ADDRESSING THE CHALLENGE OF ENERGY SECURITY

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1. Preamble

1.1 Recent changes in the global oil market, and the unprecedented price increase of oil exceeding US $ 50 some weeks ago raises major questions on the security of oil supply today and in the future. If the projections of the International Energy Agency (IEA) are to be taken into account, then the world could see the global oil market exhibiting sudden changes in price and instability in supply for a variety of reasons. The projections of the IEA clearly indicate that most of the increase in production capacity that would be needed upto 2030 would come from OPEC nations, mainly in the middle-east. It also highlights the fact that the dependence of oil importing regions on a small number of OPEC producers and Russia will increase the market dominance of those countries and their ability to impose higher prices. India would be particularly vulnerable in this regard, given that demand for oil is likely to grow from 2.5 million barrels per day (mbd) in 2002 to 5.6 mbd in 2030. India, therefore, has to look at a range of measures by which security of supply of energy can be which are ensured consistent with the objectives of healthy economic growth that is essential to wipe out poverty in this country, and meeting the aspirations of the people.

1.2 An article in the prestigious magazine Foreign Affairs authored by former US Senator Tim Wirth and two other distinguished policy analysts highlights the importance of energy in a country's security. It begins by recounting a development that took place a century ago when Lord Selborne, the first Lord of the Admiralty dismissed the idea of fueling the British navy with something other than coal, which Britain had in abundance. It was seven years later that a young Winston Churchill who was appointed as the first Lord decided to shift the British navy to oil, which would increase speed and reduce refueling time, both major strategic advantages in the race against the Germans for naval superiority. Churchill had exercised a strategic choice, which Tim Wirth et al label as "bold, creative, and farsighted". Energy policy in India requires a similar boldness, farsightedness and strategic vision. The same article states that "US dependence on oil leaves the country's economic security and environmental destiny to forces beyond America's control". The situation for India is not different, given the prospect of this country becoming a major importer of oil in the next quarter century. This would expose the Indian economy to the risk of sudden price fluctuations, which historically have had a major impact on the Indian economy.

1.3 Energy security relates to economic security for any society in the context of energy decision making. It has perhaps less to do with the danger of a sudden physical disruption in oil supply than with the harmful economic impacts of sudden and large oil price increases. Physical disruption can be countered by adequate storage and the maintenance of strategic reserves, because any such disruption would most likely last no longer than a few days if at all.

1.4 On the other hand, the economic impacts of sudden oil price increases can be disastrous, as indeed has been the case in recent history. If we go back to the first oil

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price shock we find that the increase in the wholesale price index in India was 16.55% in 1973 and 29.01% in 1974. This was, therefore, a period of unprecedented inflation which hit the Indian economy and caused severe political impacts, which do not require any elaboration. Similar economic crises hit the country in 1979-80 in the wake of the second oil price shock and in 1990-91 after the first Iraq war. It should, therefore, be clear that India pays a heavy price in terms of loss of economic welfare, social unrest and political disruption resulting from sudden oil price increases. These impacts would only become more severe with the unsustainable dependence on oil consumption and imports that would take place in the next quarter century on a business as usual path.

1.5 The coming decades would require major investments in energy supply and infrastructure. An estimate by the International Energy Agency shows the total investments required in India as:

Investment (billion dollars)	2001-2010	2011-2020	2021-2030	2001-2030
Total Currency Investment	172	247	347	766

1.6 To ensure this level of investment would require a substantial extent of reform in the energy sector as a whole, but more particularly in the power sector. In realistic terms, if modern energy sources are to become accessible to vast areas in rural India, a departure will have to be made from the current subsidy driven approach to rural electrification. If the same approach is pursued, the power sector would only get burdened further, arresting even the slow pace of reform that we see today. The answer lies largely in the creation of local institutions that allow revenues to be mobilized directly from the community and energy supply to be managed on a decentralized basis.

1.7 Reform in the power sector is critical to the country’s energy security. In the absence of reliable and adequate supply from the grid, consumers have no choice but to invest in captive power generation facilities, which essentially depend on use of petroleum products. The Electricity Act 2003 stipulates that the Central Government is to formulate a national policy for Renewable Energy and for bulk purchase and management of local distribution in rural areas through Panchayat Institutions, User institutions, cooperative societies, NGOs or franchisees.

1.8 In the oil and natural gas sector as well, economic reforms are essential. The irrational pricing of kerosene particularly in relation to diesel oil continues unchecked, leading to large scale adulteration of other petroleum products with kerosene, which results in inefficiency and poor performance of equipment and vehicles.

2. Introduction

2.1 Energy has always been an important ingredient for the economic and social progress of human society, although the form in which the energy is used has undergone a phenomenal transition. Primitive societies used energy embodied in humans and in domesticated animals to grow crops, to travel and to carry out trade. They used energy derived from burning firewood to cook food. Modern economies use complicated energy systems essentially to satisfy the same set of needs and to produce and consume an ever expanding basket of goods and services. This process of change has been hastened since the industrial revolution due to which the overall dependence of a modern economy on energy has also increased. Energy has become an universal intermediate input for the national economy and for meeting the growing demand of an expanding population.

2.2 The modernization of the economy meant the form in which energy is used has changed from purely primary forms to a large share of secondary. Instead of burning gas/oil directly for producing light, these fuels are burned in power stations to generate electricity for lighting. Moreover, the supply of energy has become more global in nature. This has given rise to massive supply chains with huge investments to deliver energy at the point of consumption. While this process has generated economies of scale and has delivered improved efficiency of energy production and consumption, it has made the consumer dependent on each and every stakeholder involved in the chain. This, coupled with the fact that often the majority of such stakeholders are located outside the local system, has given rise to energy security concerns that cross international boundaries. The ever-increasing integration of energy markets across the globe spreads the security concern from one sector to another and from one country to another.

2.3 It was the twin oil price shocks of 1973-74 and 1979-80 that first exposed the vulnerability of modern economies to energy supply risks. Since then, ensuring uninterrupted supplies of crude oil to the economy has become one of the primary aims of energy policies around the world. However, important as oil is for contemporary societies, energy security is not just about oil security, though as detailed later, there are many reasons for the special status accorded to petroleum in this respect.

2.4 Some of the fundamental changes taking place not just in the energy markets but in markets in general, like the growing recognition of the success of competitive forces and environmental externalities have introduced constraints but at the same time have also widened the options that are available for enhancing energy security. A holistic view of energy – economy linkages is warranted because there are costs and benefits of each policy aimed at enhancing the energy security of the country, and as such should be fully evaluated before making any decision in this field.

2.5 This paper takes a view that the operation of a free market in the energy sector is not necessarily detrimental to energy security. At the same time, while the role of the government cannot be minimized, the need of the hour is to have a coherent government policy that does not inhibit the free market operating in the sector.

3. Energy security defined

3.1 The World Energy Assessment (UNDP 1999) report defines energy security as - *the continuous availability of energy in varied forms in sufficient quantities at reasonable prices*. The key aspects of this definition are discussed below.

3.2 The term "continuous availability of energy" refers to the continuity in supply in both the short and the long term. The energy system should be geared towards meeting the demand of consumers at every moment. It means limited vulnerability to supply disruptions and the capacity to cater to increasing demand in the long-term. The Indian per capita commercial energy consumption at 299 Kgoe is well below the world average of 1542 Kgoe. Yet, the energy intensity of the economy at 0.648 Kgoe/$ is 214% more than the world average of 0.302 Kgoe/$. The demand for energy will keep on rising both due to increase in population and the gradual urbanization of the economy. An urban consumer demands more sophisticated forms of energy than a rural consumer and it is exactly those forms that are vulnerable to greater disruption due to their dependence on global linkages.

3.3 The ability of manage short-term disruptions is also very essential for an energy system. There can be no completely secure system. Every system is vulnerable to some risks but the strategy should be to minimize these risks till the point is reached where the marginal benefit from reducing risks becomes lower than the marginal costs of providing safeguards against these risks. In practice, conditions often provide for a zone of adequacy within which the costs and benefits are relatively stable. Ensuring energy security then means keeping security levels somewhere within that zone (Shuttleworth,

G. 2003). It is here that the evaluation of the costs and benefits of each policy option become paramount.

3.4 The second key term of the definition is the need to ensure availability of energy in its varied forms. Technological advances have made fuel substitution possible to a large extent but many substitution possibilities remain remote, chracterised by long time lags and at best costly. For example, while the loss of power from the grid can theoretically be replaced with fuel cells or oil-fired generation, the lead times involved and relatively high costs may not present choices to the majority of consumers. The problem is especially acute in the case of the transport sector, which lacks a suitable alternative to petroleum. This is also the reason for the high importance given to oil supply security. Thus, energy security is not just about oil security but ensuring availability of all forms of energy required for the smooth functioning of the economy. This is more relevant for long-run energy security because of improved substitution possibilities among fuels in the longer term. This fact also highlights the importance of energy consuming sectors such as transport and the influence of technologies adopted therein on overall energy security.

3.5 The third most important issue is that of a "reasonable price". Often the term is used in a narrow sense, meaning the price that a consumer has to pay. Though this is important, far more important is the price that society has to pay to make that form of energy available to the consumer. Climate change has added a temporal dimension to such negative externalities associated with producing or consuming energy. Thus, ever increasing consumption of coal characterized by existing combustion technologies, even for countries that have abundant reserves of it, is subject to the articulation of global concerns, and therefore, not sustainable, even if the alternative is to use imported energy. But even if one looks at price in a narrow sense, then how does one define what is "reasonable"? This is linked with the state of economic development of the economy, the existence of capital stock based on past prices, the usage pattern of the form of energy under question and with the fundamental question of the role of market forces in achieving energy security.

3.6 The view that has found credence in many countries is that energy security should be viewed as a process of managing risk – risks of hikes in prices and risks of non-availability of supplies. The question is whether such a view calls upon intervention by the government or whether market forces should be relied upon to do the job. In the absence of external costs, competitive markets may well internalize the risks and behave accordingly apart from helping in discovering rational prices. So the issue is whether there are any barriers that will prevent the market from doing so.

3.7 The traditional argument against the market is that of market failures. Energy security can be viewed as a public good. This means that consumers cannot express their individual willingness to pay for different security levels since the provision of energy security, especially for small consumers, is collective. However, it is not clear whether this sort of market failure will seriously impact energy security (Shuttleworth, G. 2003).

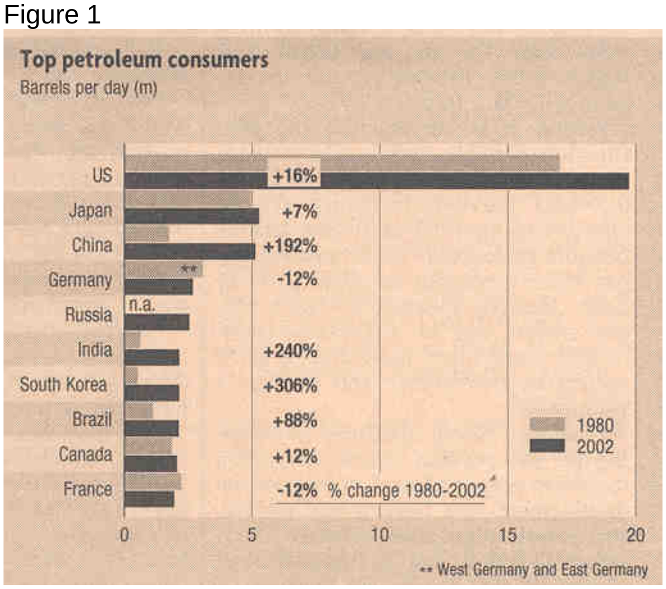
3.8 However, one important form of market failure is the inability of the market to make adequate provision in capacities to cater to rising demand in the long run. The example of the power crisis in California in 2000 is often adduced to support the need for government intervention to counter such market failures. But the real cause of the California power crisis was distorted or excessible regulation that reduced the incentives to invest in generation capacity. Energy markets are inherently volatile and investors look towards periods of high prices to earn returns on investment higher than those earned in the traditional sectors. But the general tendency is for the regulator/government to cap the prices as soon as they start climbing. Such interventions, or even the threat of such a regulation can discourage investors from funding additions in capacity and hence pose a significant threat to energy security.

3.9 There may be failures in other streams of socio-economic policy that will have an impact on energy security. For example, environmental policy will have an impact on the investments in the power sector either through the imposition of emissions norms or through renewable energy obligations. Thus policies in several sectors have to be evaluated for their impact on energy security.

3.10 Two common approaches towards energy security revolve around the need for diversity in supply sources and the need to minimize imports. However, these do not always ensure energy security. For example, for ensuring energy security in the electricity sector, diversity in supply sources should be applied not only to the fuel mix but also at the consumer end. It should be applied to the number of players in the competitive segment of the industry, the source of fuels, the supply route for fuels, the number of technologies used etc. This is in addition to the fact that there is no easy way to determine the appropriate fuel mix. Model runs should be carried out on a regular basis to forecast the demand for energy and an assessment arrived at of the future mix of supply of different forms of energy, to the extent that these change from time to time, as a result of changes in the drivers that determine energy demand and supply scenarios for the future. On the basis of model runs and scenarios for the future, energy security implications can be assessed at the global, national and sub-national levels. In particular, the implications at the household level for both rural as well as urban areas should be highlighted.

3.11 There is also growing competition for oil in the global market, with increased demand in several countries, including China and India. The change in consumption among the top consuming nations is brought out in Figure 1 during the period between 1980 and 2002.

Figure 1



Source: Financial Times

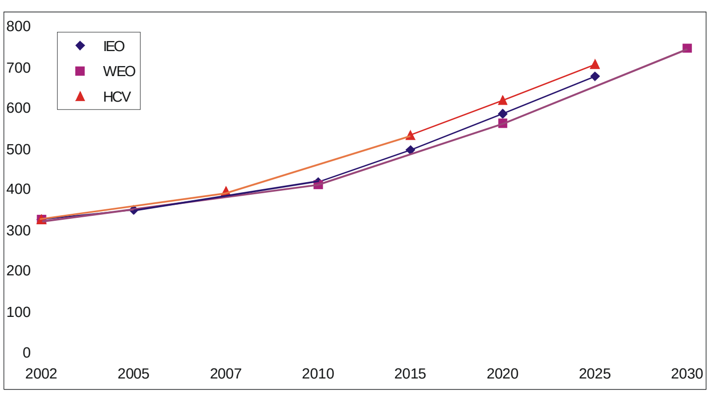
3.12 This section has identified the issues that are linked to the issue of energy security. How a government chooses to resolve these issues depends on the prevalent economic thinking in the country, the state of development of the economy and other innumerable factors. The following section looks at each of these issues in the context of the Indian economy.

4. Availability of energy – current and projected

4.1 The total primary energy supply in India has grown at a compound rate of 3.4% since independence to reach 437.7 Mtoe (Million Tonnes of Oil Equivalent) in the year 2001 (GoI 2002). While commercial primary energy grew at 5.3% over the period, the non-commercial forms grew at only 1.6%, which is not unusual given the strategy of rapid industrialization chosen in the early decades of independence. As a result, the share of commercial energy grew from 28% in 1950 to 68% in 2001 with an associated decline in that of non-commercial energy. In 2002, India accounted for 3.4% of world's commercial energy supply and for 12% of the Asia-Pacific region. In 1965, these ratios were 1.3% and 10.8% respectively. Thus, India's energy consumption has grown at a rate higher than that for the world and for the Asia-Pacific region. In terms of absolute consumption of commercial energy, India ranks 3rd in the Asia-Pacific region. But this achievement pales when one considers that our per capita commercial energy consumption is just 19% of the world average.

