Integrated Energy Policy

Report of the Expert Committee

सत्यमेव जयते

Government of India
Planning Commission
New Delhi

August 2006

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We, the Members of the *"Expert Committee on Integrated Energy Policy"*, hereby submit our Final Report.

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सत्यमेव जयते

उपाध्यक्ष
योजना आयोग
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DEPUTY CHAIRMAN
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INDIA

Foreword

Energy is a vital input into production and this means that if India is to move to the higher growth rate that is now feasible, we must ensure reliable availability of energy, particularly electric power and petroleum products, at internationally competitive prices. We cannot hope to compete effectively in world markets unless these critical energy inputs are available in adequate quantities and at appropriate prices.

The present energy scenario is not satisfactory. The power supply position prevailing in the country is characterised by persistent shortages and unreliability and also high prices for industrial consumer. There is also concern about the position regarding petroleum products. We depend to the extent of 70 percent on imported oil, and this naturally raises issues about energy security. These concerns have been exacerbated by recent movements in international oil prices. Electricity is domestically produced but its supply depends upon availability of coal, exploitation of hydro power sources and the scope for expanding nuclear power, and there are constraints affecting each source.

Achieving an efficient configuration of the various forms of energy requires consistency in the policies governing each sector and consistency in the pricing of different types of energy. There is also a need for clarity in the direction in which we wish to move in aspects like energy security, research and development, addressing environmental concerns, energy conservation, etc. To address these issues in an integrated manner, the Prime Minister had directed that the Planning Commission should constitute an Expert Committee to undertake a comprehensive review and to make recommendation for policy on this basis. The Expert Committee was constituted under the chairmanship of Dr. Kirit S. Parikh, Member, Planning Commission and has finalised its report after an extensive process of deliberation and consultation with various stakeholders. The draft report was also placed on the web site of the Planning Commission and comments were invited which have been taken into consideration in preparing the final report.

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The report of the Expert Committee provides a broad overarching framework for guiding the policies governing the production and use of different forms of energy from various sources. It makes specific recommendations on a very large range of issues. The report is a valuable input into policy making and will help shape our energy policy in the 11th Plan. Early implementation of the recommendations in the report would contribute substantially to putting the economy on a sustainable higher growth path.

(Montek S. Ahluwalia)

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Preface

The energy policies that we have adopted since independence to serve the socio-economic priority of development have encouraged and sustained many inefficiencies in the use and production of energy. We pay one of the highest prices for energy in purchasing power parity terms. This has eroded the competitiveness of many sectors of the economy. The challenge is to ensure adequate supply of energy at the least possible cost. Another important challenge is to provide clean and convenient "lifeline" energy to the poor even when they cannot fully pay for it, as it is critical to their well-being. Therein lies the importance of an effective and comprehensive energy policy.

In this context, the Prime Minister had directed the Planning Commission, to setup an Expert Committee to prepare an integrated energy policy linked with sustainable development that covers all sources of energy and addresses all aspects of energy use and supply including energy security, access and availability, affordability and pricing, as well as efficiency and environmental concerns. The committee was constituted on August 12, 2004 and was to submit its report within six months i.e., by February 11, 2005. Given the complexity involved and wider consultation needed, the term of the committee was extended upto 11th October 2005. The draft report of the Committee was put on the website of Planning Commission inviting comments. We received a large number of them from individuals, groups and institutions some of whom had organised special discussion meetings on the draft report. I thank them all. We have finalised the report after taking these comments into account. While the finalisation of the report has taken some time, it is worth noting that some of the policy suggestions made in the draft report have been in the meanwhile taken up by the Government for implementation.

It is my pleasure and also my privilege to thank all the Members of the Committee for their many important suggestions and for sparing their valuable time towards the finalisation of this report.

I am also thankful to the officers and staff of the Power & Energy Division of the Planning Commission for their contributions in the preparation of this report, particularly Shri Surya Sethi, Convenor of the Committee, for his many ideas, contributions, help in drafting the report and for ensuring consistency and clarity. S/Shri R.C. Mahajan, M. Satyamurty, R.K. Kaul, I.A. Khan, B. Srinivasan, Dr. A. Mohan, D.N. Prasad, Rajnath Ram and Dr. M. Govinda Raj provided many inputs and support.

I also thank Dr. Vivek Karandikar and Dr. Prasanna Dani of the Observer Research Foundation for their help in developing energy supply scenarios.

Finally, I want to thank Shri Sanjay Vasnik for diligently, carefully and cheerfully typing many drafts of the report.

Kirit S Parikh

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Dated: 09.08.2006

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Overview

India faces formidable challenges in meeting its energy needs and in providing adequate energy of desired quality in various forms in a sustainable manner and at competitive prices. India needs to sustain an 8% to 10% economic growth rate, over the next 25 years, if it is to eradicate poverty and meet its human development goals. To deliver a sustained growth rate of 8% through 2031-32 and to meet the lifeline energy needs of all citizens, India needs, at the very least, to increase its primary energy supply by 3 to 4 times and, its electricity generation capacity/supply by 5 to 6 times of their 2003-04 levels. With 2003-04 as the base, India's commercial energy supply would need to grow from 5.2% to 6.1% per annum while its total primary energy supply would need to grow at 4.3% to 5.1% annually. By 2031-32 power generation capacity must increase to nearly 8,00,000 MW from the current capacity of around 1,60,000 MW inclusive of all captive plants. Similarly requirement of coal, the dominant fuel in India's energy mix will need to expand to over 2 billion tonnes/annum based on domestic quality of coal. Meeting the energy challenge is of fundamental importance to India's economic growth imperatives and its efforts to raise its level of human development.

The broad vision behind the energy policy is to reliably meet the demand for energy services of all sectors at competitive prices. Further, lifeline energy needs of all households must be met even if that entails directed subsidies to vulnerable households. The demand must be met through safe, clean and convenient forms of energy at the least-cost in a technically efficient, economically viable and environmentally sustainable manner. Considering the shocks and disruptions that can be reasonably expected, assured supply of such energy and technologies at all times is essential to providing energy security for all. Meeting this vision requires that India pursues all available fuel options and forms of energy, both conventional and non-conventional. Further, India must seek to expand its energy resource base and seek new and emerging energy sources. Finally, and most importantly, India must pursue technologies that maximise energy efficiency, demand side management and conservation. Coal shall remain India's most important energy source till 2031-32 and possibly beyond. Thus, India must seek clean coal combustion technologies and, given the growing demand for coal, also pursue new coal extraction technologies such as in-situ gasification to tap its vast coal reserves that are difficult to extract economically using conventional technologies.

The approach of the Committee is directed to realising a cost-effective energy system. For this the following are needed:

(i) Wherever possible, energy markets should be competitive. However, competition alone has been shown to have its limitations in a number of areas of the energy sector and independent regulation becomes even more critical in such instances.

(ii) Pricing and resource allocations that are determined by market forces under an effective and credible regulatory oversight.

(iii) Transparent and targeted subsidies.

(iv) Improved efficiencies across the energy chain.

(v) Policies that reflect externalities of energy consumption.

(vi) Policies that rely on incentives/ disincentives to regulate market and consumer behaviour.

(vii) Policies that are implementable.

(viii) Management reforms that create accountability and incentives for efficiency.

A competitive market without any entry barriers is theoretically the most efficient way to realise optimal fuel and technology choices for extraction, conversion, transportation, distribution and end use of energy. The tax structure and regulation across energy sub-sectors should be consistent and institutional arrangements should provide a level playing field to all players. Social objectives should ideally be met through direct transfers. Environmental externalities should be treated uniformly and internalised. A consistent application of "polluter pays" principle may be made to attain environmental objectives at least-cost where prescribed environmental norms are either not applied consistently or not being adhered to. An energy market with the above features would minimise market distortions and maximise efficiency gains. An integrated energy policy is needed to ensure that energy costs and availability do not constrain India's economic growth and competitiveness.

