilities, restrictive SEB policies on wheeling, banking, and third party sale and sale of surplus power to SEB.

The restrictive captive power policy adopted by some of the states may not prove to be good in the long run. If the economy continues to grow, as expected, there will again be a huge demand supply gap and given the fact that capacity addition over the next few years from the public sector is not likely to be very significant, we will again be faced with the possibility of economic growth being hampered by lack of power.

2.f.5 Renewables & Rural Electrification

Being a tropical country, India is abundantly endowed with renewable energy sources in the form of solar, wind, biomass and small hydro. Now-a-days, several renewable technologies are not only commercially available, but are also economically viable in comparison with fossil fuels, particularly in the remote far-flung areas since they are not economically viable to connect through a conventional grid system. With a strong industrial base and successful commercialization of technologies in wind, solar photovoltaics, solar thermal, small hydro and bio-energy, India, today, is in the forefront of international efforts to harness renewable energy resources.

In the area of power generation about 3 percent (3560 MW) of power-generating capacity based on renewable energy has been installed in the country and 90 per cent of the investments have come from the private sector.

India is planning to add about 12,000 MW power generating capacity from renewables by the end of the11th. Plan, almost half of it will come from wind, 3500 MW from biomass and 2000 MW from small hydro. Renewables can play a major role in rural electrification. In India, of 80,000 villages that are not electrified as of now, 18,000 villages, mostly in remote far-flung areas, can only be electrified by using renewable resources. The features of rural electricity viz., low and dispersed loads, high transmission and distribution costs and seasonality of the load favors decentralized (*small hydro and biomass based*) power plants for meeting rural electricity needs in a sustainable manner.

Rural people are often not in a position to afford the cost of electricity and they meet their basic energy needs through the use of energy sources like firewood, cow dung, agricultural residue and kerosene. However, inefficient exploitation of these resources has led to environmental degradation. Power from renewables would reduce the consumption of kerosene (for lighting) and diesel (for lighting and irrigation) used in rural areas, leading to reduction in imports, which would have macroeconomic and security benefits.

There exists a close linkage between carbon trading and renewable energy market development. Analysis shows that renewable energy technologies are among the low cost options for carbon mitigation. In the next decade, there is a possibility for India, to earn foreign exchange through carbon trading.

2.g. Need to Develop Future Indigenous Energy Sources

2.g.1 Coal Bed Methane (CBM)

India has 400 Billion Cu. M. of CBM with heat value 8500-9000 K Cal/ Sq. Cu. M. CBM, a clean fuel for power generation, is currently being wasted during coal mining. This release not only creates safety hazards in coalmines but also causes global warming when released in the atmosphere. There is a need to explore this wasted potential. Different strategies should be worked out for unexplored and explored coalmines depending on the quality and quantity of CBM available.

2.g.2 Gas Hydrates

Gas hydrates, which contain mostly methane, are considered a clean source of energy for the future. This ice like crystalline substance is stable at high pressures and low temperatures prevailing in the deep-sea sediments and permafrost areas. As per present estimates, the potential is 6156 trillion cubic meters. India has a National Gas Hydrate Mission, which has been focusing on: laboratory studies and scientific research on physical, chemical, geological, geophysical and thermo-dynamical aspects of sea floor

stability: the environmental impacts of possible methane releases to the ocean and the atmosphere; technology developments for the exploration of methane potential using improved seismic techniques in addition to specific geophysical and geological studies including cores specimens, etc., to identify the quality, quantity and the nature of the hydrate; and finally technology development for the safe extraction of these hydrate from depths either in the form of gas or slurry as well as their storage and transportation. While the scientific research and laboratory studies continue, simultaneously a pilot scale project could be planned for technology demonstration relating to exploration and exploitation.

2.g.3 Ocean Energy

Ocean is a potential source for non-conventional energy. At present, India is developing a pilot scale technology demonstration OTEC (Ocean Thermal Energy Conversion) plant with power rating (Gross) 1 MW using the Rankine cycle with ammonia as the working fluid. It is estimated that OTEC plant in higher capacity ratings of the order of 100 MW could provide energy at a cost comparable to other conventional energy sources.