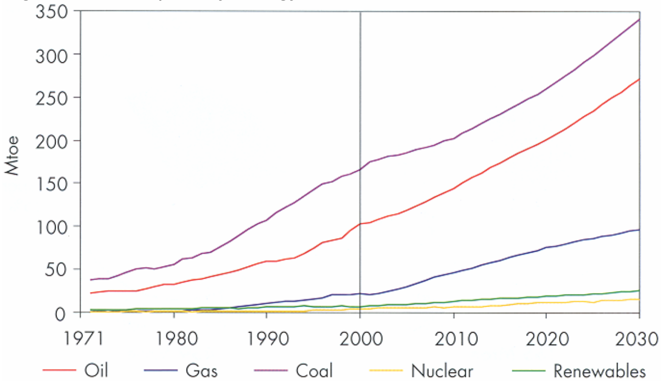
4.2 Total primary commercial energy supply in India has been projected to grow at an average rate of 3.2% over the period 2002-2025/2030 by various agencies like the International Energy Agency (IEA), the Energy Information Administration (EIA) and the Government of India (GoI) itself. These growth rates would mean a tripling of our energy requirement to reach 709 Mtoe from the current level of 325 Mtoe by 2030 (Figure 2). The overall mix of energy demand for the country based on projections made by the International Energy Agency is provided as (Figure 2a). However, our per capita energy demand is projected to grow at only 1.9% since the population is expected to grow at around 0.94% (EIA, 2003). Our energy requirement per 1000$ of GDP will fall by 1.5% per annum. These growth rates mean that our per capita commercial energy demand will rise to become 25% of the world average. Such demand growth is expected to entail significant investments in the capacity to produce and deliver these supplies of energy to the masses. This would require substantial contribution from the private sector that can be induced only if government regulation is coherent and its policies are market friendly and fair.

Figure 2 Projected energy consumption in India (Mtoe)



Note. IEO – International Energy Outlook, WEO – World Energy Outlook, HCV – Hydro Carbon Vision

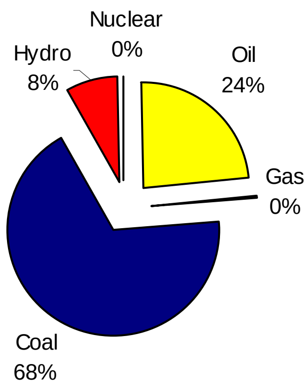
Figure 2a Total primary energy demand in India



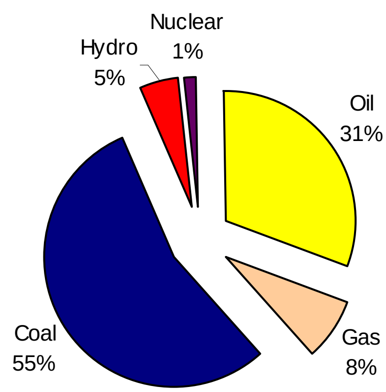
4.3 Coal

4.3.1 Coal has been the most important component of our energy matrix for a long time. Vast reserves of coal in the country have encouraged its usage. India holds 84396 million tones of proven coal reserves accounting for 8.6% of the world total (BP, 2003). Though the share of coal in India's energy mix has declined from 68% in 1965 to 55% in 2001 (Figure 3), it still remains the undisputed kingpin of India's energy policy. The policy of import substitution, followed by the government in the 1960s was extended to energy production also and hence the usage of indigenous supply sources was promoted.

Figure 3 India's energy mix over time (%)



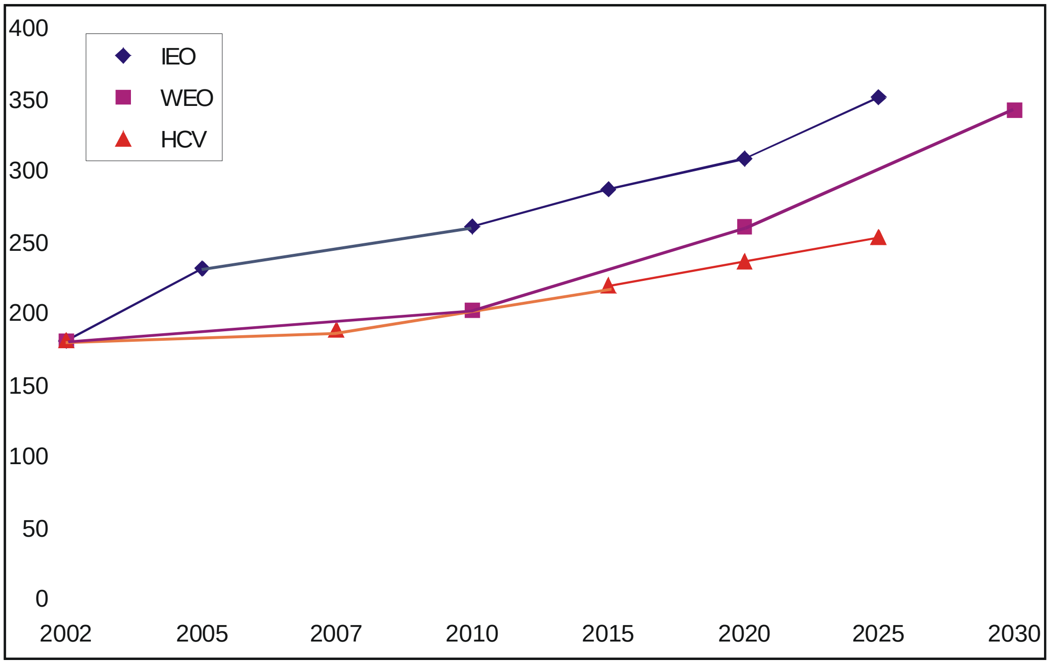
1965



2001

4.3.2 As per projections attempted by various agencies, coal consumption is expected to grow by 2.24% per annum over the period 2002-2025/2030 to reach 315 Mtoe from the current level of 180 Mtoe. The International Energy Outlook 2003 projects the highest growth rate of 2.9% while the Indian Hydro Carbon Vision 2025 projects the lowest of 1.4%. This former growth rate means a doubling of coal consumption from the present level (Figure 4).

Figure 4 Projections for coal consumption (Mtoe)
Note. IEO – International Energy Outlook, WEO – World Energy Outlook, HCV – Hydro Carbon



Vision

4.3.3 The Tenth Five Year Plan has projected coal production at 405 million tonnes (270 Mtoe) in the year 2006/7 implying an annual compound growth of 4.5% (GoI, 2002). Out of this total envisaged production, about 21% is projected to come from new mines, which will be the second largest contributor after the completed projects of various coal companies. Thus, unless investments are made by incumbents to commission the new projects, it will be difficult to meet the target. Moreover, the share of captive blocks in coal production is expected to be only 2%, which indicates the need to encourage private participation.

4.3.4 The share of underground mining in total projected production by CIL (Coal India Limited) and Singareni Collieries Company Limited (SCCL) works out to 17% and 46% respectively while that of open cast mining is 83% and 54% respectively. Open cast mines lead to environmental degradation and are not sustainable in the long run.

4.3.5 However, even these targets for production won't be able to meet the projected demand and there will be a gap of 55 million tones (36 Mtoe) in 2006/7. Thus, if efforts are not made to drastically increase production, the demand supply gap will keep on increasing. But this will be constrained by availability of land. The total projected land requirement for coal mining projects of CIL and SCCL in the Tenth Plan is 53924 hectares of which 60% is non-forest and 34% is forest land. Availability of land is very crucial if targets set for new mines are to be met (GoI 2002).

4.3.6 A move towards a more competitive coal sector has been initiated with the Tenth Plan recommending de-blocking of coal blocks held by CIL for offering to the private sector and highlighting the need for rationalizing import duty on coal for improving competitiveness of the sector. It has also proposed amendments to the coal bearing areas (acquisition and development) Act, 1957 to allow private sector rights for coal exploration and mining without taking permission from the state governments.

4.3.7 An initial set of 143 mining blocks have been identified for captive mining with an estimated coal reserve of 28 billion tones.(Ministry of Coal 2004[3]). Of these, 50 blocks have already been allotted while only 4 have started producing coal (TEDDY 2003-04). Captive mining is yet to really take off. Lack of facilities such as power and railway lines near the allotted blocks as well as difficulties in the power sector have been the important factors inhibiting progress.

4.3.8 However, there are a few other problems associated with an ever-increasing consumption of coal. Coal is a dirty fuel as far as CO_2 emissions are concerned and though India does not have any commitments to reduce CO_2 emissions for the current commitment period, high and rising levels of CO_2 emissions are not sustainable. It is true that new coal technologies like IGCC (Integrated Gas Combined Cycle) can improve both efficiency and cleanliness of coal but their cost effectiveness remains a question. An IGCC plant with an efficiency ranging from 29.1-41.5% costs 2050 $/kW (Kilo Watt) while a natural gas fired power plant with an efficiency of 36.7-60.0% costs only 750$/kW (World Gas Conference, 2003).

4.3.9 Indian coal is generally of low quality with high ash content and low calorific value. It exists predominantly in thick seams. Nearly 70% of coal reserves are locked up in seams over 3.5 m thick and of this, 58% is in seams over 5 m thick, containing extraneous matter.

4.3.10 The best quality of metallurgical coal is found in the mines of Jharia, Bihar and in some mines in Raniganj, West Bengal. The mining of these good quality coals is complicated because of the indiscriminate exploitation in these areas in the pre-nationalization era and the heavy built up areas over such deposits. Millions of tonnes of good quality coal has been left in pillars. Jharia and Raniganj mines also have large areas under fire. As a result, the production of coal from these areas has been declining over the past few years (TERI 2001).

4.3.11 Most of the coal production is restricted to the Eastern and South Eastern parts of the country while consumption centers are in the West and North India. Coal therefore has to be transported over large distances depending primarily on the railways. The coal freight of Indian Railways is very high since the freight on coal cross-subsidizes that of essential commodities and passenger fares. It would be essential to develop a pricing strategy for coal that essentially ensures :

a) Adequate returns to producers, so that they cannot only ensure proper upkeep of coalmines but also generate internal resources for expansion of capacity.
b) Eliminate subsidisation of transportation of other commodities and passenger traffic, so that coal does not bear the burden of costs of other railway movements.
c) Rehabilitation of mines takes place appropriately, so that the environmental damage particularly from open cast mining is eliminated.
d) The policy framework and pricing structure should be such that the coal industry attracts private sector investment and leads to privatisation of both coking coal as well as non-coking coalmines.

4.3.12 In spite of the substantial investments made in the coal sector, underground mining has made little progress in terms of productivity due to difficult mining conditions, low levels of skills and a large workforce. Consequently, underground mining is still not viable. On the other hand, reserves that are suitable for open cast mining are depleting rapidly. Production can be increased only if state-of-art underground mining technology is adopted and developed. In the case of deep deposits of coal, in situ gasification would be the most attractive and viable technology. ONGC is currently engaged in some work in

[3] http://coal.nic.in/list-cm-1.htm

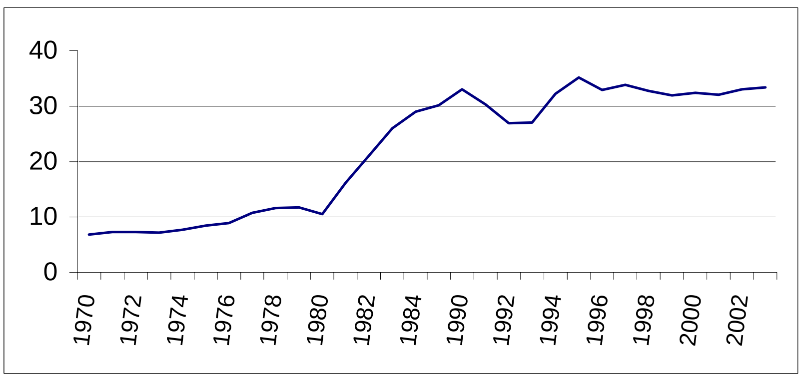
this field, but a far more ambitious programme of action is required critically in the country for long-term benefit.

4.4 Oil

4.4.1 There are three aspects of the physical dimensions of oil security. One is the availability of crude oil which could be refined to produce petroleum products, another is the availability of the refining capacity to do so and the third is the availability of infrastructure to deliver the product to the consumer.

4.4.2 The indigenous production of crude oil has remained flat for many years now (Figure 5). It received a boost from the discovery of the Bombay High field in the Western offshore area in the 1980s but any major discovery has since eluded us.

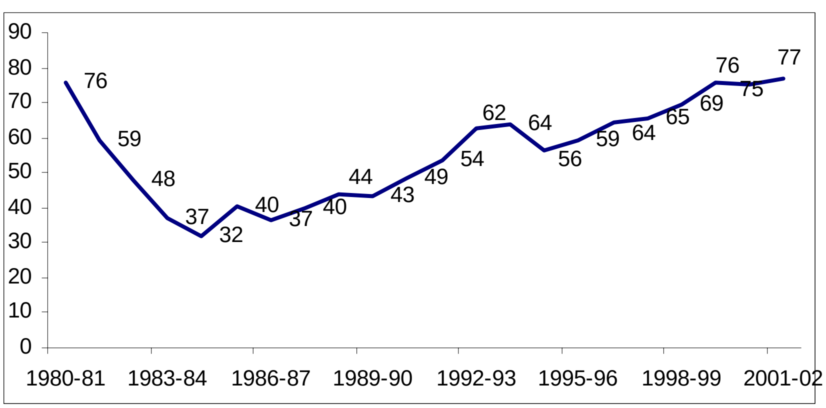
Figure 5 Trend in indigenous crude oil production (TMT)



Source: Ministry of Statistics and Programme Implementation (2004)*4*

4.4.3 We are currently importing 77% of our petroleum consumption (Figure 6) with major share accounted for by the crude oil. Over the years, the share of crude oil in our imports has risen due to significant refinery capacity additions (Figure 7).