While the medium to long-term challenges of ensuring competitive energy markets are formidable, the immediate problems of acute power shortages, adequate supply of good coal, gas shortages, and concerns of States rich in coal and hydro resources require immediate policy action. Our recommendations address immediate as well as the medium to long-term issues.

Key, high priority recommendations are summarised below:

(i) **Ensuring Adequate Supply of Coal with Consistent Quality:** Coal accounts for over 50% of India's commercial energy consumption and about 78% of domestic coal production is dedicated to power generation. This dominance of coal in India's energy mix is not likely to change till 2031-32. Since prices were de-controlled, the sector has become profitable primarily as a result of price increases and the rising share of open cast production. India would need to augment domestic production and encourage thermal coal imports to meet its energy needs. The Committee has concluded that along the western and southern coasts of India imported coal is more cost competitive compared to domestic coal and further, imported coal is far more cost competitive compared to imported gas at these coastal locations. Such a cost advantage of imported coal over imported gas is likely to continue for some time in the future. Thus:

- Domestic coal production should be stepped up by allotting coal blocks to central and state public sector units and captive mines of notified end users. Coal blocks held by Coal India Limited (CIL) that cannot be brought into production by 2016-17, either directly or through joint ventures, should be made available to other eligible candidates for development and for bringing into production by 2011-12.
- At the same time the needed infrastructure must be created to facilitate thermal coal imports. This will facilitate coastal power generation capacity based on imported thermal coal. Imports of thermal coal will also put competitive pressure on the domestic coal industry to be more efficient.
- A system of pricing coal on its gross calorific value must replace the current system of pricing coal on the basis of broad bands of its useful heat value.

- Coal companies must be asked to conform to international practice of preparing coal prior to its sale. Washed coal must become the norm and use of unwashed coal should become the exception.
- The current system of coal linkages should be replaced by long-term coal supply agreements with strict penalties for not meeting contracted supplies, quality and offtake commitments.
- Coal must be brought under independent regulation to improve exploitation and allocation of available resources, and to regulate e-auctions and coal prices and to enable a competitive coal market to take shape.
- By the end of 2007-08 the quantity of coal sold through e-auction must reach 20% of domestic production.
- Ideally, the Coal Mines (Nationalisation) Act, 1973, should be amended to facilitate: (a) private participation in coal mining for purposes other than those specified in the Act and (b) offering of future coal blocks to potential entrepreneurs. A consensus should be built on the need to reform this Act.

(ii) **Addressing Concern of Resource Rich States:** Both coal and hydro resources are concentrated in a few states. Increasingly states are becoming more assertive in demanding higher share of benefits that their local energy resources provide to the country as a whole. Even though these are national resources and should not be rendered uncompetitive because of such demands, it is conceivable that mechanisms can be put in place that result in resource rich states reaping more equitable benefits. Allowing resource rich States a share in the profits of the enterprise tapping such local resources through what is called a "carried equity interest" and further allowing the state or its residents an opportunity to invest in such projects on equal terms and appropriately revising the royalty rate etc. are possible solutions to removing hurdles in exploiting these domestic sources of primary energy. The NDC must take up this issue immediately in respect of coal and hydro resources. Over the longer term, a National Policy on Domestic Natural Resources should be formulated and enacted through the Parliament.

(iii) **Ensuring Availability of Gas for Power Generation:** There is a total generation capacity of 12,604 MW based on gas and liquid fuels. Bulk of it is base loaded under combined cycle operation. However, gas supplies have been restricted and the overall utilisation remains at only 54.5%. A significant part of this capacity was realised under the earlier liquid fuel policy while the rest has been built based on unenforceable fuel supply agreements that would have been unbankable in any other environment. While requiring that no new gas capacity be built without firm and bankable gas supply agreements, effort should be made to allocate available domestic gas supplies to the fertiliser, petrochemicals, transport and power sectors at prices that are regulated to yield a fair return to domestic gas producers. Such a practice should be enforced till a better demand-supply balance emerges and domestic gas production achieves some of the potential that is often cited. A more competitive market can then function.

(iv) **Power Sector Reforms:** These must focus on controlling the aggregate technical and commercial losses of the state transmission and distribution utilities. This is essential to creating a financially robust power sector in each state. Only financially healthy state power distribution utilities can sustain the growing generation and transmission of Central Power Sector

PSUs and State Power Sector Utilities (SPSUs) and provide the needed comfort on payment security to attract private investment in the power sector at internationally competitive tariffs. Our recommendations:

- To control AT&C losses, the Committee recommends that the existing Accelerated Power Development and Reform Programme (APDRP) be restructured to ensure energy flow auditing at the distribution transformer level through automated meter reading, a Geographical Information System (GIS) mapping of the network and consumers and the separation of feeders for agricultural pumps. Investment in developing a Management Information System (MIS) that can support a full energy audit for each distribution transformer is essential for reduction in AT&C losses. This will also fix accountability and provide a baseline which is an essential prerequisite to management reform and/or privatisation. The revised APDRP will provide incentives to State Electricity Boards (SEBs) that are linked to performance outcomes and will also include incentives to staff for reduction in AT&C losses.
- The Committee also recommends that the liberal captive and group captive regime foreseen under the Electricity Act 2003 be realised on the ground. India's liberal captive regime will not only derive economic benefits from the availability of distributed generation but will also set competitive wheeling charges to supply power to group captive consumers. This will pave the way for open access to distribution networks. It will also facilitate private generation that limits its interface with the host utility to the use of the distribution network for a fee and thus can be realised even before AT&C losses are reduced.
- To achieve these objectives, the Committee feels that it is essential to separate the cost of the pure wires business (carriage) from the energy business (content) in both transmission and distribution at different voltages. The Electricity Act 2003 recognises such separation for the transmission sub-segment. Separation of content from carriage in the distribution sub-segment, however, is considered only as a means to the provision of open access. The wires business within the distribution sub-segment is also a natural monopoly and must be regulated. Further, introduction of Availability Based Tariffs (ABT) for the intra-state sales and the upgrading of State Load Despatch Centres to the technological level of Regional Load Despatch Centres should be realised.
- Open access is resisted by incumbents as they fear that all the high value paying customers would go away and they would be left with small and subsidised agricultural and domestic customers. Since these customers have strong political constituencies, it may be difficult to raise their tariffs when needed and the incumbent utilities would not remain viable for long. These concerns can be taken care of if the cross-subsidy surcharge, wheeling charge and back-up charge are set properly. However, if these are set too high, open access could be effectively thwarted. These charges need to be periodically revised and independently regulated.
- A robust and efficient inter-state and intra-state transmission system with adequate surplus capacity that is capable of transferring power from surplus regions to deficit

regions is a must for ensuring optimal operation of the system.

- Rehabilitation of existing thermal stations could raise capacity at least-cost in the short-run. Similarly rehabilitation of hydro stations could yield much needed peak capacity at negligible cost. Both these steps must be taken up urgently.

(v) **Reduction in Cost of Power:** In terms of purchasing power parity, power tariffs in India for industry, commerce and large households are among the highest in the world. It is important to reduce the cost of power to increase both the competitiveness of the Indian economy and also to increase consumer welfare. A number of measures are suggested for this.