2.g.4 Other fuels:

Sufficient R & D efforts should be devoted to the development of fuel cells, hydrogen energy, Dy-methyl-ether (DME), cold fusion and bio-fuel, which could contribute significantly to ensure India's energy security.

Fuel cells, which convert the chemical energy of hydrogen or hydrogen-rich gas directly into electricity in an environmental-friendly manner, are on the verge of a commercial breakthrough. Some countries like Canada, Japan and the United States have already started commercial production of fuel cells. In India, fuel cells have been successfully developed and demonstrated in power plants and fuel cell vehicles.

Hydrogen energy is another promising fuel for the future. Solar hydrogen projects have been set up in Europe, Japan, and the U.S.. Furthermore, the U.S. has enacted a special hydrogen act to earmark a minimum of 30 million dollars every year for hydrogen research. Recently, the American President announced a 1.2 billion dollar Freedom Fuel initiative to develop technology needed to produce commercially viable, hydrogen-powered fuel cells. In India, hydrogen energy has been successfully demonstrated in power generating units, motorcycles and air conditioning.

In an Indian context, **bio-fuel** is another suitable source of energy. Bio-fuels like ethanol, are mainly extracted from molasses produced in the sugar-making process. The Government has already launched 5 per cent ethanol-blended petrol in certain regions of nine states, the proportion of which would be increased to 10 per cent in the later stage. India will save nearly Rs. 5,000 Crore[2] annually on oil imports by blending five per cent ethanol with petrol. There were also plans to enforce doping diesel with ethanol to reduce import dependence.

[2] 1Crore = 10 million

2.h Improving energy efficiency

Energy efficiency involves efficient utilization of scarce resources, which is essential from energy security perspective. Improving energy efficiency increases productivity, significantly reduces the green house gas (GHG) emissions and reduces solid waste production.

Policies and programs that have been used in countries worldwide to improve efficiency in the energy sector can be classified as

- Good housekeeping practices,
- Regulation and/or standards,
- Industrial cogeneration,
- Fuel switching,
- Fiscal policies like taxes, tax rebates, subsidies etc.,
- Agreements/ targets,
- Benchmarking,
- Energy audits,
- Information dissemination and demonstration, and
- Research and development.

The industrial sector in India, despite a w*in-win* situation, has not paid much attention to energy efficiency improvement for three main reasons:

- Most of the manufacturing units still depend on old machinery.
- Relatively high cost of capital as compared to European/USA standards.
- Uncertainty about the long-term growth of the particular industrial sector.

In India, energy intensive industries namely fertilizers, aluminum, textiles, cement, iron & steel, pulp & paper, and chlor- alkalis consume around 65 per cent of total industrial energy. A recent World Bank report shows that Indian Industry has the potential to save 20 to 30 per cent of total energy consumption.

Energy demand in the residential sector in India has been increasing significantly as a result of higher disposable income, changing lifestyle and patterns of energy consumption. It is generally observed that with higher per capita income, households tend to move towards cleaner, more expensive, convenient and efficient fuels. Energy appliances are becoming more and more popular in the households for recreation and comfort. Setting energy consumption standards along with energy labeling in these gadgets and appliances proposed in Energy Conservation Act would save significant amount of energy.

The enactment of The Energy Conservation Act, 2001 spells out the roadmap for the country to move up the energy efficiency ladder and would radically change the approach towards energy conservation efforts. The Energy Conservation Act aims to focus on the

enormous potential for reducing energy consumption by adopting energy efficiency measures in various sectors of the economy

The Act provides for measures to establish a statutory authority called the **Bureau of Energy Efficiency**. The Bureau will be established by merging the existing Energy Management Center to effectively co-ordinate with designated consumers and agencies for performing functions necessary for efficient use of energy and its conservation.

The Act also confers upon the Central Government, State Governments and the Bureau, certain powers to enforce measures for efficient use of energy and its conservation. There is provision for compulsory annual energy audit of large consumers.