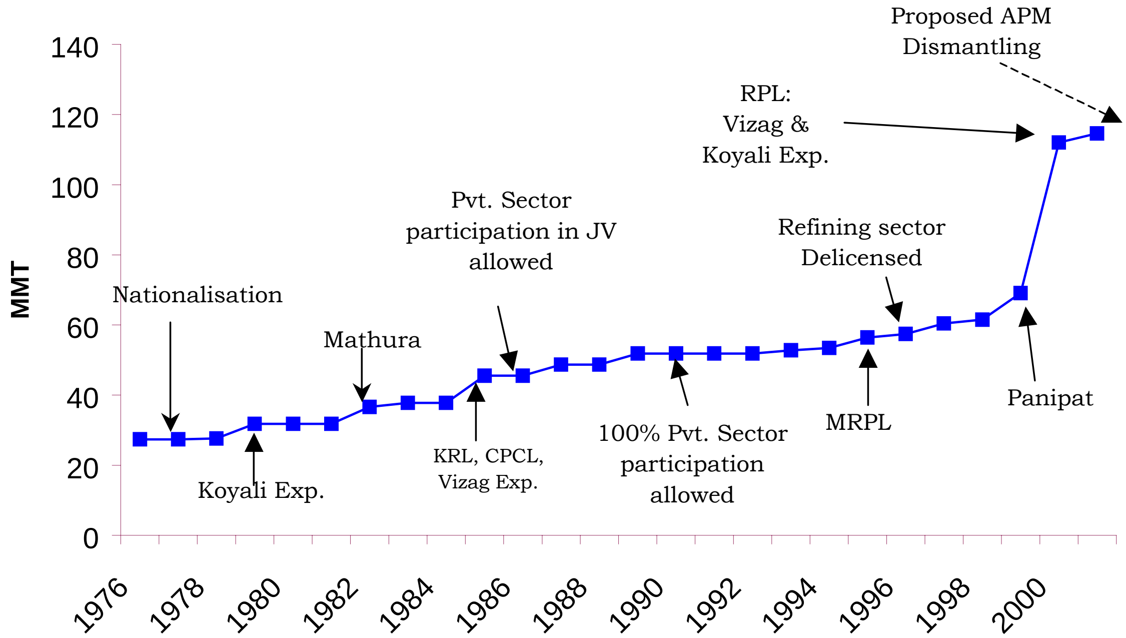
Figure 6 Imports as a percentage of petroleum consumption (%)



Source. Own calculations from Indian Petroleum and Natural Gas Statistics, 2000-01

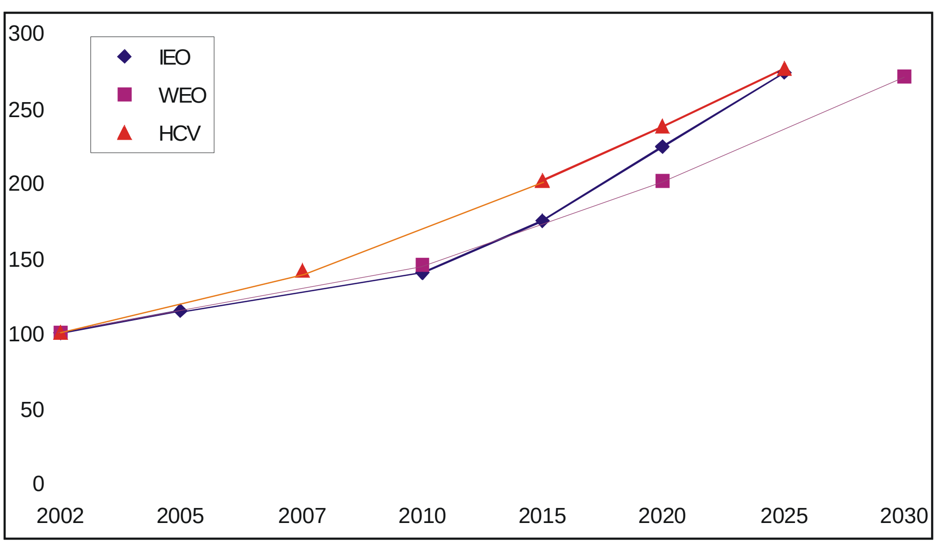
[4] http://mospi.nic.in/mospi_energy_stat.htm

Figure 7 Refinery capacity additions (MMTPA)



4.4.4 As per available projections, our crude oil demand is expected to grow by a compound rate of 4.2% per annum over the period 2002-2025/2030 to reach about 274 Mtoe (Figure 8). Assuming a refinery loss of 8% gives refinery throughput of 295 Mtoe. Our current indigenous production falls way short of this demand. By these projections, we would be importing about 88% of our consumption in 2030.

Figure 8 Projections for oil demand (Mtoe)



Note: IEO – International Energy Outlook, WEO – World Energy Outlook, HCV – Hydro Carbon Vision

4.4.5 The New Exploration and Licensing Policy, launched by the Government of India, has seen 4 rounds being held since then while the fifth is in progress. This policy has managed to attract significant investor interest. But the prospects of finding another

Bombay High remain remote. Moreover, rising demand in the economy requires four to five such large discoveries to become self sufficient in crude oil.

4.4.6 ONGC Videsh Limited (OVL), the sister concern of ONGC has been aggressively looking at acquiring exploratory and producing blocks in other parts of the world. This is certainly a laudable effort and will improve the physical availability of crude oil at the time of crisis but as pointed out below, it is not the physical availability of crude which is the major issue. Moreover, it is unlikely that such efforts will bridge the entire gap between domestic production and consumption.

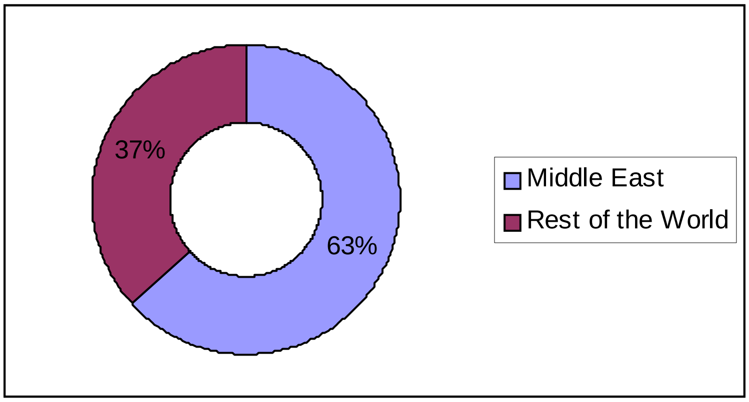
4.4.7 So given that imports of crude oil will remain important for the country, we have to ask whether oil imports really compromise our energy security and if they do, then in what way can such risks be mitigated? There is a view that imports may actually enhance our energy security by increasing the diversity of supply sources and giving the country access to crude oil reserves of other countries. But concerns on oil imports primarily stem from the apprehension that supplies may not be available at any moment and also from the geopolitics of oil.

4.4.8 This is linked to the question of whether there is enough oil available in the international market. The global proven reserves of oil have grown at a compound rate of 2.12% per annum over the period 1980-2003 to reach 156.7 thousand million tones (BP, 2004). At the current consumption of 3636.6 million tonnes, the R/C (reserves to consumption) ratio comes to 43 years and it has been around that level since late 1980s. This means that on an average, the world is at least discovering as much oil as it is consuming. According to the United States Geological Survey, there are still about 412 thousand million tonnes of conventional crude, or 3 times that of the current proven reserves, oil lying undiscovered (USGS, 2000). Then there is the tar sands project in Alberta Canada that holds some 24 thousand million tonnes of oil. Thus, the world is not running out of oil. In fact, as the current proven reserves get exhausted, the price of oil will rise, which will in turn make previously unviable fields economical to develop and thus adding to reserves and to production. However, the era of cheap oil is certainly over. Notwithstanding the prospects of Iraq and Soviet Union opening up to foreign investments, it is definitely more unlikely to find easy oil now. Exploration efforts have to move deeper in the ocean or will have to move into the perma frost of Siberia and the Arctic to find oil. All this will have a significant impact on world oil prices though longer-term availability will never be an issue.

4.4.9 However, a general concern is that about 63% of the world's proven reserves lie in the Middle East, a region prone to instability (Figure 9). Because of such huge reserves, the region has the lowest cost of production in the world (Figure 10), which makes it the "swing" supplier and hence gives it a major say in the world crude oil market.

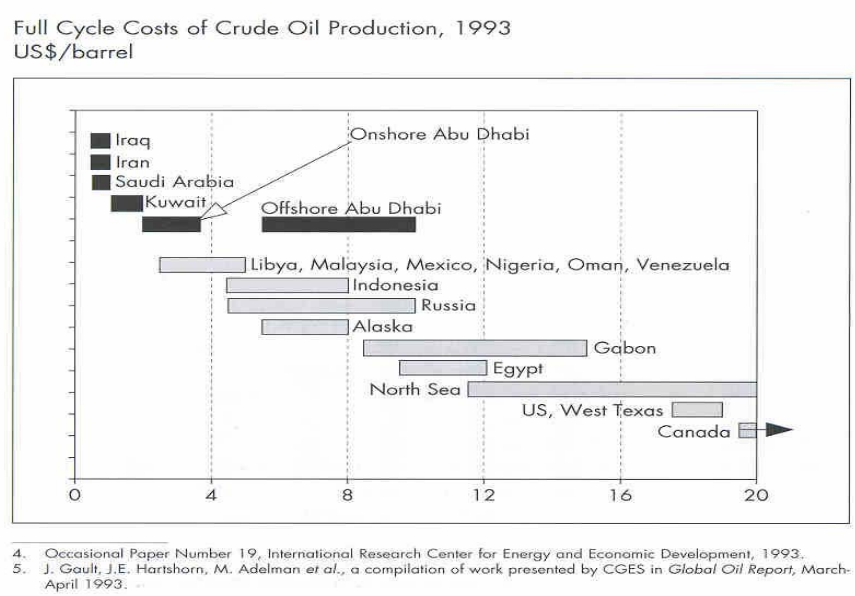
4.4.10 It is interesting to mention that the bulk of incremental oil in the future is likely to come from the members of OPEC situated in the Middle East. According to the IEA, the share of global supply from OPEC nations in the Middle East would go up from 21 mbd in the year 2000 to 51.4 mbd in 2030. This places a heavy reliance on supplies and exports from this region.

Figure 9 Distribution of world proven oil reserves (%)



Source. BP Statistical Review of World Energy, 2004

Figure 10 Full cycle costs of crude oil production ($/bbl)
Source. IEA 1999



4.4.11 Coupled with this is the fact that the region has significant excess capacity (Table 1). Saudi Arabia, with an excess capacity of about 2 Mb/d (Million Barrels per Day), acts as the swing producer, matching the global demand and supply. Total excess capacity of 160 million tonnes gives the region enough power to influence global crude oil prices. Thus the very thought that global oil prices are influenced to a large extent by an unstable region gives rise to oil security concerns and makes oil imports a source of uncertainty and risk.

Table 1 Output and Targets of oil production for countries in the Middle East (Mb/d)

	Production Jan 2003	Target Jan 2003	Capacity	Excess capacity
Saudi Arabia	8.50	7.963	10.50	2.00
Iran	3.65	3.597	3.90	0.25
Kuwait	2.00	1.966	2.20	0.20
UAE	2.07	2.138	2.55	0.48
Qatar	0.73	0.635	0.80	0.07
Iraq	2.47	NA	2.70	0.23
Total with Iraq	19.42		22.65	3.23
Total without Iraq	16.95	16.299	19.95	3.00

Source: Petroleum Argus Global Markets, Volume XXXIII, 6, 10th February 2003

Note: Other producers in the study area are not expected to have significant excess capacity

4.4.12 However, this dependence does not always flow in one direction. The major exporting countries are also dependent on the oil exports to a large extent (Table 2). This high dependency on oil and gas for export income, coupled with the fact that trade as a whole plays an important role in the economies means that these countries are also vulnerable to "*demand shocks*". This means that volatility in oil prices is not good even for the exporting countries. It also means that oil prices would never remain down for too long and thus will not discourage non-OPEC production.

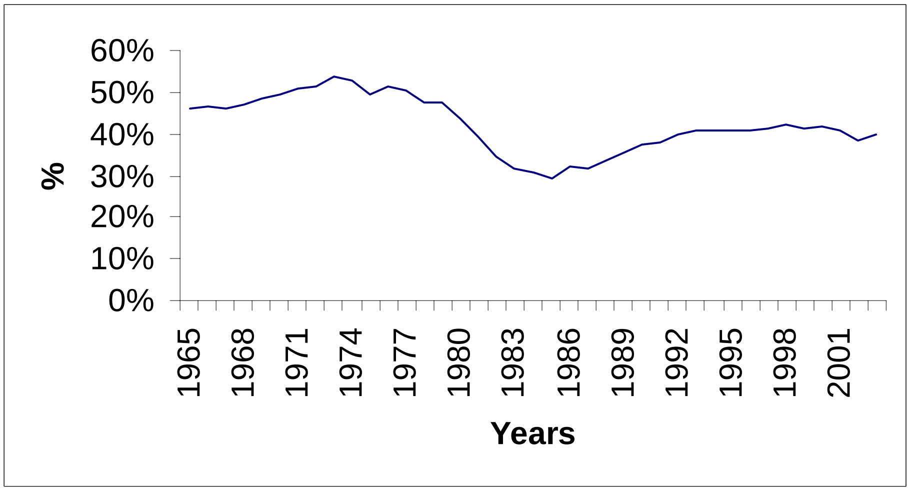
Table 2 Percentage of oil and gas in total exports for ME countries (%)

Country	Hydrocarbons as % of exports
Saudi Arabia	88
UAE	76
Yemen	88
Qatar	86
Bahrain	71
Oman	80
Iran	74
Average	80

Source: World Bank Country Statistics

4.4.13 But what prevents the prices from going up? It is the non-OPEC production and the potential impact on demand that checks the OPEC's power to raise prices. High prices, if continued for a long period of time, kill the demand by encouraging energy efficiency technologies and fuel substitution. They also encourage non-OPEC production, which threatens OPEC's market share in the long run. The share of OPEC in world crude oil production has already decreased from 46 % in 1965 to 40% in 2003 after reaching a high of 54% and a low of 29% in the intermediate years (Figure 11). Thus, OPEC has an incentive to keep prices within manageable limits. But given the fact that OPEC would have to make large investments in new capacity for supply of oil, this body would have a tendency to increase prices far beyond the stated band of $ 24 – 28 per mbd. Intense discussion is already taking place within OPEC on laying down a higher band of prices for the future

Figure 11 Trend in OPEC's market share (%)



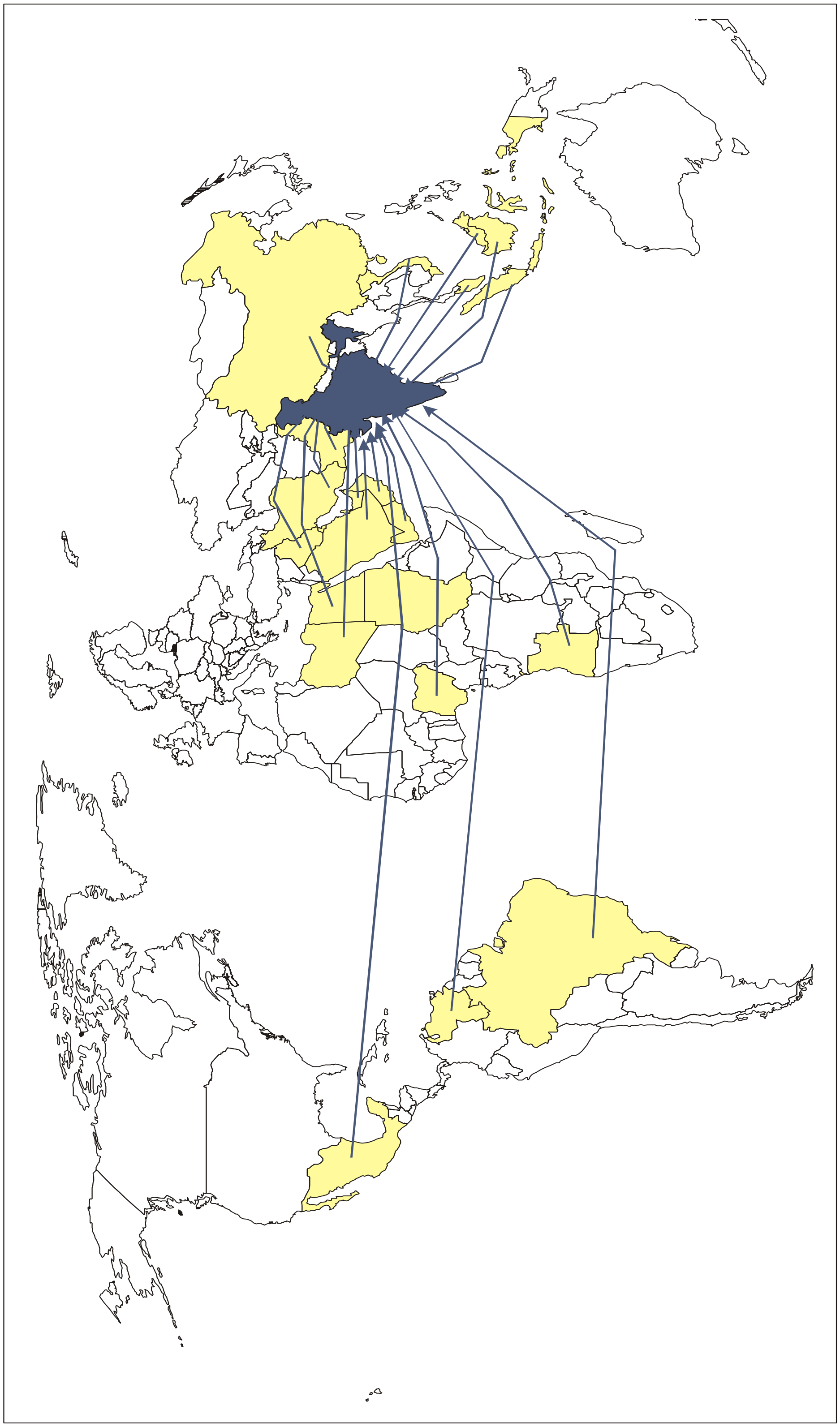
Source: BP, 2004

4.4.14 Thus, questions can be raised on the long-term availability of crude oil at reasonable prices. But the other aspect of energy security is the need to maintain supplies during a supply shock. As the events of recent years show, the mere apprehension of a shortfall in supply can lead to high prices of crude oil.