- The Government Policy should ensure that all generation and transmission projects should be competitively built on the basis of tariff-based bidding. Public Sector Undertakings shall also be encouraged to participate in such bids even though the tariff policy allows them a 5 year window wherein projects undertaken by the public sector need not be bid competitively.
- In cases where tariff continues to be determined on the basis of costs and norms, regulators may either adopt a return on equity approach or return on capital approach, whichever is considered better in the interest of consumers. In deciding the level of return provided, the regulator should *inter-alia* take into account the return available on long-term government bonds and reasonable risk premiums associated with equity investments.
- The current practice of state regulators not allowing state public sector power utilities the same returns as the central public sector utilities should be strongly opposed in the interest of strengthening fair competition which alone will bring down prices in the long-run. Similarly differential payment security structures for Central Power Sector PSUs and the private sector should be abolished.
- Consumer prices for electricity are currently set by State Electricity Regulatory Commissions on cost plus basis. Regulators should set multi-year tariffs and differentiate them by time of day.
- Government should seed the capital markets to develop market-based instruments that effectively extend the tenure of debt available to power projects to, perhaps, 20 years. This will reduce the capacity charge in the earlier years and spread it more evenly over the life of the project.
- Unit sizes should be standardised and global tenders invited for a number of units to get substantial bulk discount.
- Distribution should be bid out on the basis of a distribution margin or paid for by a regulated distribution charge determined on a cost plus basis including a profit mark up similar to that paid for generation as suggested above.

(vi) **Rationalisation of Fuel Prices:** Relative prices play the most important role in choice of technology, fuel and energy form. They are thus the most vital aspect of an Integrated Energy Policy that promotes efficient fuel choices and facilitates appropriate substitution. In a competitive set up, the marginal use value of different fuels, which are substitutes, should be equal at a given place and time so that the prices of different fuels at different places do not differ by more than the cost of transporting the fuels. The resulting inter-fuel choices will then be economically efficient. Further:

- Prices of different fuels should not be set independently of each other. As a general rule, all commercial primary energy sources must be priced at trade parity prices at the point of sale, namely the Free-on-Board (FOB) price for products for which the country is a net exporter and Cost, Insurance and Freight (CIF) price for which it is a net importer. The price of a product for which the country is self-sufficient in a competitive market with many suppliers and buyers would fluctuate between the two depending upon the ease of import/ export and reliability of supplies. In a situation with a monopoly supplier with exportable surplus at import parity price, the price would be in between the two depending on the price elasticity of domestic demand. This principle is extremely relevant for the petroleum sector wherein bulk of the crude oil is imported and India has become a net exporter of petroleum products.
- To cushion domestic prices against short-term volatility of prices on the international market (FOB or CIF) domestic prices can be set on the basis of median prices over the previous month or a three month period.
- The petroleum and natural gas sector is, once again, devoid of any competition and independent oversight of either upstream or downstream activities. On the upstream side, Directorate General Hydrocarbons (DGH), an arm of the Ministry, oversees allocation and exploitation of oil & gas reserves and enforces profit sharing with exploration & production companies. The current arrangement needs to be strengthened and made independent. On the downstream side, despite the dismantling of the Administered Price Mechanism, the GOI continues to control the pricing of automotive fuels, LPG, large part of domestic natural gas and PDS kerosene. There is no real competition in the sector other than in some peripheral products such as lubricants, despite the presence of a large domestic private player in refining and the likely emergence of other private players in this field. In fact, the prevailing pricing and taxation policies and the market structure provide significant protection to the private refineries. The result is that India's refining capacity exceeds the demand by 18% already. There is an urgent need to have an independent regulator for both upstream and downstream sectors. The notification of the Petroleum & Natural Gas Regulatory Board Act, 2006, is thus welcome.
- In the petroleum sector, full price competition at the refinery gate and the retail level would lead to trade parity prices as described above. Thus instead of administering prices, full price competition should be introduced.
- Coal prices should ideally be left to the market and trading of coal, nationally and internationally, should be free. Only a competitive free market can do an efficient job of price determination. A competitive market requires that there are multiple producers and that there are no entry barriers to new producers or to importers. Pending the creation of such a competitive market, independent regulation of coal prices becomes essential.
- Apart from CIL's virtual monopoly in coal supply, coal prices cannot be determined in a competitive market open to all users as long as the largest coal consuming sector, i.e. power, has coal cost as a pass through. However, since other

users of coal are numerous and consume substantial quantities of coal, a strategy for competitive price discovery is possible. We recommend as follows:

- High quality coking and non-coking coal which are exportable may be sold at export parity prices as determined by import price at the nearest port minus 15%. This practise is currently being adopted for supply of good quality coking coal to the steel industry.
- 20% of the production may be sold through e-auction. Quantities to be sold through e-auction from different mines must be determined annually with a monthly mine-wise schedule to be independently monitored and enforced by a coal regulator.
- Remaining coal should be sold under long-term Fuel Supply and Transport Agreements (FSTAs). Regulated utilities should be allowed upto 100% of their certified requirements through FSTAs. Other bulk consumers could be allowed partial FSTAs based on coal availability. Any shortfalls should be met through e-auction supplies or imports.
- Pithead price of coal under FSTAs should be revised annually by a coal regulator on a basis that *inter-alia* takes into account prices obtained through e-auction, FOB price of imported coal (both adjusted for quality) and production cost, inclusive of return based on efficiency standards.
- Coal prices may be made fully variable based on Gross Calorific Value (GCV) and other quality parameters.

❑ Natural Gas is not an easily tradable commodity. Making gas tradable requires significant investments in pipelines or, alternatively, in liquefaction, cryogenic shipping & regasification. Comparing local gas prices to spot LNG prices in the international market is grossly misleading. Again, linking gas prices to crude price movements is also misleading. Long-term supply contracts such as those in Europe are more representative of natural gas prices. Natural gas price can be determined through competition among different producers where multiple sources and a competitive supply-demand balance exist. As long as there is shortage of gas in the country and the two major users of gas, namely fertiliser and power, work in a regulated cost plus environment, a competitive market determined price would be highly distorted. Such distortions would get further amplified by the prevailing regime of fertiliser subsidies & power sector subsidies and cross subsidies. In such a situation price of domestic gas and its allocation should be independently regulated on a cost plus basis including reasonable returns.

❑ Another option could be to price gas on a net-back basis. If gas becomes a key component in India's energy mix, it is pointed out that beyond the level of gas consumption in the fertiliser, petrochemical, automotive and domestic sectors, gas must compete with coal as the key alternative for power generation. This implies that the cost of generating peak or base electricity using gas cannot exceed the cost of peak or base electricity from coal, the cheapest alternative. A competitive coal market is thus important for setting a proper price of natural gas on a net-back basis. An alternative for a gas producers is to export gas, in which case the domestic gas price could be the net realisation of the domestic natural gas producer after investing and getting a return on the investment needed to make the natural gas tradable across borders in either a trans-border pipeline or through liquefaction and shipping facilities. For the foreseeable future, domestic gas supplies to both the fertiliser and the power sector, that together account for about 80% of the current gas usage, would need to be allocated based on availability and charged at regulated price that reflects cost of production and a reasonable profit.

- Central and State taxes on commercial energy supplies need to be rationalised to yield optimal fuel choices and investment decisions. Relative prices of fuels can be distorted if taxes and subsidies are not equivalent across fuels. This equivalence should be in effective calorie terms. In other words they should be such that producer and consumer choices as to which fuel and which technology to use are not affected by the taxes and subsidies. Socio-economic benefits such as employment generation and positive impact on energy security may support differential taxes on alternate fuels.
- Environmental taxes and subsidies, however, are levied precisely to affect choices. Differential taxes can be justified here if they appropriately reflect environmental externalities. A consistent application of the "polluter pays" principle or "consumer-pays" principle should be made to attain environmental objectives at least-cost where prescribed environmental norms are either not applied consistently or not being adhered to.