2.i Energy security for the poor

The poor are major victims of environmental degradation and at the same time they pay substantially higher price for energy services than any other group in society in terms of time, labor and health. Since the poor are largely dependent on natural resources for their survival, depletion of natural resources, large population growth and lack of income generating activities further increases the poverty.

To facilitate the access to energy by the economically weaker segments of society, appropriate and efficient energy delivery mechanisms need to be established. Market intermediaries (distribution, dealers, retailers), facilitators (credit offering agencies and service capacity, repair and maintenance) and local participation are all necessary for ensuring widespread and effective distribution of energy products/service to empower the poor.

In India, though kerosene and LPG are highly subsidized to meet certain social objectives, the access to these commercial fuels is still poor due to lower income and inadequate distribution network. The government should strengthen the Public Distribution System (PDS) system for kerosene and explore innovative financing mechanism for LPG for better access. The government should also re-orient and widen the improved cook-stoves and community size biogas program.

Solar lighting could be a clean option for remote rural households. This will result in an estimated saving of Rs 26,758 million annually on subsidies to kerosene, which can be used to subsidize solar lanterns to the extent of 50 per cent, according to a study conducted by The Energy and Resources Institute (TERI), India.

2.j Require building a National Energy Map from the viewpoint of national resource endowment

This necessitates the development of a comprehensive database on production, consumption, transportation/transmission, utilization of principal primary and secondary energy sources; and other techno-socio-economic parameters, which are available in scattered form with various organizations like the Planning Commission, the Central

Electricity Authority (CEA), The Energy and Resources Institute (TERI), the Oil and Natural Gas Corporation (ONGC), the National Productivity Council (NPC), Coal India Limited (CIL) etc. Once the data set is prepared, one can proceed for the computer modeling for generating National Energy Map.

III EXTERNAL ISSUES RELATED TO INDIA'S ENERGY SECURITY

3.a Diversification of sources of oil imports in addition to the Middle East region.

The proven oil and gas reserves in the Caspian region are estimated at about 29 billion barrels and 9.3 TCM respectively, which would certainly affect the energy policies of the countries in the Asian region in the years to come. A snapshot of country-wise oil and gas resources in this region is presented in Table 2. The oil industry in the region has witnessed a flurry of foreign investment to initiate/expand exploration and production activities.

Table 2. Oil & Gas Resources in Central Asia.

	Oil Reserves			Gas Reserves		
Country	**Proven BBL**	**Possible BBL**	**Total BBL**	**Proven TCM**	**Possible TCM**	**Total TCM**
Azerbaijan	**3.6-11**	**27**	**31-38**	**0.3**	**1.0**	**1.3**
Kazakhastan	**10-16**	**85**	**95-101**	**1.5-2.4**	**2.5**	**4-4.9**
Turkmenistan	**1.4-1.5**	**32**	**34**	**2.8-4.4**	**4.5**	**7.3-8.9**
Uzbekistan	**0.2-0.3**	**1**	**1**	**2.1-2.5**	**1**	**3.1-3.5**
Total	**15.4-29**	**163**	**178-191**	**6.7-9.6**	**9.3**	**16-18.9**

(Source: EIA, 1998)

The main hurdle in utilizing Caspian oil and gas resources is the lack of export facilities. Pipelines, which are the only viable mode of transport, are still far form adequate. Although a number of pipelines have been proposed, progress on these projects has been lagging due to various technical, financial and political reasons.

3.b Investment in oil equity abroad- Russia, Kazakhstan, Vietnam, Iran, Sudan, Middle East, Indonesia etc.

In order to minimize risks by diversifying the oil import portfolio, the government of India has decided to acquire acreage in other countries. ***ONGC Videsh Limited***, the overseas venture arm of ONGC, has entered into a production-sharing contract with British Petroleum in Vietnam. Other ongoing negotiations for oil exploration with ONGC, which are under various stages of development, include countries like Iraq, Russia, Kazakhastan, Azerbaijan, Sudan etc. Recently, Reliance Industries discovered oil in an onshore block in Yemen, which is expected to be equivalent to about half of

Reliance's share of crude oil from the Panna-Mukta-Tapti offshore fields in Bombay High. However, these efforts are inadequate when compared to the current holdings of countries like China and Malaysia, whose National Oil Companies have more than 30 joint ventures with 22 of them in the upstream sector. In the Middle East, because of the presence of international oil majors, it would be difficult for Indian Companies to get any contacts. Under such circumstances, India should aggressively explore avenues on more difficult areas that are less attractive to the oil majors for reserve accretion

3.c Regional energy co-operation

South Asian countries need capital and energy to propel economic growth and improve the quality of life in an environmentally responsible manner. The region is endowed with untapped energy resources but their development, efficient distribution and utilization will require cooperation and trade among the countries in this region.