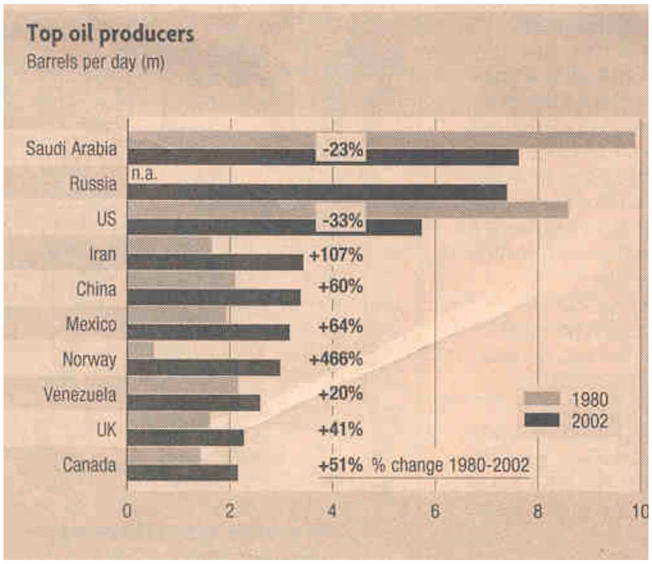
4.4.15 One view is that oil imports are a concern because they make the country dependent on a source or crude oil that may not be available during a crisis. Such a crisis could be a war in the Gulf or an accident in the Straits of Hormuz or the Straits of Malacca or the Suez Canal etc. An important strategy here would be to increase the diversity in supplies of crude oil. Figure 12 shows the countries from where oil imports are being sourced by Indian companies.

4.4.16 The international trade in crude oil and petroleum products has been going up for many decades. While the world oil demand rose at a compound rate of 1.3% over the period 1971-2001, the world imports of crude oil and petroleum products rose at a compound rate of 1.8% over the same period. Thus, while the world oil trade was 0.6 times that of world oil consumption in 1971, the ratio rose to 0.7 in 2001 indicating the increasing importance of trade in world oil consumption (IEA 2002). In the history of oil disruptions, the single biggest was the one that occurred during Iraq's invasion of Kuwait. During the period August 1990 – October 1990, some 4.5 Mb/d of crude oil was taken out of the market. This represented 6.8% of world crude oil production and consumption and 14% of world crude oil trade. Currently, India accounts for just 3.12% of world crude oil consumption and 3.5% of world crude oil imports(BP Stats 2004). And with more and more of crude oil being traded in the spot market, the availability of crude oil to the country is not a big concern. It is the economic impact of high prices that is likely to hurt the country the most. The important question is whether market forces can minimize the impact of such disruptions on the economy or is it the government that has to intervene.

Figure 12 Oil import sources for India



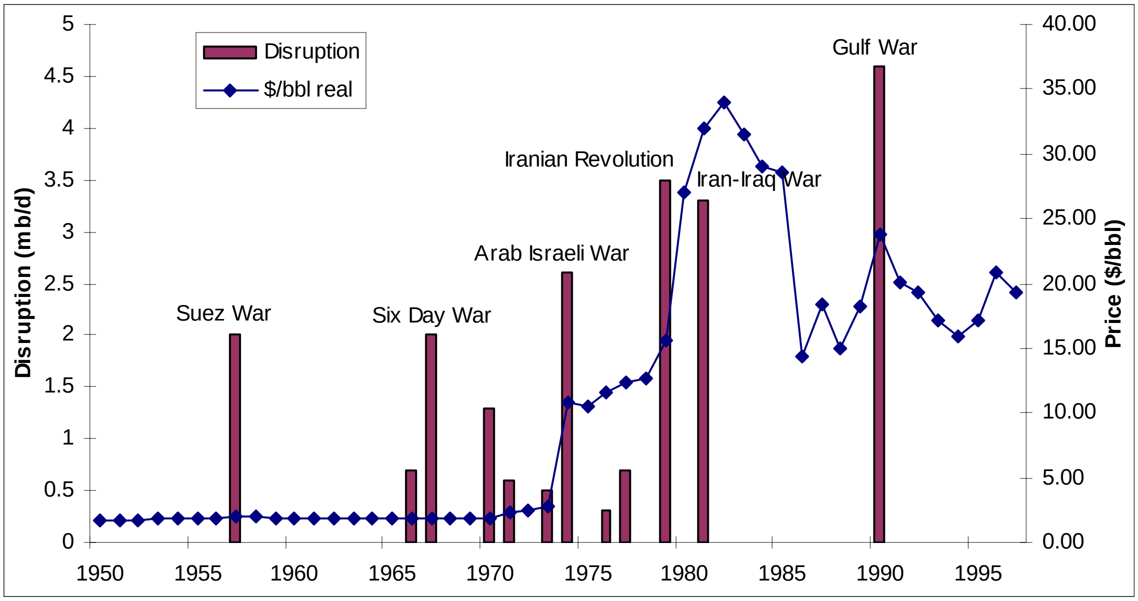
4.4.17 Figure 13 shows the current levels of production in major producing countries.



Source: Financial Times

4.4.18 Any disruption in the international oil market manifests itself in higher prices of crude oil (Figure 14) and petroleum products everywhere and given that prices in our country are also linked to international parity, this gives rise to pressure for high domestic prices irrespective of the fact that we have had surplus refining capacity for many years now. Any hike in price of crude oil is invariably passed on to the consumer by the public sector marketing monopolies. After all, the costs to produce and deliver gasoline to the consumers includes refinery processing costs, marketing and distribution costs, retail station costs and profits for all the players in the chain, in addition to the cost of crude oil to the refineries. That the prices are artificially held stable by the government is no consolation since the difference, which is paid by the government, is reflected in huge budgetary deficits and is ultimately borne by the taxpayers. In the ultimate analysis the sooner the Government of India allows oil product prices to be set by market forces the better it would be for the oil industry and for the consumer. The social obligation of supplying the oil products to every location in the country, irrespective of financial viability, can be ensured by an appropriate policy mix consisting of incentives of transparent subsidies.

Figure 14 Major disruptions and the price of crude oil



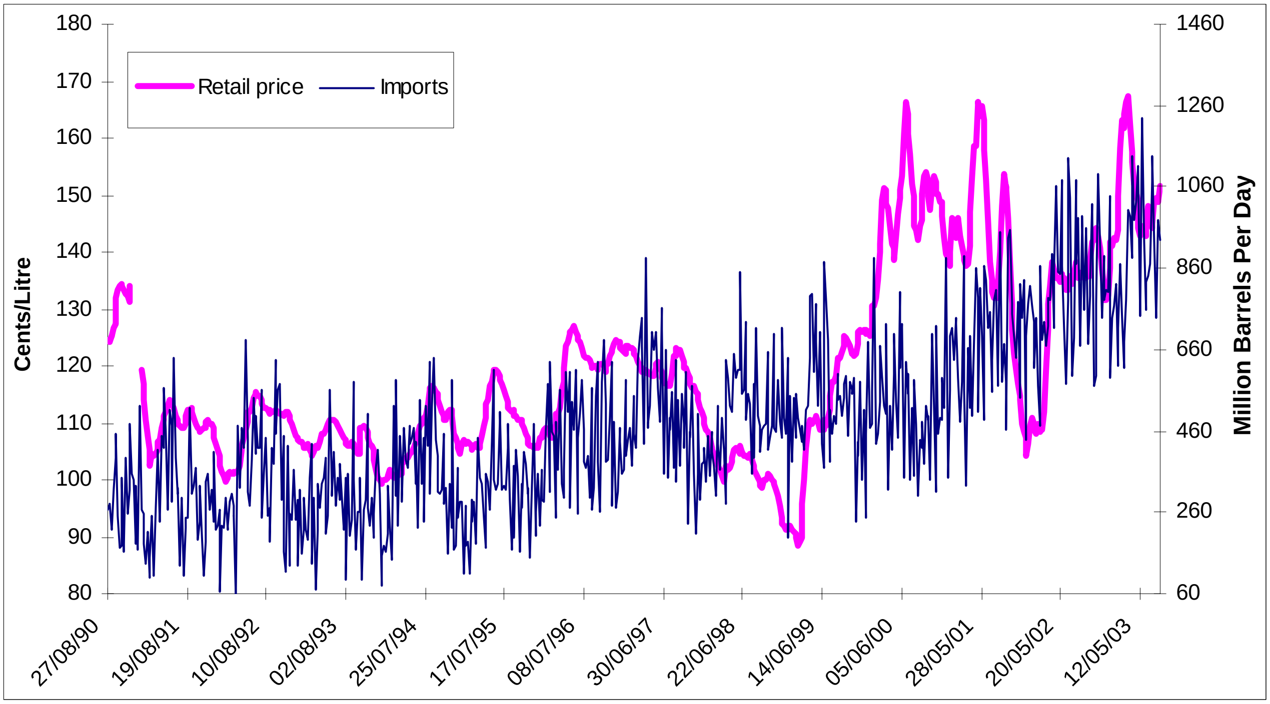
4.4.19 Oil prices since 1970, preceding the first price shock are shown in nominal and real terms in figure 15.

Figure 15

Source: Financial Times

4.4.20 The following figure (Figure 16) gives the movement in the weekly retail gasoline prices in USA along with the weekly import volumes. As can be seen, prices do go up along with imports indicating the fact that imports of gasoline supply the product at the margin. But gasoline imports in India have dried up and we are in fact exporting gasoline due to the excess refinery capacity in the country. It should be recognized that in the event of surplus refining capacity, import parity is not the true opportunity cost of consuming gasoline. Now that we have excess capacity, prices should be deregulated and full competition should be permitted so that product prices are competitive to a large extent. This will have various benefits.

Figure 16 Retail prices in gasoline and the imports



Source. Energy Information Administration, USA

4.4.21 First of all, consumers' won't be shouldering the burden of high prices to give exorbitant returns to the incumbents. Prices at each location will never go beyond the ceiling set by the import parity if imports are made competitive. Making imports competitive will also provide a cushion during supply shocks, as imports will be only as costly as the indigenous supply. And as long as consumers are willing to pay high prices, there is no reason to suppose that there will be any physical shortages. Moreover, high prices during a crisis will reduce the demand for products and hence will help to reduce the requirement of crude oil. This then reduces the need for strategic reserves. This will also make the players in the refining sector more efficient since cost of production will be the key competitive element. And not only will the processing costs go down, refiners will also try and reduce the cost of crude oil, thereby looking at alternative crude oil sources and exploring hedging strategies to minimize risks in supply. Thus, supply security concerns will also be addressed to a large extent.

4.4.22 But what about the long-term security of supplies? Is our refinery capacity expected to remain in surplus forever? This depends on the investment that this sector can attract which in turn depends on the return that the sector can generate. The table below shows the capacity additions envisaged in the Tenth Five Year plan for the period 2002/03 to 2006/07.

Table 3 Planned capacity additions (MMTPA)

Year	Refinery	Company	MMTPA
2002/03	Barauni	IOC	1.80
	Haldia	IOC	1.40
	Mumbai	HPCL	0.33
	Narimanam	CPCL	0.50
	Jamnagar	RPL	6.00
	Jamnagar	Essar	10.50
Sub-total			20.53
2003/04	Koyali	IOC	4.30
	Panipat	IOC	6.00
	Mumbai	BPCL	5.10
	Chennai	CPCL	3.00
	Bongaigaon	BRPL	0.35
	Paradip	IOC	9.00
	Jamnagar	Essar	1.50
	Cuddalore	NOCL	6.00
Sub-total			35.25
2004/05	Kochi	KRL	6.00
Sub-total			6.00
2005/06	Jamnagar	RPL	17.00
	Jamnagar	Essar	12.00
	Bhatinda	HPCL	9.00
Sub-total			38.00
2006/07	Bongaigaon	BRPL	0.30
	Bina	BORL	6.00
Sub-total			6.30
Total X Plan			106.08

Source: Report on the sub-group on refining for the Tenth plan, GoI

4.4.23 These numbers bring out the importance of a well-designed tariff structure. Today India has perhaps the highest levels of import tariffs on oil products and therefore, very high levels of effective protection. This is likely to be detrimental to the interest of consumers and of downstream industries who would be required to operate increasingly against global competition.

4.4.24 If all these capacity additions materialize, then the refinery capacity will rise to 220 MMTPA (Million Tonnes Per Annum) by the year 2006/07, which would be sufficient to meet our refining requirement for the next 30 years. But not many of these investments are expected to materialize. Plans for four grassroots refineries at Bhatinda, Bina, Cuddalore and Paradip, totaling to 30 MMTPA, have already been postponed or shelved. Essar's 10 MMTPA refinery is also delayed by several years and the exact year of commissioning is uncertain. Together with the proposed expansion plans of these refineries, total capacity addition of 53.5 MMTPA looks doubtful. If only the expansion plans of current refineries materialize, the total refinery capacity will end up 160 MMTPA by the end of this decade, which will be not sufficient to meet the demand for petroleum products by the year 2015.

4.4.25 For investments in the refinery sector to materialize, a good network of pipelines as well as market determined prices of transportation fuels (accounting for 45% of total demand) is needed. Refiners like Reliance export much of their output at lower than domestic prices because the company does not have marketing outlet or access to pipelines to move its products at low cost. This reduces the return that the company can expect to earn on its investments in capacity additions.

4.4.26 Sale of HPCL (Hindustan Petroleum Corporation Limited) and divestment of BPCL (Bharat Petroleum Corporation Limited) will go a long way in improving the competitive structure of the market and will make investments in refinery capacity attractive. The government has also introduced the Petroleum Regulatory Authority Bill that will establish the Petroleum Regulatory Board to oversee the functioning of the sector. The board will lay down the rules for common access to the pipelines which would help to stimulate investments in the pipeline sector. In general, competition among different oil companies would help to bring about greater security of supply.

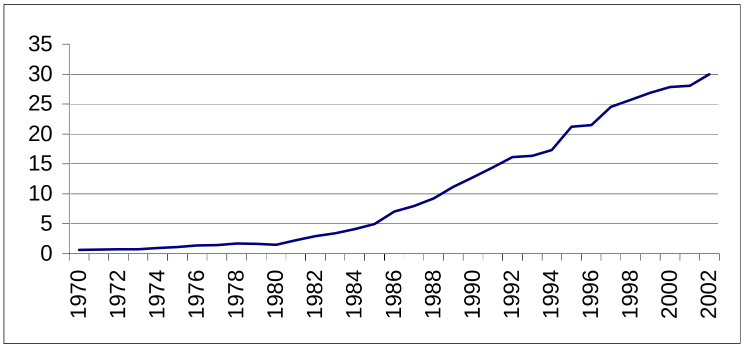
4.4.27 But there is no better way of improving security than reducing intensity of usage and moving towards non-oil sources of energy. By using more efficient technology, the oil intensity of the economy can be improved. The oil intensity rose from 5.33 Kgoe/1000 Rs in 1965 to 8.50 Kgoe/1000 Rs in 1989 after which it stabilized and has dropped marginally since. The recently formed Bureau of Energy Efficiency is planning to make energy audits mandatory for the industrial and commercial sector, which will improve the efficiency of usage. Phasing out of older vehicles in major cities in the country is also a positive step in this regard. An appropriate auto oil policy for the country would be critical in ensuring not only proper air quality, which has serious health implications, but also in ensuring energy security. Even more important is the need for major expansion and improvement in public transport both inter-city and intra-city. The greatest challenge in achieving such a goal lies in creating a financial framework and structure that would allow the operation of public transport without driving it to bankruptcy. The country requires a major thrust in improving the efficiency of energy production and use throughout the system.