(vii) **Energy Efficiency and Demand Side Management:** Lowering the energy intensity of GDP growth through higher energy efficiency is important for meeting India's energy challenge and ensuring its energy security. The energy intensity of India's growth has been falling and is about half of what it used to be in the early seventies. Currently, we consume 0.16 kg of oil equivalent (kgoe) per dollar of GDP expressed in purchasing power parity terms. India's energy intensity is lower than the 0.23 kgoe of China, 0.22 kgoe of the US and a World average of 0.21 kgoe. India's energy intensity is even marginally lower than that of Germany & OECD at 0.17 kgoe. However, Denmark at 0.13 kgoe, UK at 0.14 kgoe and Brazil & Japan at 0.15 kgoe are ahead of India. These figures and many sectoral studies confirm that there is room to improve and energy intensity can be brought down significantly in India with current commercially available technologies.

Lowering energy intensity through higher efficiency is equivalent to creating a virtual source of untapped domestic energy. It may be noted that a unit of energy saved by a user is greater than a unit produced, as it saves on production losses as well as transport, transmission and distribution losses. Thus a "Negawatt", produced by a reduction of energy need has more value than a Megawatt generated. The Committee feels that with an aggressive pursuit of energy efficiency and conservation, it is possible to reduce India's energy intensity by up to 25% from current levels.

Efficiency can be increased in energy extraction, conversion, transportation, as well as in consumption. Further, the same level of output or service can be obtained by alternate means requiring less energy. The major areas where efficiency in energy use can make a substantial impact are mining, electricity generation, electricity transmission, electricity distribution, water pumping, industrial production processes, haulage, mass transport, building design, construction, heating, ventilation, air conditioning, lighting and household appliances. As the Indian economy opens up to international competition, it will have to become more energy efficient. This is well demonstrated by India's steel and cement industry. However, the Committee recommends the following policies for raising energy efficiency. Some of these policies can be implemented through voluntary targets undertaken by industry associations as opposed to external dictates and enforcement.

- Merge Petroleum Conservation Research Association (PCRA) with Bureau of Energy Efficiency (BEE). The merged entity should be an autonomous statutory body under the Energy Conservation Act, be independent of all the energy ministries and be funded by the Central Government. It must:
    - Force the pace of improvement in energy efficiency of energy using appliances, equipment and vehicles, and create "golden carrot" incentives in the form of substantial rewards to the firm which first commercialises equipment that exceeds a prescribed energy efficiency target.
    - Enforce truthful labelling on equipment, and impose major financial penalties if the equipment fails to deliver stated efficiencies. In extreme cases, resort to black listing of errant suppliers on consumer information web sites and in government procurement.
    - Establish benchmarks of energy consumption for all energy intensive sectors.
    - Disseminate information, support training and reward best practices with national level honours in energy efficiency and energy conservation.
- Increase the gross efficiency in power generation from the current average of 30.5% to 34%. All new plants should adopt technologies that improve their gross efficiency from the prevailing 36% to at least 38-40%.
- Require a least-cost planning approach to provide a level playing field, to Negawatts and Megawatts so that regulators permit the same return on the investment needed to save a watt as to supply an additional watt.
- Promote minimum life cycle cost purchase instead of minimum initial cost procurement by the government and the public sector.
- Promote urban mass transport, energy efficient vehicles and freight movement by railways through scheduled freight trains with guaranteed, safe and timely deliveries. Enforce minimum fuel efficiency standards for all vehicles.
- Institute specialisations in energy efficiency/conservation in technical colleges and commence certification of such experts.

(viii) **Augmenting of Resources for Increased Energy Security:** India's energy resources can be augmented by exploration to find more coal, oil and gas, or by recovering a higher percentage of the in-place reserves. Developing the thorium cycle for nuclear power and exploiting non-conventional energy, especially solar power, offer possibilities for India's energy independence beyond 2050.

At a growth rate of 5% in domestic production, currently extractable coal resources will be exhausted in about 45 years. However, only about 45% of the potential coal bearing area has currently been covered by regional surveys. It is also felt that both regional as well as detailed drilling can be made more comprehensive. Several possible options are recommended:

- Covering all coal bearing areas with comprehensive regional and detailed drilling could make a significant difference to the estimated life of India's coal reserves.
- India's extractable coal resources could be augmented through in-situ coal gasification which makes use of those coal deposits which are at greater depth and cannot be extracted economically by conventional methods.
- Extracting coal bed methane before and during mining could augment the country's energy resources.
- Enhanced oil recovery and incremental oil recovery technologies could improve the proportion of in-place reserves that could be economically recovered from abandoned/depleted fields.
- Isolated deposits of all hydro carbons including coal may be tapped economically through sub leases to the private sector.

(ix) **Using Energy Abroad:** In case India can access cheap natural gas overseas under long-term (25-30 years) arrangements, it should consider setting up captive fertiliser and/or gas liquefaction facilities in such countries. This would essentially augment energy availability for India.

(x) **Role of Nuclear and Hydro Power:** Even if India succeeds in exploiting its full hydro potential of 1,50,000 MW, the contribution of hydro energy to the energy mix will only be around 1.9-2.2%. It is clarified that hydro share in the primary energy mix comes out lower because of the way oil equivalence of hydro electricity is calculated. A hydroelectric plant converts a unit of primary energy in the form of potential energy to almost one unit of electricity. The fossil fuel route or the nuclear route needs almost 3 units of a primary energy source to produce the same unit of electricity. Thus while hydro's share in primary energy mix is lower than that of nuclear, the kWh produced from hydro is higher. Similarly, even if a 20-fold increase takes place in India's nuclear power capacity by 2031-32, the contribution of nuclear energy to India's energy mix is also, at best, expected to be 4.0-6.4%. If the recent agreement with the US translates into a removal of sanctions by the nuclear suppliers' group, possibilities of imports of nuclear fuels as well as power plants should be actively considered so that nuclear development takes place at a faster pace.

Nuclear energy theoretically offers India the most potent means to long-term energy security. India has to succeed in realising the three-stage development process described in the main report and thereby tap its vast thorium resource to become truly energy independent beyond 2050. Continuing support to the three-stage development of India's nuclear potential is essential.

Though its contribution to energy requirement is limited, hydro electricity's flexibility and suitability to meet peak demand makes it valuable. Moreover, the development of hydropower, especially storage schemes, are critical for India as our per capita water storage is the lowest among other comparable countries. Creating such storages is critical to India's water security, flood control and drought control. The environmental concerns and the problem of resettlement and rehabilitation of project affected people

(PAPs) can and must be satisfactorily handled. The PAPs should benefit from the project as much as other beneficiaries. This can be accomplished, for example, as follows:

- Require compulsory land consolidation and impose a betterment levy in kind of (say) 5 percent of land on the command area farmers. Use this land to resettle and compensate all PAPs.

(xi) **Role of Renewables:** From a longer-term perspective and keeping in mind the need to maximally develop domestic supply options as well as the need to diversify energy sources, renewables remain important to India's energy sector. It would not be out of place to mention that solar power could be an important player in India attaining energy independence in the long run. With a concerted push and a 40-fold increase in their contribution to primary energy, renewables may account for only 5 to 6% of India's energy mix by 2031-32. While this figure appears small, the distributed nature of renewables can provide many socio-economic benefits.