Although limited exchange of electricity already occurs between Nepal, Bhutan and India, multilateral cooperation to develop and exchange energy resources will have far-reaching economic and security benefits. India can benefit from electricity and gas imports from neighboring countries to foster its development aspirations; Bangladesh, Nepal, Bhutan and Myanmar could realize significant economic benefits from the development and export of hydroelectric power and natural gas and Pakistan's economy could also benefit from electricity export from independent power producers.

Trans-country Power Transmission

A preliminary feasibility study on the interconnection of the transmission systems of four countries including Nepal, Bhutan, Bangladesh and India in the "chicken neck" region of northeastern India has been completed. This interconnection will be able to match the projected hydroelectric power surpluses in Bhutan and Nepal with projected deficits in India and Bangladesh. In terms of trans-national electricity exchanges in Asia, an integrated policy planning approach has been developed for the Greater Mekong sub-region, including Laos, Myanmar, Thailand, and Vietnam. This approach would be expanded to cover the whole ASEAN region. In this regards, it is necessary to devise common agreed principles for determining the rates for exchanges of power including long term contracts for supply of power on sound commercial principles.

India - Sri Lanka Energy Cooperation

Hydroelectricity contributes the major share of Sri Lanka's power portfolio but there is not much hydro potential to be economically exploited. Sri Lanka is looking for alternate sources of generation to meet their short/medium term demand based on gas/liquid fuel, which are costlier options. Sri Lanka may look into the possibility of conserving hydro resources by importing power from India as base load and supporting Southern Grid of India during peak demand.

NEXANT, a professional services firm, had carried out a pre-feasibility study and had examined among others the option of a 30 kilometer submerged High-Voltage Direct Current (HVDC) link through the Palk Straits between the two countries for export of 500 MW power to Sri Lanka. The effort is to form a commercially viable link for mutual benefits of two countries.

Recently, Lanka IOC, a subsidiary of Indian Oil Corporation Limited, India, launched a downstream petroleum business in Sri Lanka as part of the agreement between Indian Oil and Ceylon Petroleum Corporation (CPC), Sri Lanka's national oil company. CPC has divested 100 retail outlets to Lanka IOC out of 1070 retail outlets under its control. In addition, CPC has agreed to extend assistance to Lanka IOC in taking over 150 dealers and franchise retail outlets soon. In all, LIOC will operate 250 Retail Outlets across Sri Lanka.

Lanka IOC has initiated the refurbishment of the 100 retail outlets in a phased manner. In addition, Lanka IOC has taken over the possession of Trincomalee Tankfarm after executing a tripartite agreement between the Government of Sri Lanka, CPC, and LIOC. Lanka IOC plans to invest 300 million Sri Lankan Rupees for the refurbishment of eight out of 99 oil storage tanks it leased in eastern Trincomalee, each with a capacity of 11,000 tons.

South Asia Regional Energy Coalition (SAREC)

SAREC, which is a non-governmental effort and is established under the aegis of the U.S. Chamber of Commerce, focuses on and promotes the concept of an integrated South Asia energy market by establishing a networking mechanism through which public and private sector stakeholders can influence regional energy policy, consumption patterns and sectoral reform throughout South Asia. In this context, it is necessary to build a model to facilitate viable energy projects. Other aspects, which need to be considered, include:

- Creating a comprehensive energy database and analysis on energy production, consumption, export, import, prices, demand forecasting and elasticity values for the development of regional energy market;

- Reforming and restructuring the energy sector;

- Establishing uniform energy codes, technical specifications and standards for all the countries in this region for smooth regional energy trade; and

- Promoting public awareness programs on the benefits of regional energy cooperation and cross border sales of electricity, oil and natural gas along with commitments and bold decisions from each government in the region.