4.4.28 In the short run, of course, security can be ensured through the provision of an appropriate strategic reserve of petroleum or products. There should also be emergency plans for reducing consumption of energy and oil products in a manner that minimizes the economic impacts for short periods of time. These emergency conservation efforts should be prepared with a clear evaluation of various options and their implications.

4.5 Natural Gas

4.5.1 Gas consumption in India has grown at a compound rate of 14.31% since its usage began in the early sixties. It got a boost from the discovery of the Western Offshore hydrocarbon fields in the early seventies. Natural gas offtake at 29972 MCM in 2002/03 was 6.9% higher as compared to 28037 MCM in 2001/02. However, it has slowed down a bit in the recent years due to the constraint posed by indigenous production (Figure 17).

Figure 17 Trend in natural gas consumption in India (BCM)

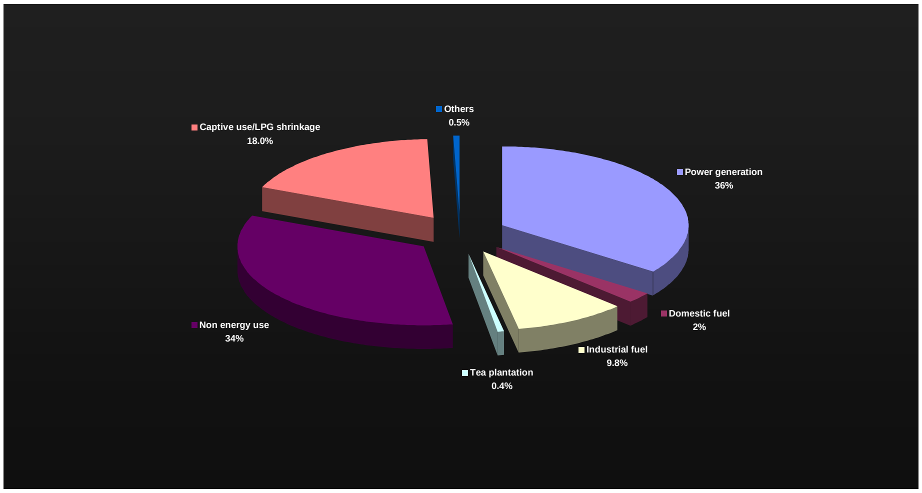


Source: Ministry of Statistics and Programme Implementation (2004)[5]

4.5.2 The power sector accounts for the bulk of natural gas consumption in the country followed by the fertilizer industry (Figure 18). This pattern is not expected to change drastically over the coming decades. Hence, developments in these two sectors are likely to play an important role in the economics of any gas import plan.

4.5.3 The basic reason for promoting the use of natural gas in the country is to enhance energy security. At the broadest level, the more diversified the fuel supply sources, the more secure is the energy supply. The country has substantially diversified its energy matrix since the 1950s when coal was the predominant fuel. Though coal still remains an important fuel, the shift towards hydrocarbons is evident (Figure 2a). Thus, further diversification of energy sources will enhance energy security. Then, there are a few problems associated with ever increasing consumption of coal as pointed out above.

Figure 18 Sector-wise natural gas consumption in India in 2002-03 (%)



Source. TEDDY 2003-04

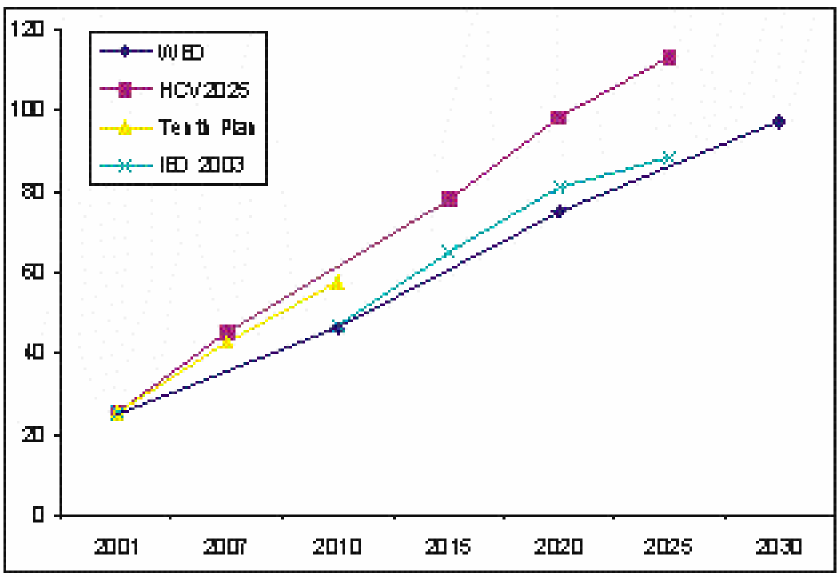
4.5.4 The recently enacted Electricity Act 2003 is also expected to boost the demand for gas in the power sector. Lower costs, higher efficiency, lower gestation period, and high standardization of the equipment of a gas fired plant as compared with a coal based plant means that a private sector player looking to maximize the present value of investments will find gas more attractive than coal. Moreover, the Act also gives a boost to captive power plants and given the high level of shortages, it is possible that many industrial

[5] http://mospi.nic.in/mospi_energy_stat.htm

users will install gas based captive power plants. This is not to suggest that natural gas can replace coal from power generation. Both have their specific places in the energy matrix of the country and judicious mix of both will go a long way in ensuring energy security for the country.

4.5.5 This is reflected in the demand projections made by several agencies. The Hydrocarbon Vision 2025, released by the Government of India in 1999 projected natural gas demand at 113 Mtoe in the year 2025 of the total primary commercial energy demand of 706 Mtoe, giving natural gas a share of 16%. The International Energy Outlook 2003 (IEO) has pegged Indian gas demand at 88.4 Mtoe in the same year, giving it a share of 13%, while the World Energy Outlook 2004 (WEO) sees gas demand of 97 Mtoe in the year 2030. The Tenth Five-Year Plan has projected demand for natural gas in the country at 43 Mtoe in the year 2006/7, rising to 58 Mtoe in the year 2011/12 (Figure 19), giving a share of 10% in both years. The growth rates for natural gas as envisaged by these projections vary from a high of 9.60% in the Tenth Plan to 4.75% in the WEO. As against these demand projections, the current production of 27.36 Mtoe (MoPNG 2004) falls way short.

Figure 19 Demand projections for natural gas (Mtoe)



Note. IEO – International Energy Outlook, WEO – World Energy Outlook, HCV – Hydro Carbon Vision

4.5.6 However, these demand projections must be viewed in relation to price expectations. There is no uniform price of natural gas in the country. However a ceiling of Rs 2850/ has been pegged. Adding the transmission tariff of Rs. 1150/MCM gives the delivered price (excluding duties and taxes) as $2.73/MMBtu along the HBJ (Hazira-Bijapur-Jagdishpur) pipeline, the longest transmission pipeline in the country.

4.5.7 Currently, about 10.37% (MoP 2004) of the installed electricity capacity in the country is based on natural gas. Of the total capacity addition of 46939 MW (Megawatt) planned during the period 2002-2007, about 6400 MW or 14% would be based on gas. Further, of the total planned capacity addition of 62213 MW during the next five-year period of 2007-2012, about 9000 MW or 15% would be based on gas. However, coal remains the major competitor for natural gas in the power sector, the above-mentioned advantages of gas notwithstanding.

4.5.8 The government of India is not oblivious to the above facts. It has taken several steps to ensure that the deficit in natural gas does not become unmanageable. The initiatives taken under the New Exploration and Licensing Policy (NELP) have started bearing fruit in the form of few major and minor gas discoveries. The most significant is Reliance's KG basin discovery. With a possible production of 45 MMSCMD, it promises to increase the current production by 1.5 times. ONGC has made six new discoveries during the year 2003/04 (East Lakhibari (oil) in Assam, Sonamura (gas) in Tripura, Degam (oil) in Gujarat, Sitarampuram (gas) in Andhra Pradesh, NMT-2 (gas) in western offshore, and G-4 in Bay of Bengal). The G-4 discovery in the KG (Krishna Godavari) basin is ONGC's first deep-sea discovery and is estimated to hold 0.8 TCF (trillion cubic feet) of gas. Private and Joint Venture companies have also made a few discoveries in the Krishna-Godavari Basins, Gulf of Cambay and onland Rajasthan. For instance, NIKO announced gas production of 15 – 20 MSCFD (million standard cubic feet per day) from April 2004 from its Bheema field in onshore Surat basin in Gujarat. The year 2003-04 also witnessed a number of international explorations. ONGC Videsh - GAIL - Korea Gas Company - Daewoo (20-10-10-60) consortium discovered a 11-17 TCF gas field at block A1 offshore Myanmar.

4.5.9 But will the recent discovery obviate the need for gas imports? The critical variable is the cost of production, which in turn is dependent on several issues like the capital cost, the operation, & maintenance costs, the profit-sharing between Reliance and the GoI (Government of India) and the rate of draw down of reserves. Our analysis, based on the above-mentioned factors, suggests a cost of about $2/MMBtu. At this cost, this gas is more likely to remain in Southern India only, covering the states of Andhra Pradesh, Karnataka, and Tamil Nadu. Recently, Tata Power opened negotiations with ONGC for gas supplies from the marginal undeveloped fields in the Western Offshore for its 1350 MW power station at Trombay in Maharastra after initial discussions with Reliance got nowhere. Reliance has also shown interest in supplying 10[6] MMSCMD of gas to the Bidadi power plant near Bangalore in Karnataka. This indicates that Reliance's gas is going to remain in Southern India only. Thus, it is not Reliance's gas in itself but the prospects of more such discoveries that could seriously affect future gas import plans. And with government offering 6 deepwater blocks Fifth round of NELP, the prospects for another "significant" discovery do not look far-fetched. But as mentioned earlier, time is the critical factor.

4.5.10 The various sources from which gas imports have been planned (Figure 20) are -

1. In the form of Liquefied Natural Gas at -
   a) Hazira - 2.5 MMTPA
   b) Dhabol- 5 MMPTA
   c) Kochi- 2.5 MMTPA
   d) Ennore- 2.5 MMTPA
   e) Pipavav- 2.6 MMTPA
   f) Kakinada – 2.5 MMTPA
   g) Gopalpur- 5 MMTPA
   h) Jamnagar- 5 MMTPA

2. Via pipelines
   a) Iran-India pipeline
   b) Bangladesh - India pipeline
   c) Myanmar - Bangladesh - India pipeline

4.5.11 The first LNG import and regassification terminal was commissioned in the year 2004 in South Asia at Dahej. The LNG import terminals at Hazira is at an advanced stage of completion and hence is certain to be commissioned. This ismore likely to be utilized in

6 http://www.thehindubusinessline.com/bline/2003/05/11/stories/2003051101520300.htm

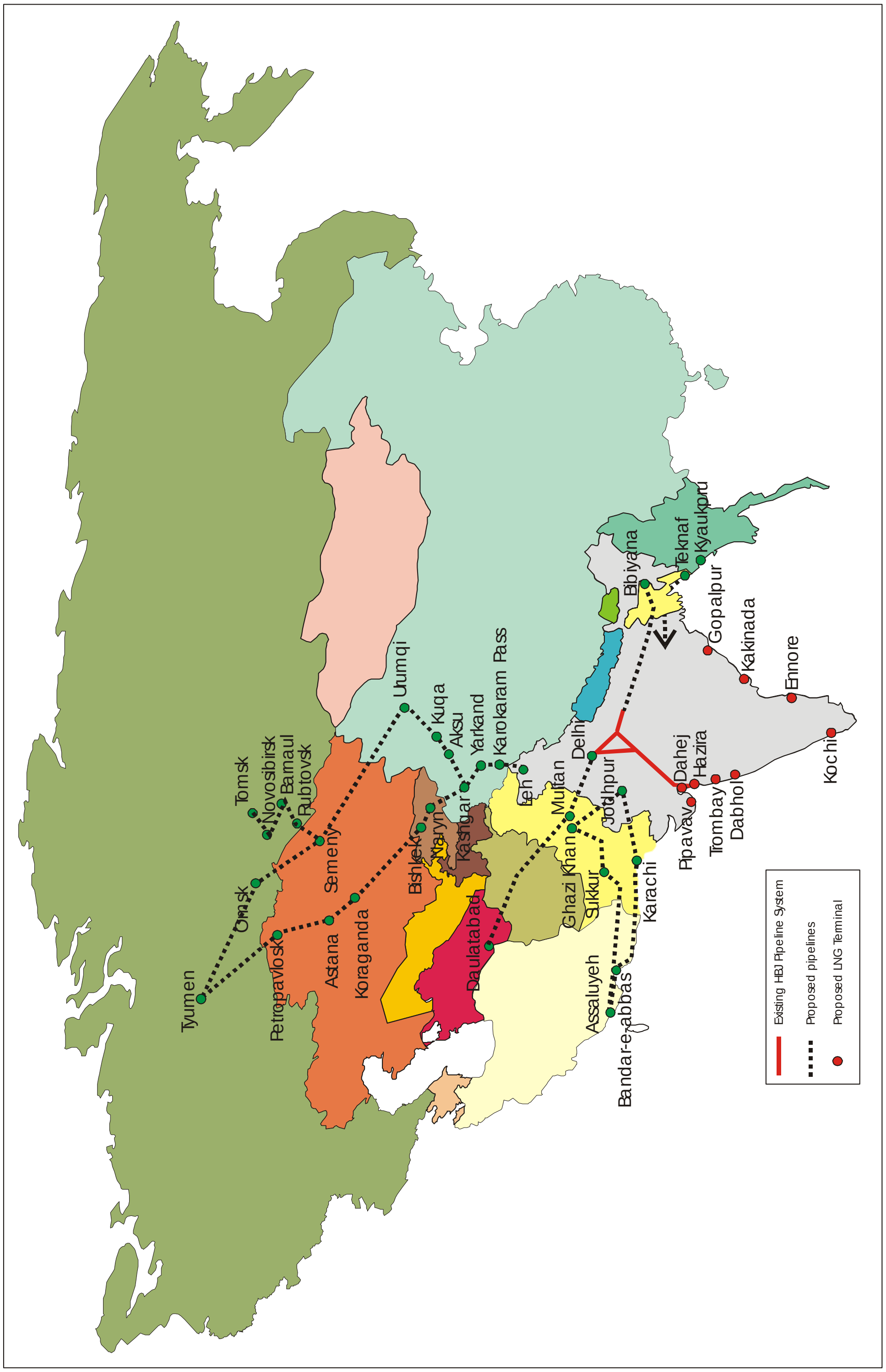
the North-West India. Thus, the deficit in Northwestern India will be reduced to 22.62 MMSCMD by the year 2006. Assuming no other LNG terminal (especially Dabhol) comes on stream, this is the market available for these import plans in the year 2006/7, but this will grow in later years.

4.5.12 Apart from these, recently India signed an agreement with Iran to import 7.5 MT of LNG under a 25-year agreement beginning 2009. Iran would sell LNG to India at a price linked to Brent Crude oil. An upper ceiling of $31 a barrel has been set. According to WEO 2004 estimates, LNG imports are expected to reach 10 BCM by 2010 and 30 BCM by 2030. Witnessing the increased dependence of India on LNG, it will become a key issue of concern for gas security. .