Subsidies for renewables may be justified on several grounds. A renewable energy source may be environmentally friendly. It may be locally available thereby making it possible to supply energy earlier than in a centralised system. Grid connected renewables could improve the quality of supply and provide system benefits by generating energy at the ends of the grid where otherwise supply would have been lax. Further, renewables may provide employment and livelihood to the poor. However, the subsidies should be given for a well-defined period or upto a well-defined limit.

- The Committee recommends that for promoting renewables, incentives should be linked to outcomes (energy generated) and not just outlays (capacity installed). Even when a capital subsidy is needed, it should be linked to outcomes. For example, capital subsidy could also be given in the form of a Tradable Tax Rebate Certificate (TTRC) that could be based on actual energy generated. The rebate claim would become payable depending upon the amount of electricity/energy certified as having been actually supplied.
- Power Regulators must create alternative incentive structures such as mandated feed-in-laws or differential tariffs to encourage utilities to integrate wind, small hydro, cogeneration etc. into their systems.
- An annual renewable energy report should be published providing details of actual performance of different renewable technologies at the state and national levels. This should include actual energy supplied from different renewable options, availability, actual costs, operating and maintenance problems etc. It should also report on social benefits, employment created, and women's participation and empowerment.
- Policies for promoting specific alternatives are suggested in the main text. These include fuel wood plantations, bio-gas plants, wood gasifier based power plants, solar thermal, solar water heaters, solar photovoltaics, bio-diesel and ethanol.
- It is also recommended that the Indian Renewable Energy Development Agency Ltd (IREDA) be converted into a national refinancing institution on the lines of NABARD/National Housing Bank (NHB) for the renewable energy sector. IREDA's own equity base can be expanded by the financial institutions of the country

instead of continuing the current system of GOI support.

(xii) **Ensuring Energy Security:** India's energy security, at its broadest level, is primarily about ensuring the continuous availability of commercial energy at competitive prices to support its economic growth and meet the lifeline energy needs of its households with safe, clean and convenient forms of energy even if that entails directed subsidies. Reducing energy requirements and increasing efficiency are two very important measures to increase energy security. However, it is also necessary to recognise that India's growing dependence on energy imports exposes its energy needs to external price shocks. Hence, domestic energy resources must be expanded. For India it is not a question of choosing among alternate domestic energy resources but exploiting all available domestic energy resources to the maximum as long as they are competitive.

The Committee, however, felt that obtaining equity oil, coal and gas abroad do not represent adequate strategies for enhancing energy security beyond diversifying supply sources. In contrast, pipelines for importing gas do enhance security of supply if the supplying country makes a major investment in the pipeline. The most critical elements of our energy security, however, remain the measures suggested herein to increase efficiency, reduce requirements and augment the domestic energy resource base.

Ensuring energy security requires dealing with various risks. The threat to energy security arises not just from supply risks and the uncertainty of availability of imported energy, but also from possible disruptions or shortfalls in domestic production. Supply risks from domestic sources, such as from a strike in CIL or the Railways, also need to be addressed. Even if there is no disruption of supply, there can be the market risk of a sudden increase in energy price. Even when the country has adequate energy resources, technical failures may disrupt the supply of energy to some people. Generators could fail, transmission lines may trip or oil pipelines may spring a leak. One needs to provide security against such technical risks. Risks can be reduced by lowering the requirement of energy by increasing efficiency in production and use; by substituting imported fuels with domestic fuels; by diversifying fuel choices (gas, ethanol, orimulsion tar sands etc.) and supply sources; and by expanding the domestic energy resource base. Risks can also be dealt with by increasing the ability to withstand supply shocks through creation of strategic reserves, the ability to import energy and face market risk by building hard currency reserves and by providing redundancy to address technical risks. We recommend as follows:

- Maintain a reserve, equivalent to 90 days of oil imports for strategic-cum-buffer stock purposes and/or buy options for emergency supplies from neighbouring large storages such as those available in Singapore. The buffer stocks could be used to address short-term price volatility. Operating the strategic/buffer reserves in cooperation with other countries who maintain such reserves could also increase their effectiveness.
- Since 80 percent of global hydrocarbon reserves are controlled by national oil companies controlled by respective governments, oil diplomacy establishing bilateral economic, social and cultural ties can reduce supply risk.

(xiii) **Boosting Energy Related R&D:** India will find it increasingly harder to import its required quantities of commercial energy as her share of the incremental world supply of fossil fuels could rise from a low of 13% in the most energy efficient scenario to a high of 21% in the coal dominant scenario by 2031-32. This assumes that the world's supply of fossil fuels grows by only 2% per annum till 2031-32. Research and Development (R&D) in the energy sector is critical to augment our energy resources, to meet our long-term energy needs and to promote energy efficiency. Such R&D would go a long way in raising our energy security and delivering energy independence over the long-term. R&D requires sustained and continued support over a long period of time. Energy related R&D has not been allotted the resources that it needs. India needs to substantially augment the resources made available for energy related R&D and to allocate these strategically. To take an innovative idea to its commercial application involves many steps. Basic research leading to a fundamental breakthrough may open up possibilities of applications. R&D is needed to develop conceptual breakthroughs and prove their feasibility. This needs to be followed up by a working, laboratory scale model. Projects that shows economic potential could then be scaled up as pilot projects, while keeping in mind cost reductions that could be achieved through better engineering and mass production. Demonstrations of such projects, economic assessments and further R&D to make the new technology acceptable and attractive to customers could follow, before finally leading to commercialisation and diffusion. Some key policy initiatives relevant to energy related R&D are detailed below:

- A National Energy Fund (NEF) should be set-up to finance energy R&D. Our expenditure on R&D excepting for atomic energy, which as of today provides less than 3 percent of our total electrical energy supply, is miniscule compared to what industry and governments spend in developed countries. In the latter, firms generally spend more than 2 percent of their turnover for R&D. The total expenditure on R&D in 2004-05 was Rs.610 crores* for Atomic Energy and Rs.70 crores for Ministry of Power, Coal and Non-Conventional Energy Sources. Even at one-tenth of the rate at which firms in developed countries spend on R&D, i.e. 0.2% of the turnover of all energy firms whose turnover exceeds Rs.100 crores a year, we end up with Rs.1000 to Rs.1200 crores per year which will increase overtime. We should be spending much more than this on R&D. Much of R&D can be considered a public good. It is thus better financed by the Government. Initially an allocation of Rs.1000 crores should be made for energy R&D excluding atomic energy. To begin with, individuals, academic research institutions, consulting firms, private and public sector enterprise, should all compete for this fund. Firms may also be encouraged to enhance their expenditure on R&D through tax incentives.

  - The resources devoted to research in different areas depend on the economic importance of that particular area, the availability of technology and the likelihood of success. The latter changes with time as new developments in science and technology take place and uncertainties reduce. R&D

* Only about 15% of this amount or about Rs.90 crores, was for R&D on nuclear power. The rest of the expenditure is for R&D on non-electricity applications of Radiation Technology and Fundamental Research.

priorities have to be based on a dynamic strategic vision which is frequently updated. Of critical importance is research and analysis for the energy policy to outline technology road maps. The NEF should encourage and fund such studies on a regular basis in a number of institutions and should also commission them from experienced and qualified individuals.

- The NEF should support energy policy modelling activities in a number of institutions on a long-term basis. The different modellers should be brought together periodically in a forum to address specific policy issues.
- A number of technology missions should be mounted for developing near-commercial technologies and rolling out new technologies in a time bound manner. These include coal technologies (where India should focus) for efficiency improvement; in-situ gasification; IGCC and carbon sequestration; solar technologies covering solar-thermal and photovoltaics; bio-fuels such as bio-diesel and ethanol; bio-mass plantation and wood gasification, and community based bio-gas plants.
- Coordinated research and development in all stages of the innovation chain to reach a targeted goal (such as that in place in the departments of atomic energy and space research) should be used to develop more efficient industrial plant, machinery & processes, efficient appliances, hybrid cars, super batteries, nuclear technologies related to thorium and fusion, gas hydrates, and hydrogen production, storage, transport and distribution.
- The NEF could provide R&D funding in support of applications, innovative new ideas, fundamental research etc. to researchers in different institutions, universities, organisations and even individuals working independently.
- A number of academic institutions should be developed as centres of excellence in energy research.