3.d. Security of the sea-lanes

Since most of our oil and LNG imports are shipped across the Indian Ocean, the issues of safety and security of the sea-lanes are causing concern. It also becomes imperative for us to ensure the security of the maritime routes between the Straits of Malacca and the Strait of Hormuz, which took a heavy toll on tanker traffic during Gulf War, causing serious supply disruptions. Proper security arrangement should also be undertaken for offshore and deep-sea oil production and exploration in Indian Territory since one cannot rule out the possibility of a war or terrorist activities.

Another issue related to the security of sea-lanes is the territorial dispute amongst the nationals over the Spratley Islands in South China Sea. Apart from being a leading sea route through which about one-fourth of world's maritime trade takes place, the region is rich in hydrocarbon and other natural resources. Geo-political tension has already developed among China, Taiwan, Philippines, Vietnam and Malaysia to take control over the region. The development of the deep-sea port of Gwadar on the Makran coast of Baluchistan by China could pose a serious threat to our energy supplies from the Persian Gulf. Regional bodies like SAARC, ASEAN, Gulf Cooperation Council etc could be empowered to resolve the disputes.

3.e Gas import through pipelines

Inter-country gas pipeline is the most cost-effective way of transporting gas from the source to the demand centers. Being environmentally clean and less volatile than oil price, share of gas in India's future energy mix would be substantial and much of this future gas demand would be met by import through pipelines. Inter-country pipeline requires good political relationship with not only source countries but also with transit countries. Though pipeline could be a future source of risks, it could also be seen as an incentive to build good political relations with transit countries because of *win-win* situations. This section outlines possible inter-country gas pipeline to India, techno-economic feasibility study of some of them is already underway.

3.e.1 Qatar-Pakistan-India Pipeline

A 1,670 km (over 1,000 miles) gas pipeline from Qatar's North Field extending through the port of Diba in UAE could bring gas to Karachi through a sub-sea route. The pipeline is supposed to be technically feasible and it would bypass Iran. An alternative option could be picking up Iranian gas along the way to India via Pakistan. This will bring down the costs and open up a larger market. However, due to financial weakness and uncertainty about the future demand growth, Pakistan appears to be less enthusiastic about the project.

3.e.2 Turkmenistan-Afghanistan-Pakistan-India Pipeline

The 2,000 km pipelines initially proposed by Unocal and later by the Asian Development Bank (ADB) are economically viable and should become a reality after the end of the

Taliban regime in Afghanistan. An initial 1,400 km pipeline would bring gas from Turkmenistan to Multal in Pakistan, which could be extended further 600 km to New Delhi. The landed cost of gas is estimated about $2.4-3 per MMBTU.

3.e.3 Iran-India Pipeline

There are four major ways to bring gas from the Persian Gulf to India:

1-Offshore, from the Persian Gulf to the Gulf of Oman and India
2-Onshore and offshore, from Iran and along the Pakistani coast to India
3-Onshore, from the Iranian gas field terminal at Assaluyeh to the Pakistani boarder and through Pakistan to India
4-Shipping of liquid natural gas (LNG) from Iran to India by tankers (Iran is going to install large facilities to export LNG of South Pars field abroad.)

The preliminary data on feasibility studies for a sub-sea pipeline in the Pakistan shelf showed a major technical obstacle when the pipeline reaches the area where the Indus River pours in the Arabian Sea. The expected cost for transmitting gas would resultantly be higher ($4 billion) than the land route.

There have been a few positive indications in the recent past regarding the construction of a land gas pipeline from Iran to India via Pakistan. Pakistan has been assuring India it would not disrupt gas supply, for example. However, though it has been found the overland pipeline option is economically the most viable ($3 billion for transmitting 30 bcm per year of gas with low operating cost), there are serious security aspects for India that need to be looked into comprehensively. The Iranian side referred to its proposal to establish an international consortium to implement the project in order to ensure guaranteed supply of gas to India.