4.5.13

Source: World Energy Outlook 2004

Figure 20 Proposed gas import infrastructure



4.5.14 As far as import of gas through pipelines is concerned, none of the proposed projects have really taken off, because of various geo-political problems as well as political deadlocks. Recently, there has been renewed focus on Indo-Iran pipeline, imports of gas from Myanmar and Turkmenistan-Afghanistan-Pakistan gas pipeline.

4.5.15 Table 4 shows the comparative natural gas reserves and other important variables among the countries from where the natural gas imports for India are being talked about.

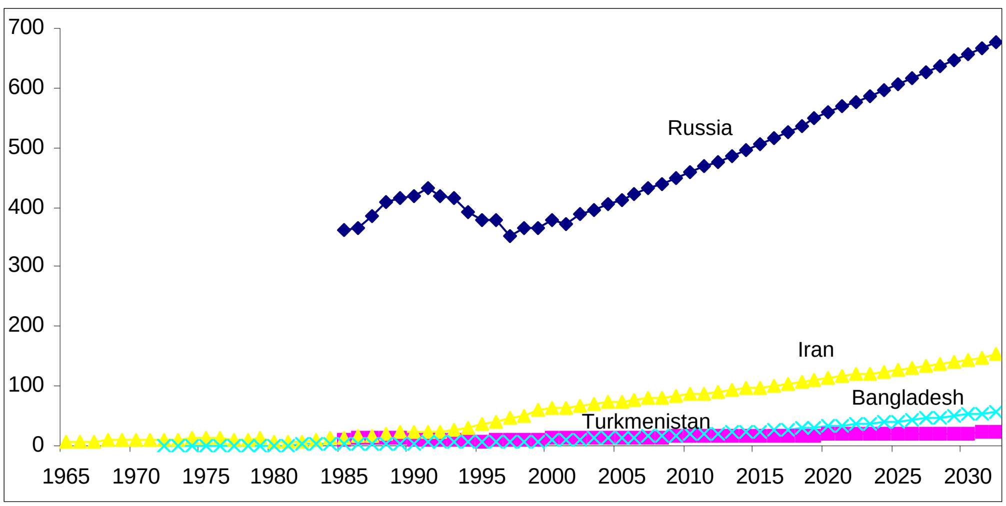
Table 4 Relative natural gas indicators (2003)

Country/Indicators	Reserves (BCM)	R/P Ratio	Consumption (BCM)	R/C Ratio
Iran	26690 (15.2)	> 100	80.4	332
Russia	47000 (26.7)	81.2	405.8	116
Bangladesh	340(.2)	27.8	12.2	28
Turkmenistan	2900 (1.6)	52.6	14.6	199

Source: BP 2004; Note: Figures in bracket indicate share of the country in the world; Figures for Myanmar are not available

4.5.16 As shown, Russia and Iran together account for about 26.7% of world's proven gas reserves. The R/P (Reserve to Production) ratios are also very healthy. However, another useful measure would be R/C (Reserve to Consumption) ratio. This is because every exporting country is likely to take the stand that its domestic requirements must be met before it considers exports. Figure 21 shows the trend in consumption of natural gas for some relevant countries. The projections are made based on compounded annual growth rate estimated in the World Energy Outlook 2003 either for the country or for the region in which the country falls.

Figure 21 Trend in natural gas consumption-historical and projected (BCM)



Source: Historical data from BP; Projections from the growth rates estimated in World Energy Outlook 2003

4.5.17 As a result of this growth in consumption, the R/C ratios in the countries will progressively decline. In the year 2032, assuming that the reserves will remain unchanged, then R/C ratio will be 70 for Russia, 90 for Turkmenistan, 151 for Iran, and 5 for Bangladesh. This shows that former three countries are most prospective as far as level of reserves required to support the Indian demand is concerned. Thus, from the point of view of gaining access to big natural gas reserves, the Iran-India pipeline seems most favorable.

4.5.18 While the policy makers in India are rightly concerned with the question of oil security, the question of gas security has been long ignored. Reason for this may be that gas occupies a less important position in our energy matrix (9% of total commercial energy supply) and due to the fact that it can be replaced by an alternate fuel like oil in its most applications. On the other hand, 49% of oil goes in the transportation sector that is largely lacking a substitute. It is entirely possible to convert natural gas to liquid fuel through established gas to liquid technologies that are now being used increasingly. Hence, a substitute for oil can be created while at the same time diversifying sources of supply in favour of pipeline imports of natural gas. Recently, there has been some debate on building strategic reserves for natural gas as well. Another major policy objective is the need for shifting greater traffic, both freight and passenger, to the Indian Railways. This of course can only happen if major improvements are brought about in the quality and range of services provided by the railways.

4.5.19 However, this obsession with oil security has totally overshadowed the fact that the potential gas demand and supply gap is becoming larger. And the indirect impacts of this deficit like continuing deficit in electricity generation and demand and the imminent increase in pollution if more coal were used are also undermining our overall energy security.

4.5.20 Gas security can be classified in 3 board terms (IEA 1995):

i) Technical risk: This arises when as a result of some external action, some supply facility is put out of action

ii) Availability risk: This is the failure to mobilize long-term supply or ensure deliverability. This describes the situation of "non-availability" of supply where gas demand outpaces gas supply.

iii) Risk of political events: These risks include both the possibility of a disruption to an existing supply, for a shorter or longer period, for political reasons and the possibility that gas supplies which are economically available from a particular source will not be mobilized because political risks are too high.

4.5.21 Given the current thin infrastructure for gas supply in India, the first two factors present a considerable threat to our gas security. The entire gas market in the country is based on isolated systems of gas supply which due to lack of interconnection give rise to security concern. The growing gap between gas demand and supply is a well-known fact. Thus, it is only the risks of third sort are currently not present in the country.

4.5.22 The question is whether the Iran-India pipeline will enhance or will further undermine our gas security. Let us take each of these factors individually.

4.5.22.1 Technical Risks

4.5.22.1.1 Given the nature of the project, no pipeline is free from such risks. Breakdown in supplies due to an accident, terrorist incident or a natural calamity can happen to any pipeline system, including our HBJ. Given the fact that majority of gas sales in India are dependent on this single pipeline does not augur well for our gas security. This aspect of security can be dealt with through an adequate risk-management program, a program for early resolution of the problem, with storage facilities at intermittent locations, with interruptible supply contracts, with a flexible network and facility to gain access to any other pipeline system, and with excess and varying capacity in different sections of the network.

4.5.22.1.2 The Iran-India pipeline, bringing 10 BCM per annum of gas will entail investments in a complementary network to cater to the demand in Northwest India that the total risk of the system is minimized.

4.5.22.2 Supply side issues

4.5.22.2.1 Gas fields operated by ONGC (Oil & Natural Gas Corporation) are the main source of supply to North West India and the fact that they are on a decline gives rise to significant risks of non-availability of gas supplies. In the form of Iran-India pipeline, India will have access to huge gas reserves in Iran with R/P and R/C ratios of more than 100 years and with sufficient excess capacity built in the system. Hence, such risks can be addressed through the Iran-India pipeline.

4.5.22.3 Political Risks

These risks are admittedly there but are in no way insurmountable. A few options that can be explained for tackling the issue are:

4.5.25.3.1 Set up a consortium of companies

a. Setting up of a consortium of companies, each handling specific sections of the pipeline (and related infrastructure) and bound together by contractual obligations could be the first step to set up the pipeline. Though the general trend in recent years has been to move towards shorter term-contracts, a long "take-or-pay" contract can go a long way in enhancing the security of gas supplies through the pipeline. It should not matter whether the company is private or public as long as the contracts provide a level playing field and companies are selected through a bidding process. Such "take-or-pay" agreements will serve as a sort of penalty on any company that fails to deliver gas to the next section of the pipeline.

4.5.25.3.2 Build enough storage facilities for natural gas

a. Even indigenous gas pipelines are not entirely secure. Natural calamities like earthquakes can also cause a leakage or even a rupture in the pipeline. The way out is first to have a program for damage control and to have adequate storage facilities at a few intervals. Of course, this would entail costs but such risks would ideally need to be covered under the LNG option also. The best way to estimate the cost of such risks is the insurance premium as judged to be applicable to the pipeline and its comparison with the insurance premier applicable to the LNG option.

4.5.25.3.3

4.5.25.3.4 Excess re-gasification facilities

Another options that can be looked into in detail is building excess re-gasification capacity if the two terminals currently under construction do not have such capacity. The Petroleum Regulatory Board Bill seeks to declare LNG receiving and re-gasification facilities as common access facilities. Again, there are costs to this option. While the capital costs can be annuitised and built into the agreement for sourcing gas, the extra costs of procuring the natural gas when the supplies from the pipeline are disrupted can be build into the contract.

4.5.25.3.5 National gas grid

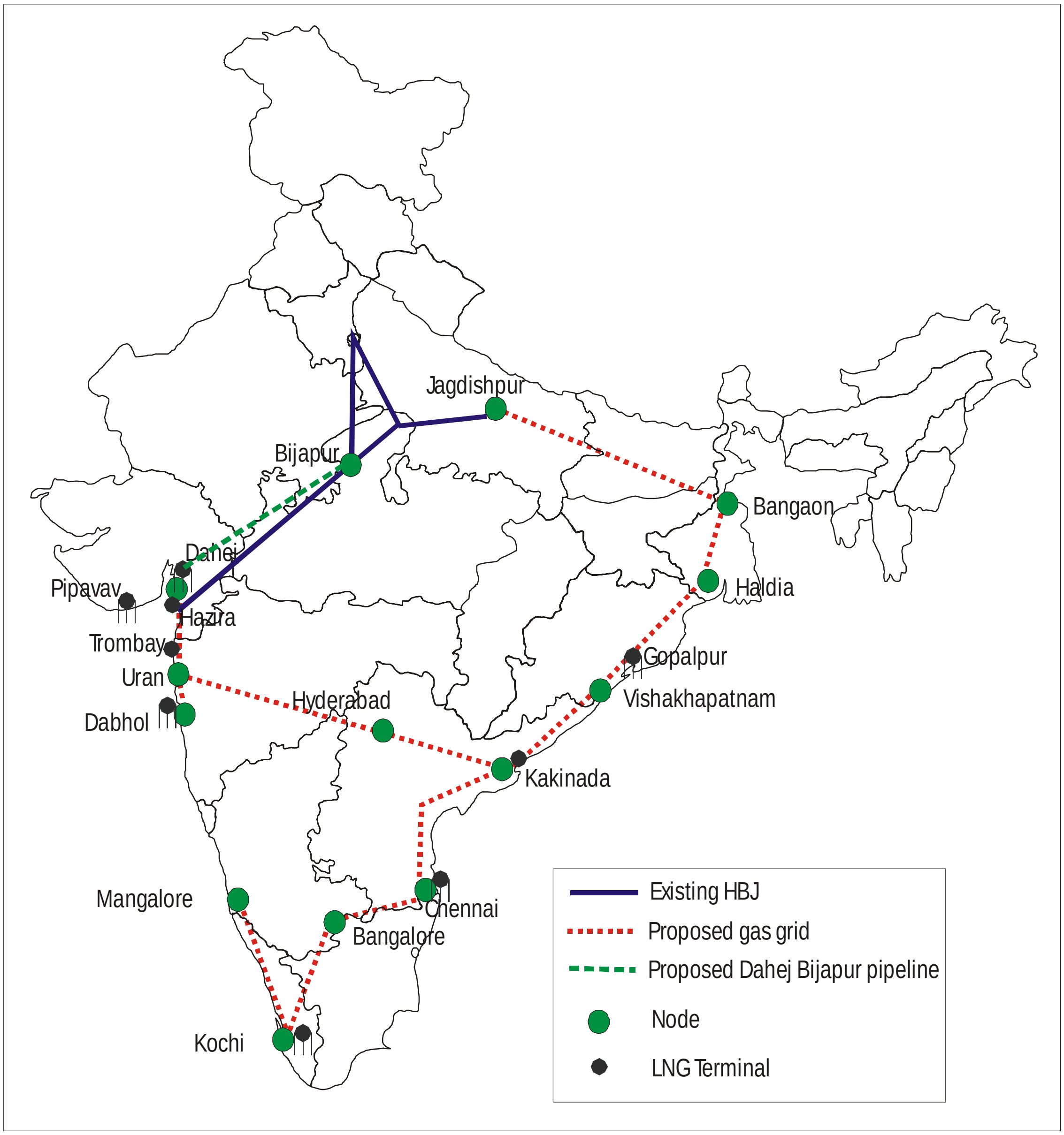
a. The most important means of enhancing our gas security is to develop a national gas grid that provides an alternative to each pipeline in the system. One possible configuration of such a grid is shown in Figure 22.

b. The presence of market forces in the gas sector in India is much better than that in other sectors. This may be because of the fact that gas is used primarily by the bulk consumers and that private companies who are getting international parity prices are producing significant quantity of gas. As ONGC’s production from Western Offshore declines and as the share of NELP fields and gas imports rise, gas prices are expected to become more and more market driven. This will play an important role in attracting private investment.

c. Efforts are also on to increase the indigenous production of gas through Coal Bed Methane, Gas Hydrates and conventional gas exploration. Private investors have shown some interest in exploring these sources of gas and coherent government policies are needed to further their interest.

d. The national gas grid has to be function on the condition of access to all parties as a common carrier. In due course, therefore, it would be essential that irrespective of ownership national gas pipelines within the country are accessible to all parties, with pricing provisions and other operating rules that are specified and administered by an independent authority.

Figure 22 Proposed National Gas Grid and LNG terminals



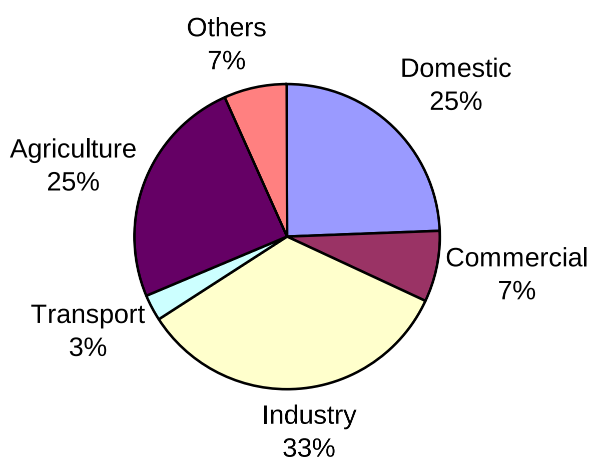
4.5.25.3.6 Electricity consumption pattern

a. Electricity demand in India has experienced a rapid growth during the 1990s. The growth has been consistently over 8% during this period, recording a growth of 8.7% in 2001/02. The consumption of electricity has risen from 4157 GWh in 1950 to 339598 GWh in 2002/03. The per capita consumption is to the tune of 567 kWh in 2002/03 as against 253 kwh in 1990 (CEA 2002/03). The number of consumers has grown from 69.6 million in 1990 to about 126.9million (as on March 2002/03) (CEA 2002/03).

b. The demand for power during 2003/04 was 84.6 GW (Giga Watt) (peak) and 559 BU (Billion Unit) (energy). Availability of power was falling short of this and as a result, the country experienced an estimated 7.1% of shortage of energy and .11.2 % shortage of peaking power.

c. Industry has traditionally been the single largest consumer of electricity in the country accounting for more than one third of the total consumption in 2002/03. However, its share in electricity consumption has been declining and has come down from 62% in 1980 to about 33% in 2002/03. The agriculture sector's share has increased from 12% to 25% during the same duration. However the share of agriculture is estimated to reduce in the future. Figure 23 gives the sectoral mix in energy sales in 2002/03.