(xiv) **Household Energy Security - Electricity and Clean Fuels for All:** One of the toughest challenges is to provide electricity and clean fuels to all, particularly rural populations given their poor paying capacity, the limited availability of local resources for clean cooking energy, and the size of the country and its population. The considerable effort spent on gathering biomass and cow-dung and then preparing them for use is not priced into the cost of such energy. These fuels create smoke and indoor air pollution, are inconvenient to use, and adversely affect the health of people, particularly women and children. Yet, given the fact that women and girls carry most of the burden of the drudgery and also bear the brunt of indoor air pollution, the urgency to meet the challenge should be high. Such steps are needed for our broader need to achieve universal primary education for girls, promote gender equality and empower women. Easy availability of a certain amount of clean energy that is required to maintain life should be considered as a basic necessity. Energy security at the individual level implies ensuring supply of such a lifeline energy need. India cannot be energy secure if her people remain without secure supply of energy for lifeline needs. Ensuring this would require targeted subsidies as many households would be unable to pay for safe, clean and convenient commercial energy to meet lifeline needs. This requires:

- *Electrification of All Households:* The government has announced its commitment to ensure this by 2009-10.
- *Provision of Cooking Energy:* We may set a goal to provide clean cooking energy such as LPG, NG, biogas or kerosene to all within 10 years. It may be noted that the requirement of cooking energy does not increase indefinitely with income. Thus the total amount of LPG required to provide cooking energy to 1.5 billion persons is around 55 Mtoe.
- *Other Sources:* We may provide fuel wood plantations within one kilometre of all habitations. Those who do not have access or cannot afford even subsidised clean fuels, rely on gathering wood. Neighbourhood plantations can ease their burden and the time taken to gather and transport wood.

The Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) was launched to achieve electrification of all households. By 2009-2010 the RGGVY aims to electrify the 1,25,000 villages, still without electricity; to connect all the estimated 2.34 crore un-electrified households below the poverty line with a 90% subsidy on connecting costs; and finally, to augment the backbone network in all the electrified 4.62 lakh villages. The 5.46 crore households above the poverty line which are currently unelectrified, are expected to get electricity connection on their own without any subsidy. Going by current experience, all these households above the poverty line may not seek such connectivity on their own.

To make RGGVY sustainable, a business plan with a viable revenue model needs to be elaborated. A clear pricing and subsidy policy and the means of targeting the subsidy need to be announced soon. Local bodies, panchayati raj institutions, NGOs or even local entrepreneurs can take the franchise to run the local network. Women's self-help groups can also be empowered to do so.

The consumer pays about 40% of the import parity price for kerosene sold through the Public Distribution System (PDS). The balance 60% of the price is being funded largely by oil sector PSUs and to a small extent by the Government through the budget. However, subsidies do not reach the intended beneficiaries due to poor targeting. The real issue is to improve targeting within the subsidy programme well and ensure that those falling outside the subsidy net pay the full cost of supply. Additionally, a well-targeted subsidy regime may only marginally raise the current subsidy burden.

- The best way for providing subsidy for electricity and cleaner fuels, kerosene or LPG, is to entitle targeted households to 30 units of electricity per month and LPG, kerosene or bio-gas purchased from a local community size plant equivalent to 6 kg of LPG per month. A system of debit cards may be introduced to deliver such a subsidy. The entitlements can only be used for purchase of these products. With modern ICT, debit card readers operated on battery and feeding data using mobile technology, can work in rural areas of the country as well.

In addition to the above subsidy, other actions are also needed that create energy secure villages. We suggest:

- Finance a large scale socio-economic experiment to operate community sized bio-gas plants as a commercial enterprise either by a community cooperative or by a commercial entrepreneur. Bio-gas plants on this scale could meet the need for clean cooking energy of a sizable segment of the rural population.
- Even with subsidies for clean fuel, it may not be easy to reach clean fuels to the poor and they may continue to use fuelwood. As part of the above programme, improve the efficiency of domestic chullahs and lanterns from the prevailing 10-12% to 20-25%, which is easily attainable and couple this to improving ventilation in the cooking area of the dwellings. The surplus biomass released as a result of better efficiency could be used in gasifiers for generating electricity.
- Generate electricity through wood gasifiers or by burning surplus bio-gas from the community bio-gas plants. Such distributed generators may be able to take electricity to villages sooner than the grid. This will encourage local generation and could conceivably feed the grid with surplus power at an agreed feed in tariff at a future date. Formulate a tariff policy for such distributed generation for both household and productive use including agriculture.
- To reduce drudgery of those who still need to gather fuel, develop woodlots within one kilometre of the village. Provide finance through self-help groups to transform women, who, today are only energy gatherers, into micro-entrepreneurs engaged in rural energy markets and energy management. Women's groups can form co-operatives for developing and managing fuel wood or oil seed plantations with the same effort that they put towards searching and gathering fuel wood today.
- For setting up of off-grid generation facilities in rural areas, encourage the organised sector to adopt rural community/communities in their areas of operation.

(xv) **An Enabling Environment for Competitive Efficiency:** Apart from pricing policies, an environment that allows multiple players in each element of the energy value chain to compete on transparent and equal terms is essential to realising efficiency gains within the energy sector. Currently the sector is dominated by large Public Sector Companies and some sub-sectors have natural monopoly characteristics potentially offering economies of scale. Given this ground reality, independent & informed regulation becomes essential to realising competitive efficiency. Such regulation can play an important role to see that competitive markets develop and mature. Such regulation must in the very least ensure that:

- The regulatory responsibility/ functions of the State are separated from the Ministries that control the Public Sector Units dominating the energy sector; and
- Till effective competitive markets emerge, independent regulators should fix prices or price caps to mimic competitive markets based on principles summarised in para (v) above. Even when competitive markets emerge, the regulators' role will continue to remain important.

(xvi) **Climate Change Concerns:** Concern *vis-a-vis* the threat of climate change has been an important issue in formulating the energy policy. Even though India is not required to contain its GHG emissions, as a signatory to the UN Framework Convention on Climate Change and a country which has acceded to the Kyoto Protocol, India has been very active in proposing

Clean Development Mechanism (CDM) projects. By May 2006, a total of 297 projects had been approved by India with approximately 240 million tonnes of CO_2 reduction. Also, since the impact on the country's poor, due to climate change, could be serious, this report has suggested a number of initiatives that will reduce the green house gas intensity of the economy by as much as one third. These are:

- Energy efficiency in all sectors
- Emphasis on mass transport
- Active policy on renewable energy including bio-fuels and fuel plantations
- Accelerated development of nuclear and hydro-electricity
- Technology Missions for clean coal technologies
- Focussed R&D on many climate friendly technologies

The broad policy framework and the thrust of development suggested here need to be made more specific. To this end once the policy framework is accepted, detailed roadmaps of development should be chalked out and specific policy measures for implementation drafted.

With the recommendations of the Committee, India can meet her energy requirements in an efficient, cost effective way and be on a path of sustainable energy security.