The most favorable option for India would be to bring Iranian Gas through a deep-sea pipeline, though there are technical difficulties in the construction and maintenance of a pipeline lying on the mountainous seabed, three thousand meters below the sea's surface. The expected cost of this option would be around $4.4 billion (Maleki, 2001).

3.e.4 Myanmar- Bangladesh-India Pipeline

The proposal to transport gas from Myanmar to India through a pipeline via Bangladesh is one from which all parties stand to gain. Even Bangladesh would consider supplying its gas to India on the same lines—although still acquiring some revenue by allowing the passage of Myanmar gas to India through Bangladesh's territory.

In addition to economic development, this proposal would also serve the main aspect of regional co-operation since both of the gas-rich countries (Bangladesh & Myanmar) would have a regional market (India).

3.e.5 Uzbekistan-Turkmenistan-Kazakhstan-Russia-China-India Pipeline

ONGC Videsh Limited has contemplated building a pipeline that would originate in Russia and proceed through Turkmenistan, Uzbekistan, Kazakhstan, to Kashi in western China, and then along the military cease-fire line with China to the Siachen glacier in Kashmir, then finally into India. The proposed pipeline is expected to enter India through Ladakh in Kashmir or Himachal Pradesh before proceeding farther down into Delhi.

3.e.6 Trans-ASEAN gas pipeline (TAGP)

The ASEAN Ministers on Energy concluded the Memorandum of Understanding on the Trans-ASEAN Gas Pipeline Project in July 2002. The MOU is a framework for ASEAN member countries to cooperate towards the realization of TAGP project to help ensure greater regional energy security. It covers the study of cross border issues relating to security of supply and emergency supply arrangements, access and use of the pipelines, and financing of the construction, operation, and maintenance of the pipelines among other things.

The master plan study for the Trans-ASEAN Gas Pipeline identified seven new possible gas interconnections covering a length of 4,500 kilometers, with total investment requirements of US $7 billion. The TAGP project would optimize the utilization of natural gas by linking gas demand and utilization centers with a pipeline infrastructure tapping the gas fields of the Andaman Sea, the Gulf of Thailand, the South China Sea, and Kalimantan and Sumatra in Indonesia. The major gas demand centers are Bangkok, Kuala Lumpur, Singapore, Batam, Jakarta, Surabaya and Manila. The infrastructure could be further extended to link the East Asian markets.

IV: CONCLUSION

The increase in current as well as future import dependence has repercussions on the country's security. With globalization taking place, supply disruptions from one region would affect the other regions as well. Safeguarding energy security is an important element in any strategy designed to achieve sustainable development, which requires short and long run measures.

This article flagged various internal as well as external issues pertaining to India's energy security, some of them require immediate attention while others need long term planning. In the short-run, government should be prepared to take emergency responses to unexpected supply disruptions and in long-run, initiatives need to be taken to promote energy portfolio diversification, integrated resource planning, regional cooperation and efficiency improvement programs.

Abbreviations

ADB	Asian Development Bank
APM	Administered Price Mechanism
BOP	Balance of Payment
CBM	Coal Bed Methane
CDM	Clean Development Mechanism
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CNG	Compressed Natural Gas
CIL	Coal India Limited
DAE	Dept. of Atomic Energy
GDP	Gross Domestic Product
GHG	Green House Gas
GTCC	Gas Turbine Combined Cycle
IGCC	Integrated Gassification Combined Cycle
koe	Kg. Of Oil Equivalent
LPG	Liquefied Petroleum Gas
MW	Mega watt
MMT	Million Metric Ton
MMTOE	Million Metric Ton Oil Equivalent
NELP	New Exploration Licensing Policy
NHPC	National Hydroelectric Power Corporation
NPC	National Productivity Council
O&M	Operation & Maintenance
ONGC	Oil & Natural Gas Corporation
PSU	Public Sector Undertaking
SEB	State Electricity Board
SERC	State Electricity Regulatory Commission
T&D	Transmission and Distribution
TERI	The Energy and Resources Institute

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