Figure 23 Energy sales consumer category wise(2002/03)



Source: TEDDY 2003-04

d. The total installed generating capacity under utilities in India has increased to 112058.42 MW in 2003/04 from 107973 MW in 2001/02 (CEA 2003/04).. This includes thermal (coal, gas, liquid fuel), hydro, nuclear and wind based capacity. The fuel mix is shown in Figure 24. The annual electricity generation in utilities is about 558 BU in 2003/04 (TEDDY 2003/04). There is also a constituency of captive power generation, to the tune of 18361.622 MW In 2002/03 (TEDDY 2003/04).

e. The Transmission & Distribution system comprises of a wide network spanning over 500,000 ckt-km. . The total length of EHV (66kV and above) transmission lines in the central sector increased from 29 733 Ckt Km (as on 31 March 2002) to 46 246 Ckt Km (as on 31 March 2003) i.e. an increase of 55% over the previous year. The state of Andhra Pradesh has the largest transmission and distribution network of 1 005 599 circuit Km in the country. The states of Haryana, Punjab, Rajasthan, Uttar Pradesh, Gujarat, Madhya Pradesh, Chattisgarh, Karnataka, Kerala, Tamil Nadu, Bihar, Orissa and West Bengal have more than 100 000 circuit Km of T&D lines. India also has interconnections with Nepal and Bhutan.

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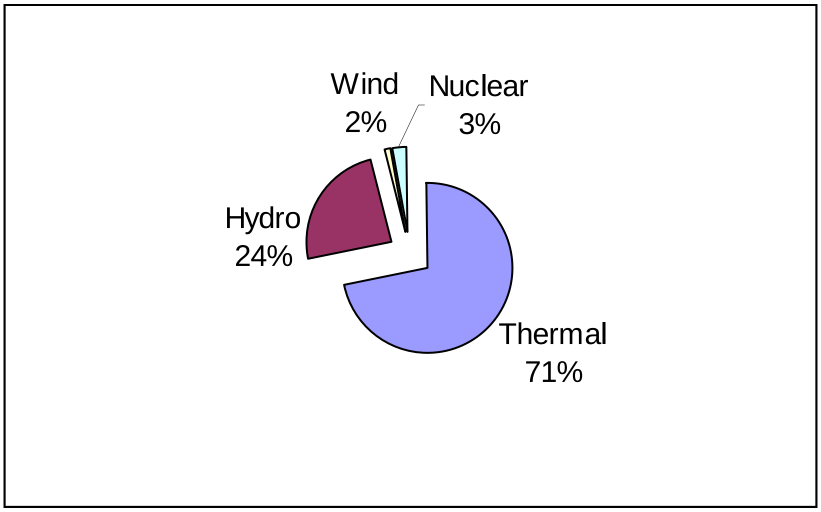
Figure 24 Technology Mix in Installed Capacity (MW), March 31, 2004



Source: TEDDY 2003-04

f. Figure 25 & 26 show the past trend in growth of installed generating capacity and electricity generation in the country with Table 5 showing the details for year 2001-2. Presently fossil fuel, in particular, coal is the main stay for power generation in India. The hydro: thermal: nuclear mix has changed from 44: 54: 2 in 1970-71 to 13:84:3 in 2003/04(TEDDY 2003/04). Hydropower's share in generation has been steadily falling (from 44 percent in 1970 to 13 percent in 2003). Considering the environmental advantages and the immense hydro potential in the country (84,000MW), the government is renewing its thrust on hydro development. Of late, emphasis is also being laid on non-conventional energy sources especially bagasse/biomass, solar and wind for grid as well as off-grid applications. In India more than 2000 gasifiers are estimated to have been established with a capacity in excess of 22 MW and a substantial number of villages have been electrified with bio-mass gasifiers based generators.

g. From the point of view of long term energy security and environmental concerns, further options such as nuclear and hydropower gain significance for a country like India. In order to reduce India's dependence on foreign oil imports these sources need to be tapped to the maximum potential. An increasing number of industrial consumers are trying the captive option, given the unreliable and inadequate supply from the SEBs.

h. Viable hydro potential in India is assessed to be about 84,000 MW at 60% load factor (1,48,7000 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% of the potential have been harnessed and 7% is under various stages of development. Thus the remaining 78% of the potential remains untapped. The utilization of hydropower in India is much lower than the countries like Norway (58%), Canada (41%) and Brazil (31%).

i. The present share of nuclear power in the country, currently, is only 2.59% (2720 MW) of the total installed capacity. The Department of Atomic Energy in the Vision 2020, however, envisages a cumulative installed capacity of 20000 MW.

j. 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 USA based on Boiling Water Reactor technology using imported enriched uranium. Nuclear power needs to be prioritized, primarily because in the recent years, India's nuclear power plants have been operating at good capacity utilization levels. Moreover, 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 location 1000 KM away from the coal pitheads. Reduction in capital costs and improvement in the performance of the nuclear power plants would further reduce the cost of nuclear power. 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 on towards technology development for first breeder reactors; enhancement of thorium utilization; engineering development of thorium based advanced heavy water reactors and matching development in the fuel cycle areas; high temperature reactors employing gaseous or advanced liquid metal alloy coolants and source drive reactors and reprocessing of spent fuels.

Figure 25 Trend of all India installed generating capacity (MW)

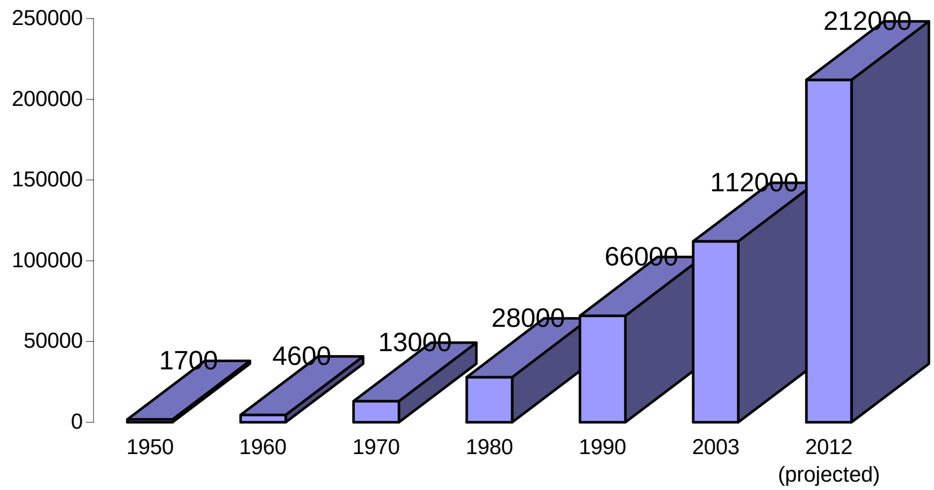


Figure 26 Trend of all India Gross electrical energy generated (BU)

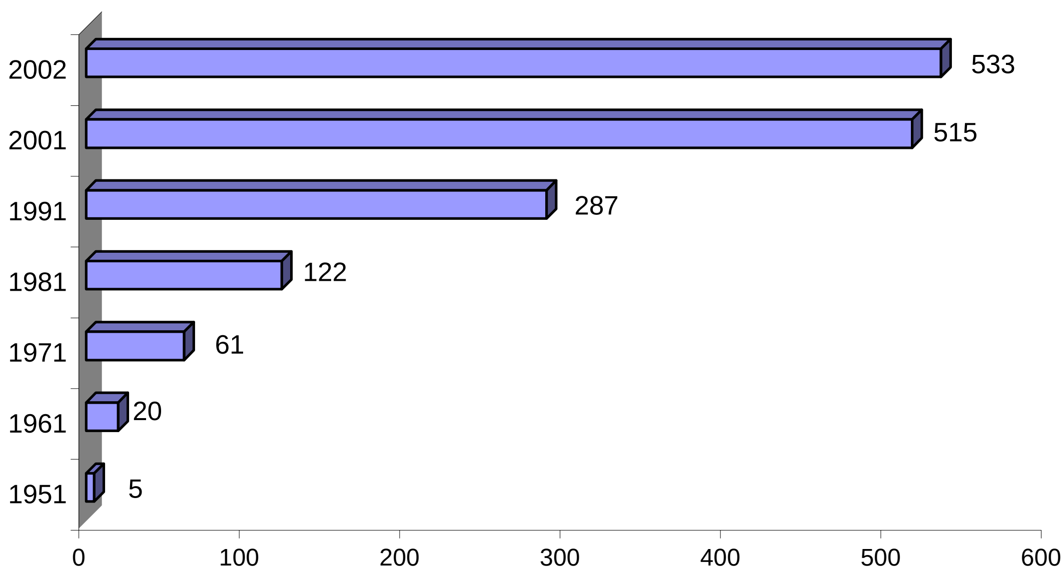


Table 5 Region wise power supply position during 2001-2

Region	Installed Capacity	Requirement		Availability		Shortage (%)	
		Peak	Energy	Peak	Energy		
	(MW)	(MW)	(MU)	(MW)	(MU)	Peak	Energy
Northern Region	28087	23200	150383	21346	142410	8	5.3
Western Region	31395	26510	175016	22024	156793	17	10.4
Southern Region	26954	22757	140516	19201	128095	15.6	8.8
Eastern Region	16190	7940	50687	7648	50197	3.7	1.0
North Eastern Region	2241	1148	5935	1043	5855	9.1	1.4
All India	104917	81555	522537	71262	483350	12.6	7.5

k. The Ministry of Power (MoP)/Central Electricity Authority (CEA) in consultation with the Planning Commission has programmed a capacity addition of 41,110 MW(excluding non-conventional energy sources) during the 10th Plan (2002 – 2007). Out of the feasible 41,110 MW, the capacity addition of 14393 MW has been envisaged in hydro, 25,417 MW in thermal and 1300 MW in nuclear respectively.

l. The shares of central, state and private sectors in the 10th Plan (2002-2007) target are given in the Table 6 below:

Table 6 Sectoral shares in planned capacity additions

Sector	10th Plan target (2002-2007) (MW)	Share (%)
Central	22832	55.41%
State	11157	27.14%
Private	7121	17.32%
Total	41110	100%

m. Because of the reforms that have been initiated in the sector, most state electricity boards are being trifurcated and subsequently privatized. Thus, over time, the importance of private sector is set to grow in the Indian electricity sector. Assuming that almost all the capacity addition envisaged by the private sector will be based on natural gas, the total investment requirement will be Rs 22787 Crores in the generation alone. For such huge investment to materialize over the next five to ten years, important reforms will need to be undertaken and existing policies need to be strengthened.

n. The regional power system are proposed to be operated in two clusters by 2007-8, one comprising Northern, Eastern and North eastern regions and the other Western and Southern region, each cluster operating in a synchronous mode. Synchronous operation of both clusters is expected by 2012-13. Currently, the Eastern region accounts for 78% of total power exchange taking place among the regions (Table 7)

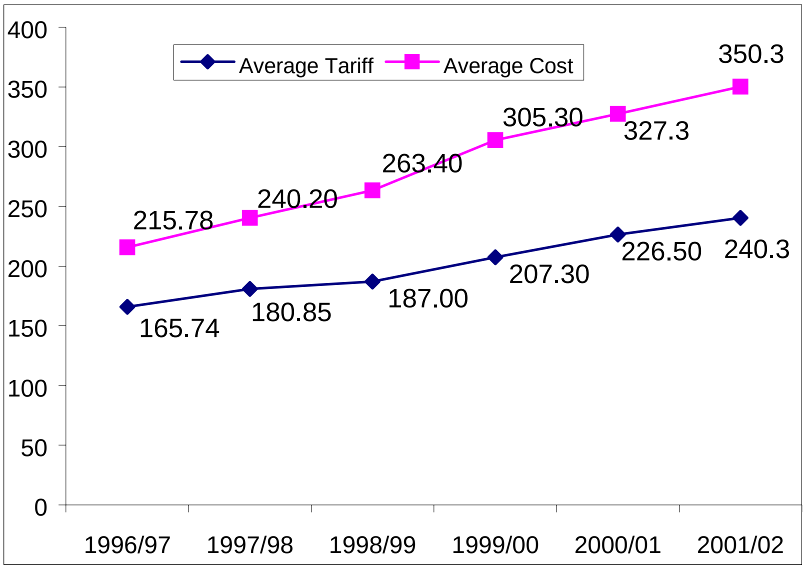
Table 7 Inter-regional power exchange (MU)

From/To	Northern	Western	Southern	Eastern	North-Eastern	Total
Northern		975.4		22		997.4
Western	299.1		798.9			1098
Southern		621				621
Eastern	1768	2380	4742		665	9555
North-Eastern						0
Total	2067.1	3976.4	5540.9	22	665	12271

Source: CEA 2003

o. The All-India average unit cost of power supply was 350.30 Paise/Kwh whereas the average tariff was 240.3 Paise/Kwh in 2001-02. This shows (Figure 27) that a large uncovered gap still exists between the costs and tariffs of power supply in India.

Figure 27 Average tariff and average costs (Paise/KWH)



p. The percentage of unit cost of supply recovered through consumer tariffs is estimated to be 64.66% and the subsidy to sales revenue ratio is 43.3% in FY 2001-02. Most of the SEBs in India incur huge losses every year. The total deficit of all SEBs in FY 2001-02 is Rs. 24837 crores (with subsidy) and Rs. 33177 crores (without subsidy). This is a serious impediment to the free market operation and should be corrected via market reforms if the gap between generation and demand is to be bridged.

q. In spite of significant growth in electricity generation over the years, the shortage remains. Most regions of the country continue to experience significant shortage in peak power and energy. At the beginning of the Ninth Plan, the energy shortage was 11.5 % and peak deficit was 18%. The actual power supply position as on March 2003/04 indicates energy deficit of 7.1 % and peak deficit of 11.2%. The present shortage is mainly on account of growth in demand for power, outstripping the growth in generation and generating capacity addition.

Table 8 Projected power supply position in 2006/7

Region	Peak Demand (MW)	Peak Availability (MW)	Surplus deficit (MW)	Surplus Deficit (%)	Energy Requirement (MU)	Energy Availability (MU)	Surplus deficit (MU)	Surplus Deficit (%)
Northern Region	35540	29667	-5873	-16.5	220820	181468	-39352	-17.82
Western Region	36223	30210	-6013	-16.6	224927	191947	-32980	-14.66
Southern Region	31017	25348	-5669	-18.3	194102	158687	-35415	-18.25
Eastern Region	11990	14221	2231	18.6	69467	83273	13806	19.87
North Eastern Region	1876	2035	159	8.5	9501	11057	1556	16.38

A&N	49	40	-9	-18.4	238	183	-55	-23.11
Lakshadweep	11	6	-5	-45.5	44	28	-16	-36.36
All India	116706	101527	-15179	-13.0	719099	626643	-92456	-12.86

r. Table 8 shows that the Eastern and the Northeastern regions are expected to have surplus electricity by the year 2006/7. Given the fact that significant inter-regional transfer of electricity already takes place in the country, this power is likely to be evacuated to other regions facing deficit, primarily Southern and Western regions.

s. Several measures have been undertaken or proposed to improve the availability of power in the long term.

Short term measures

The following short-term measures are being taken to improve power supply in the country: -

Export of power from surplus regions to deficit regions

In order to optimize utilization of available energy in the country and to reduce the shortages prevailing in different regions/states, transfer of power from the surplus region(s) to the deficit region(s) has been accorded highest priority. Table 9 gives the past and present inter regional energy exchanges.