Abbreviations Used

A

ABT-Availability Based Tariff

APDRP-Accelerated Power Development and Reform Programme

AT&C-Aggregate Technical and Commercial

APM-Administered Price Mechanism

ADB-Asian Development Bank

ATF-Aviation Turbine Fuel

APEC-Asia Pacific Economic Cooperation

ALCC-Annualised Life Cycle Cost

AMR-Automatic Meter Reading

B

BEE-Bureau of Energy Efficiency

BPL-Below Poverty Line

BCS-Best Case Scenario

BAU-Business as Usual

BCM-Billion Cubic Meters

BARC-Bhaba Atomic Research Centre

BESCOM-Bangalore Electricity Supply Company Ltd.

BP-British petroleum

BCCL-Bharat Cocking Coal Limited

C

CAGR-Compounded Annual Growth Rate

CASE-Commission for Additional Sources of Energy

CIL-Coal India Limited

CIF-Cost Insurance and Freight

CDM-Clean Development Mechanism

CO_2-Carbon dioxide

CEA-Central Electricity Authority

CMIE-Centre for Monitoring Indian Economy

CNG-Compressed Natural Gas

CBM-Coal Bed Methane

CONCOR-Container Corporation of India Ltd.

CHP-Combined Heat & Power

CIS-Common wealth of Independent States

CMPDIL-Central Mine Planning & Design Institute Ltd.

CLASP-Collaborative Labelling and Appliance Standards Programme

CSIR-Council for Scientific and Industrial Research

CERC-Central Electricity Regulatory Commission

CEA-Central Electricity Authority

CO-Carbon Monoxide

CH_4-Methane Gas

CER-Certified Emission Reduction

D

DAE-Department of Atomic Energy

DGH-Directorate General of Hydrocarbons

DSM-Demand Side Management

DSCL-DCM Sriram Consolidated Ltd

DTI-Department of Trade & Industry, U.K.

DG-Distributed Generation

DST-Department of Science & Technology

DME-Dimethyl Ether

DBT-Department of Bio Technology

E

EMPs-Environment Management Plans

ECL-Eastern Coal Fields Limited

EIA-Energy Information

Administration
EOR-Enhanced Oil Recovery
EIL-Engineers India Limited
EE-Energy Efficiency
EC Act-Energy Conservation Act.
ESCOs-Energy Service Companies

F FFA- Free Fatty Acids
FSA-Fuel Supply Agreements
FOB-Free on Board
FSTA-Fuel Supply and Transport Agreement
FDI-Foreign Direct Investment
FBRs-Fast Breeder Reactors
FBTR-Fast Breeder Test Reactor
FO-Fuel Oil
FSI-Floor Space Index

G GAIL-GAIL (India) Limited
GIS-Geographical Information System
GOI-Government of India
GCV-Gross Calorific Value
GDP-Gross Domestic Product
GHG-Green House Gases
GSPC-Gujarat State Petroleum Corporation
GEF-Global Environment Facility
GTL-Gas to Liquids
GSI-Geological Survey of India

H HDI-Human Development Index
HHs-Households
HOG-High Output Growth
HSDO-High Speed Diesel Oil
HVDC-High Voltage Direct Current

I ICRISAT-International Crops Research Institute for the Semi-Arid Tropics
IREDA-Indian Renewable Energy Development Agency Ltd.
IGCC-Integrated Gasification Combined Cycle.
ICT-Information and Communication Technologies
IEA-International Energy Agency
IRADe-Integrated Research and Action for Development.
IHV-India Hydrocarbon Vision 2025
IOC-Indian Oil Corporation
IC-Internal Combustion
IOR-Improved Oil Recovery
IPP-Independent Power Producers
ICCEPT-Imperial College Centre for Energy Policy and Technology

K KG-Krishna Godavari

L LPG-Liquefied Petroleum Gas
LNG-Liquefied Natural Gas
LWRs-Light Water Reactors
LDO-Light Diesel Oil
LSHS-Low Sulphur Heavy Stock

M MSW-Municipal Solid Waste
MECL-Mineral Exploration Corporation Limited
MIS-Management Information System
MS-Motor Spirit
MOPNG-Ministry of Petroleum and Natural Gas
MOP-Ministry of Power
MNES-Ministry of Non-Conventional Energy Sources
MSP-Minimum Support Price

N NHB-National Housing Bank
NABARD-National Bank for Agriculture and Rural Development
NDC-National Development Council
NEF-National Energy Fund
NG-Natural Gas
NGOs-Non-Governmental Organisations
NSS-National Sample Survey

NSSO-National Sample Survey Organisation

NCDMA-National Clean Development Mechanism Authority

NLC-Neyveli Lignite Corporation

NCDC-National Coal Development Corporation

NEEPCO-North Eastern Electric Power Corporation Limited

NHPC-National Hydro Electric Power Corporation

NSG-Nuclear Suppliers Group

NELP-New Exploration Licensing Policy

O

OECD-Organisation for Economic Co-operation and Development

ONGC-Oil and Natural Gas Corporation

ORF-Observer Research Foundation

OIL-Oil India Limited

OMCs-Oil Marketing Companies

P

PSUs-Public Sector Undertakings

PDS-Public Distribution System

PCRA-Petroleum Conservation Research Association

PAP-Project Affected People.

PPP-Purchasing Power Parity

PLF-Plant Load Factor

PWC-Price Waterhouse Coopers

POWERGRID-Power Grid Corporation of India Limited

PHWRs-Pressurised Heavy Water Reactors

PFBR-Prototype Fast Breeder Reactor

R

RSPM-Respiratory Suspended Particulate Matter

R & D-Research and Development

RGGVY-Rajiv Gandhi Grameen Vidyutikaran Yojana

ROR-Run of the River

RCs-Regulatory Commissions

REGA-Rural Employment Guarantee Act.

S

SEBs-State Electricity Boards

SPM-Suspended Particulate Matter

S & T-Science and Technology

SPR-Strategic Petroleum Reserve

SPSUs-State Power Sector Utilities

So_x-Sulphur Oxides

SHGs-Self-Help Groups

SWH-Solar Water Heater

SERC-State Electricity Regulatory Commission

SO_2 – Sulphur Oxide

T

TIFAC-Technology Information, Forecasting & Assessment Council

TTRC-Tradable Tax Rebate Certificates

TPES-Total Primary Energy Supply

TPCES-Total Primary Commercial Energy Supply

TERI-The Energy and Resources Institute

TPNCES-Total Primary Non-Commercial Energy Supply.

T & D-Transmission and Distribution

TOD-Time of Day

TPA-Tripartite Agreement

U

UNFCC-United Nations Framework Convention on Climate Change

UK-United Kingdom

UNDP-United Nations Development Programme

UAE-United Arab Emirates

UP-Uttar Pradesh

USA-United States of America

UHV-Useful Heat Value

V

VOCs-Volatile Organic Compounds

The Challenges

India faces formidable challenges in meeting its energy needs and providing adequate and varied energy of desired quality to users in a sustainable manner and at reasonable costs. India needs economic growth for human development, which in turn requires access to clean, convenient and reliable energy for all. As we near the 8-10% growth rate that we aspire for, the quantity & quality of energy we need, will increase substantially. Thus the energy challenge is of fundamental importance. The nature and dimension of this challenge becomes clear when we look at the energy scene in the country today. This chapter lays out the contemporary energy scene, highlighting issues of concern, and then makes the case for an Integrated Energy Policies to address these.