Table 9 Inter-regional Energy exchanges during 9th Plan (MU)

Region		1997-98	1998-99	1999-00	2000-01	2001-02
From	To					
Northern	Western	115	1060	700.2	984	975.4
	Eastern	5	15	29.4	16.8	22.0
	Southern	0	184	70.8	83.8	0
	Sub-total	1159	1259	800	1085	997
Western	Northern	377	376	599	573.5	299.1
	Southern	521	1500	1067	323.9	798.9
	Eastern	1	0	0	0	0
	Sub-total	899	1876	1666	897	1098
Southern	Western	536	522	518	658	621
	Sub-total	536	522	518	658	621
Eastern	Northern	0	88	395	455.4	1768
	Western	1200	1461	2773	2471.4	2380
	Southern	820	1683	2492	3812.6	4742
	N.Eastern	454	395	397	493.6	665
	Sub total	2474	3628	6056	7233	9558
N.Eastern	Eastern	23	11.0	0	0	0
	Sub total	23	11.0	0	0	0
Total		5093	7297	9041	9874	12275

Source: CEA Executive Summary March 2002

Medium term measures: -

1. Renovation & Modernisation (R&M) and life extension of existing old and inefficient generating units. Special funds under the APDRP for undertaking R&M schemes are being provided to States.
2. Strengthening/augmentation of sub-transmission and distribution systems through funds from APDRP to the States.
3. Maximizing the inter-state and inter-regional power transfer by construction of missing transmission links and system improvement.

4. Early stabilization of newly commissioned units and overall increase in plant load factor of thermal units.
5. Pricing energy to reflect the actual marginal cost of supply, to the extent possible.

Long term measures: -

1. Expeditious implementation of capacity addition programme to enable doubling of the existing generation capacity by 2012.
2. Exploitation of hydro potential in the country at a faster pace.
3. Promoting energy efficiency and conservation measures.

4.6 India being a tropical country is abundantly endowed with renewable resources and by the end of the Eleventh Plan India plans to add about 12000 MW power generating capacity from these resources. Almost half of this will come from wind, 3500 from biomass and 2000 MW from small hydro. Renewables can also play a major role in rural electrification. In India, out of the 80,000 villages which are not electrified 18,000, mostly in remote far-flung areas, can be electrified by using renewable resources only. The features of rural electricity viz., low and dispersed loads, high T&D costs and seasonality of the load favors decentralized (*small hydro and biomass based*) power plants for meeting rural electricity needs in a sustainable manner.

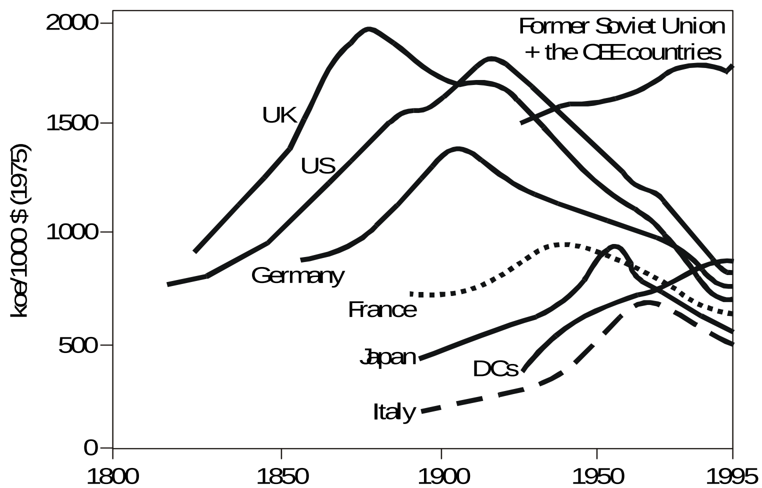
4.7 People in the rural areas are often not in a position to afford the cost of electricity and they meet their basic energy needs through the use of energy sources like firewood, cow dung, agricultural residue and kerosene. However, inefficient exploitation of these resources leads to environmental 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 have macroeconomic and security benefits.

4.8 Also, 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 sufficient foreign exchange through carbon trading.

5. Towards an Energy Efficient Economy

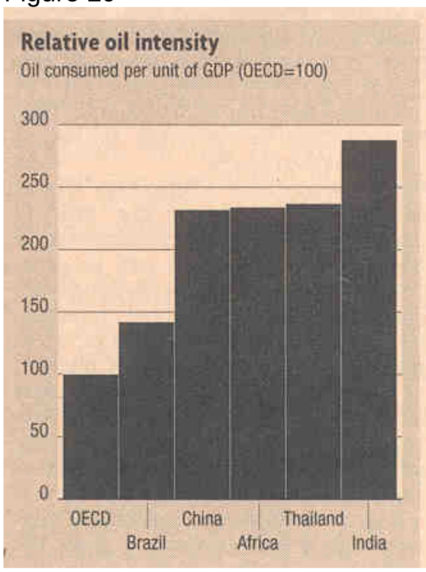
5.1 The assurance of energy security lies not only in a secure supply of energy of various forms, but also in achieving efficiency of energy use such that the demand for energy can be moderated to a level that would minimize the impacts of sudden price changes or physical problems of supply. India is likely to exert a growing influence on the world energy market in future. Including traditional fuels, the country already accounts for 5% of total world demand for energy. Even though it is expected that the demand for energy will grow at a lower rate than the growth of GDP, the demand for oil is expected to reach a level of 5.6 mbd in the year 2030. A large share of this will be demand imposed by the transport sector. Overall India has to adopt policies that deviate substantially from the path set by the developed countries when they were at similar stages of growth. This is entirely possible, given the fact that India has access to technologies and infrastructure options that could result in much more efficient use of energy than recorded by the developed countries. Even among the developed countries, differences in energy efficiency are substantial. This is brought out by the familiar diagram of the relationship between energy and growth historically shown in figure 28.

Figure 28



5.2 India has a long way to go in terms of energy intensity in general and oil intensity in particular as shown in figure 29.

Figure 29



Source: Financial Times

6. Strategic petroleum reserves

6.1 Strategic reserves of crude oil and petroleum products were first recognized as a policy tool in the aftermath of first oil shock in 1973. Major industrialized nations got together and formed the International Energy Agency (IEA), which was charged with the task of coordinating the purchase of oil during a future shock and of coordinating the drawdown of reserves during the hour of crisis. Currently, IEA member countries hold strategic stocks of about 90 days of net imports and there are already talks of increasing the cover to 120 days. Strategic reserves do not come cheap. According to an estimate prepared by the Engineers India Limited (EIL), the capital cost of building a strategic reserve of 5 MMT of crude oil at Rajkot (2.5), Mangalore (1.5) and Vishakhapatnam (1.0) are Rs.1225.2 crores with a mixture of concrete tanks and rock caverns. The maintenance cost of these facilities is calculated as 29.3 crores. This excludes the cost of crude, which at $25/bbl will come to around Rs.4214 crores and this will provide cover of only 24 days.

6.2 But are strategic reserves really beneficial? The benefits of an emergency oil stock are the losses it can avoid; the principal element being avoided is the GDP loss. GDP losses from an oil shock can be divided into two categories, a production frontier shrinkage following the resource scarcity imposed by higher prices and adjustment losses imposed by the surprise element of the shock, price rigidities and real costs of resource allocations. Empirically, the latter component is at least as large as the former. The sensitivity of GDP to oil price shocks is captured in oil price-GDP elasticity. For India, it has been estimated at 0.16% for every dollar rise in crude oil price per barrel.

6.3 No extensive exercise has been done evaluating the benefits of SPR for India. APEC (APEC, 2000) concluded “emergency oil stocks could be the most effective means for minimizing the economic cost of interrupted supplies and high oil prices”. (APEC – Emergency oil stocks and Energy Security, Tokyo March 2000). It further said that this was true for a large economy or a group of economies. Similar conclusion was reached by Leiby and Bowman (The Value of Expanding the U.S. Strategic Petroleum Reserve, Paul N. Leiby 7 David Bowman, Oak ridge National Laboratory, November 2000) who concluded that benefits from expanding the size of reserves for the US economy are enormous.

6.4 The strategic reserves of crude oil/petroleum products, held by developed countries serve as a global common good. Draw down of such reserves during a crisis has an impact on the world oil market, which is integrated to a fair extent. Thus, poorer countries can reap the benefits of strategic reserves without holding it. Otherwise also, it seems practical to have regional strategic reserves that would not only entail lower costs but will also expand the possible benefits among many countries. Regional cooperation in South Asia in this respect can be fruitful. For a country like India, given the uncertainty about benefits, it may be more economical to hold the minimum reserves required to tide over very-short term supply disruptions.

6.5 To monitor energy security on a regular basis and to ensure that no economic disruption takes place, it would be essential to set up buffer stocks in different locations. This can be done through appropriate optimize to arrive at optimized solutions based on specific assumptions of risks. In addition it is important for the country to also arrive at an optimal depletion policy, so that we retain some advantage in security of supply through adequate domestic production capacity. Another important approach would be to ensure international cooperation in the energy sector as part of India's larger foreign policy. Through such an approach India can not only receive energy supply from diverse sources on a mutually beneficial basis such as hydroelectric power from Nepal and Bhutan; natural gas from Iran, Bangladesh, Myanmar and Central Asia; as well as crude oil from investments to be made by the country in other locations in the world.

7. Regional co-operation and energy security

7.1 Strengthening regional co-operation is not an untried strategy to enhance energy security for the parties involved. The very formation of IEA after the first oil shock is a prominent example of this. Other forms of regional co-operation like the well developed pipeline system in Europe or the well developed electricity transmission system in the Nordic countries may have been stimulated less by energy security concern but nonetheless play an important role in ensuring the same.

7.2 Admittedly, given the growing recognition of the role of private sector in the energy sector in the sub-continent, such a regional venture has to make commercial sense in order to induce private sector to invest in the scheme. Several schemes are already in operation, primarily in the electricity sector. Several have been pursued vigorously by interested parties like the Bangladesh-India gas pipeline and the Iran-Pakistan-India gas pipeline. Several more possibilities exists like the India (Tripura)-Bangladesh-India gas pipeline and a petroleum products pipeline from North-East India to Bangladesh. Lack of political will has, however, emerged as a major constraining factor for several of these schemes, especially in the oil and gas sector.

7.3 Obstacles of different kind also exist. Elevating the regional grids in a country to an inter-regional one definitely involves serious technological and policy issues. But these have been overcome elsewhere and there is no reason as to why they cannot be overcome in South Asia.

8. Energy security for the poor

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

8.2 To facilitate the access of energy to the economically weaker sections, appropriate and efficient energy delivery mechanism 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.

8.3 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. Government should strengthen the Public Distribution System (PDS) system for kerosene and explore innovative financing mechanism for LPG for better access. Government should also re-orient and widen the improved cook-stoves and community size biogas programme. Solar lighting could be a clean option for remote rural households. This will result in an estimated saving of Rs 26758 million annually on subsidy to kerosene, which can be used to subsidize solar lanterns to the extent of 50 per cent (TERI).

8.4 In the long run the Indian economy has to attain higher levels of energy efficiency. Different countries today display very different levels of efficiency in energy use. Improvements in India would require upgradation of technologies in existing capital stock and ensuring that the most efficient technologies are used in new capital stock to be installed. Overall, in taking these initiatives, India would have to be guided by a carefully articulated energy security strategy. Energy efficient capital stock, restructuring of the Indian economy towards higher energy efficiency and diversification of energy sources would have to be compelling objectives for ensuring India's energy security.

8.5 9. Developing future indigenous energy sources

9.1 Coal Bed Methane (CBM)

9.1.1 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.

9.2 Gas Hydrate

9.2.1 Gas Hydrates containing mostly methane is considered as a clean source of energy for the future. This ice like crystalline substance is stable at high pressures and low temperatures prevailing in the sediments of deep sea and also permafrost areas. As per present estimate, 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 and environmental impacts of possible methane releases to ocean and atmosphere; technology development for exploration of the 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 safe extraction of these hydrate from depths either in the form of gas or slurry and store/transport them for various uses.

9.2.2 India has taken a major lead in establishing a base for renewable energy developments. However, much needs to be done to realise the full potential both economically and technologically in this large field. The work of the Centre would involve bringing out a detailed report on how renewable energy could substitute conventional energy sources for enhancing the country's energy security. Financial resources would be sought for undertaking this study taking into account both national as well as international developments.

9.3 Ocean Energy

9.3.1 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 Rankine cycle with ammonia as 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 of other conventional energy sources.

9.4 Other fuels:

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

9.5 Fuel cell, which convert chemical energy of hydrogen or hydrogen-rich gas directly into electricity in an environmental-friendly manner, is on the verge of commercial breakthrough. Some countries like Canada, Japan and USA 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.

9.6 Hydrogen energy is another promising fuel for the future. Solar hydrogen projects have been set up in Europe, Japan, USA. Furthermore, USA has enacted a special hydrogen act to earmark a minimum of 30 million dollars every year for hydrogen research. Recently, 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.

9.7 In Indian context, bio-fuel is another suitable source of energy. Bio-fuels like ethanol, is mainly extracted from molasses produced in the sugar-making process. 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[7] 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.

10. Conclusions

10.1 The assurance of energy security for India would come only from two sets of policy initiatives, which have equal importance. India has to develop an energy efficient economic structure, for which pricing measures, incentives and disincentives must be designed rationally. The second driver of policies for energy security would require establishment and control over enough capacity for supply of energy of different forms to ensure healthy economic growth and equitable access for all elements of Indian society.

10.2 The present Government of India has placed priority on energy security as articulated in the statement of May 2004 "The UPA government will pursue an independent foreign policy keeping in mind its past traditions. This policy will seek to promote multi-polarity in world relations and oppose all attempts at unilateralism". Recent developments in the global oil market only highlight the importance of energy security as an important part of India's economic policy.

10.3 It is particularly important for Indian society to adopt and pursue lifestyles which are energy efficient. To ensure this, regulatory measures, pricing of various forms of energy, creating awareness among the population and providing knowledge on energy issues would be vital elements of a suitable energy strategy. Overall the Indian economy and Indian society need to be models of energy conservation.

10.4 Some sectors which have not been considered important in defining India's energy policy need to be brought into the overall ambit of energy decision making. These include the transport sector, the housing and construction industry as well as the production of energy using appliances. The country cannot afford to get locked into energy intensive infrastructure and technologies, because the cost of any subsequent changeover would prove unacceptably high.

10.5 The cardinal principles defining energy policy in the future may, therefore, be summed up by stating that the country should:

10.1.1 Keep the dependence on oil imports to a level that does not jeopardize the country's security in strategic and economic terms.
10.1.2 Maximize the use of indigenous energy resources, particularly those that are renewable in nature to enhance energy security and minimize adverse environmental impacts.
10.1.3 Create an economic structure and policy framework by which the country enhances the efficiency of energy use across the entire economy.
10.1.4 Build in appropriate measures including strategic petroleum reserves such that any short-term crises can be dealt with effectively without jeopardizing the country's economic welfare.

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Abbreviations

ADB	Asian Development Bank
BCM	Billion Cubic Metre
CBM	Coal Bed Methane
CEA	Central Electricity Authority
CIL	Coal India Limited
CO_2	Carbon di-oxide
EIA	Energy Information Administration
GDP	Gross Domestic Product
GLC	Gas Linkage Committee
GoI	Government of India
GW	Giga Watt
HBJ	Hazira-Bijapur-Jagdishpur
HCV	Hydro Carbon Vision
IEA	International Energy Agency
IEO	International Energy Outlook
IGCC	Integrated Gas Combined Cycle
KG	Krishna-Godavari Basin
Kgoe	Kilogram of Oil Equivalent
kW	Kilo Watt
LNG	Liquefied natural gas
LPG	Liquefied Petroleum Gas
LRMC	Long Run Marginal Cost
Mb/d	Million Barrels per Day
ME	Middle East
MMBtu	Million British Thermal Unit
MMSCMD	Million Standard Cubic Meters Per Day
MMTPA	Million Metric Tonnes Per Annum
MoPNG	Ministry of Petroleum and Natural Gas
Mtoe	Million Tonnes of Oil Equivalent
MW	Megawatt
NELP	New Exploration and Licensing Policy
OPEC	Organization of the Petroleum Exporting Countries
OTEC	Ocean Thermal Energy Conversion
R&M	Renovation & Modernisation
SCCL	Singareni Collieries Company Limited
TAP	Turkmenistan – Afghanistan – Pakistan
TMT	Thousand Metric Tonnes
UNDP	United Nations Development Programme
WEO	World Energy Outlook