1.1 THE ENERGY SCENE

2. Per capita consumption of energy in India is one of the lowest in the world. India consumed 439 kg of oil equivalent (kgoe) per

Table 1.1
Selected Energy Indicators for 2003

Region/Country	GDP Per Capita-PPP (US $ 2000)	TPES Per Capita (kgoe)	TPES/GDP (kgoe/ $-2000 PPP)	Electricity Consumption Per Capita (kWh)	kWh/ $-2000 PPP
China	4838	1090	0.23	1379	0.29
Australia	28295	5630	0.20	10640	0.38
Brazil	7359	1094	0.15	1934	0.26
Denmark	29082	3852	0.13	6599	0.23
Germany	25271	4210	0.17	6898	0.27
India*	2732	439	0.16	553	0.20
Indonesia	3175	753	0.24	440	0.14
Netherlands	27124	4983	0.18	6748	0.25
Saudi Arabia	12494	5805	0.46	6481	0.52
Sweden	27869	5751	0.21	15397	0.55
United Kingdom	26944	3906	0.14	6231	0.23
United States	35487	7835	0.22	13066	0.37
Japan	26636	4052	0.15	7816	0.29
World	7868	1688	0.21	2429	0.31

TPES: Total Primary Energy Supply

***Data for India are corrected for actual consumption and the difference in actual and IEA assumed calorie content of Indian coal**

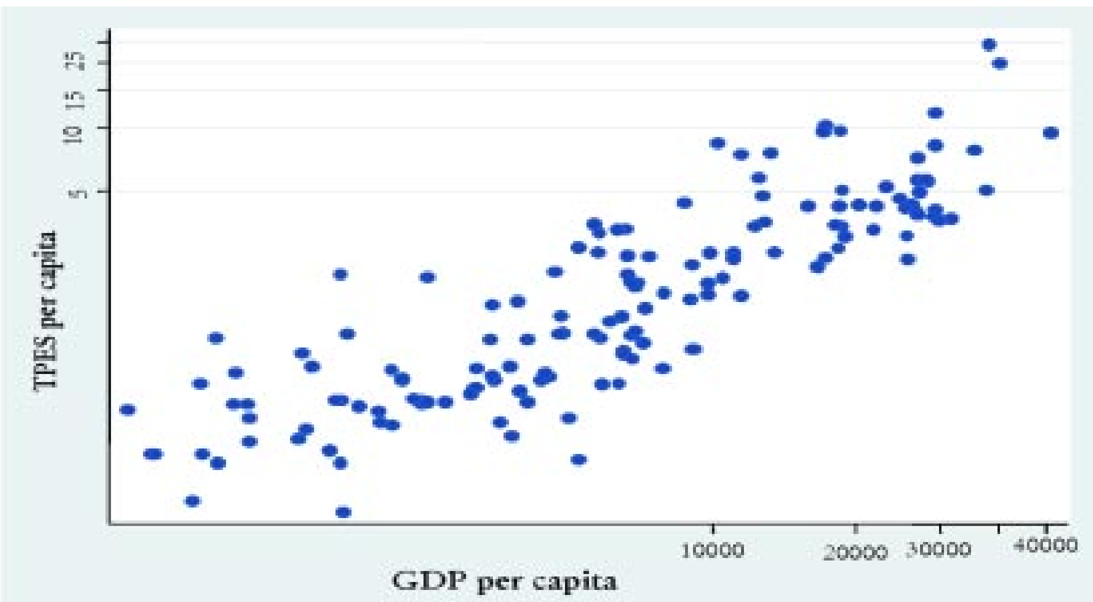
Source: IEA (2005), *Key World Energy Statistics 2005*, International Energy Agency, Paris, http://www.iea.org person of primary energy in 2003 compared to 1090 in China, 7835 in the U.S. and the world average of 1688. India's energy use efficiency for generating Gross Domestic Product (GDP) in Purchasing Power Parity (PPP) terms is better than the world average, China, US and Germany (*see Table 1.1*). However, it is 7% to 23% higher than Denmark, UK, Japan and Brazil. Clearly, significant reduction in the energy intensity of growth can be achieved based on existing technologies.

3. The level of per capita energy supply is a good indicator of the level of economic development as seen in *Figure 1.1* where per capita energy supply is plotted against per capita GDP. *Figure 1.2* shows the relationship of per capita electricity supply with the level of economic development. *Figures 1.1 and 1.2* are plotted on logarithmic scale and thus their slopes indicate elasticity of per capita energy supply w.r.t. per capita GDP i.e. percent change in per capita energy supply for every percent change in per capita GDP.

4. If we look at the consumption of electricity - one of the most convenient forms of energy - we see that per capita consumption in India is far below that in other countries. Moreover, access to electricity is very uneven. Even though 85 percent of villages are considered electrified, around 57 percent of the rural households and 12 percent of the urban households i.e. 84 million households (over 44.2% of total) in the country did not have electricity in 2000. Improvement in human development is also strongly associated with access to electricity. In *Figure 1.3*, the Human Development Index (HDI), which is calculated from literacy rate, infant mortality rate and per capita GDP (UNDP, 2004) is plotted against per capita electricity consumption.

5. Even those who have access to electricity suffer from shortages and poor quality of supply. Unscheduled outages, load shedding, fluctuating voltage and erratic frequency are common. Consumers and the economy bear a large burden of the consequences of this poor quality of supply. This is evident through many examples. Motors are over designed and consume more electricity than required for the task. Voltage stabilisers are needed for expensive equipment. Diesel generators provide backup power to industrial and commercial consumers, while inverters[1] to

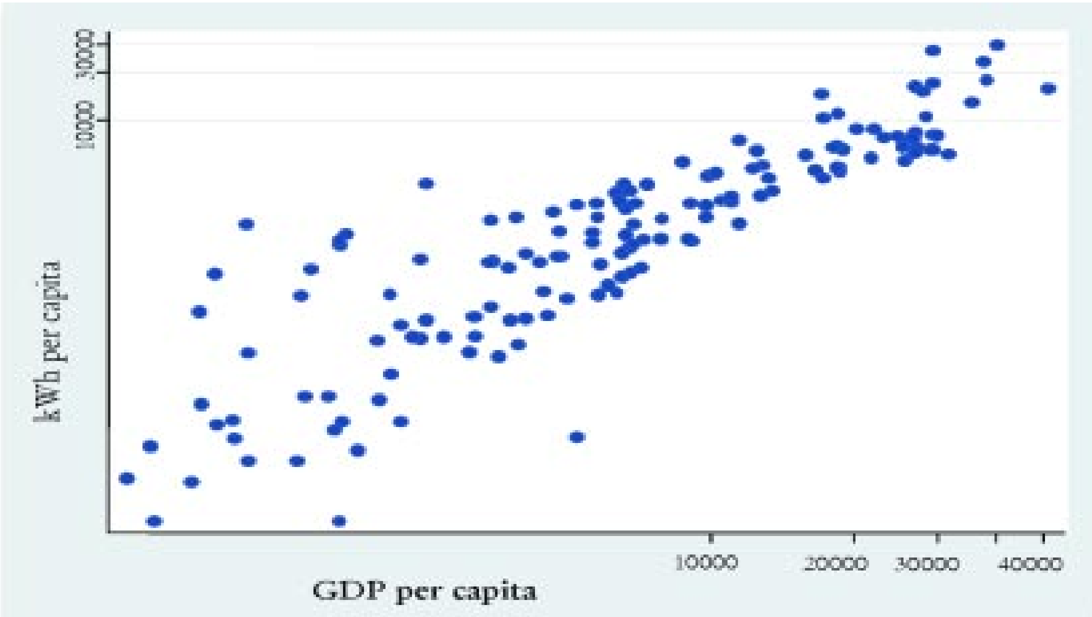
Figure 1.1
Total Primary Energy Supply (TOE) Per Capita (2003) vs. GDP Per Capita (PPP US$2000)



Source: IEA (2005)

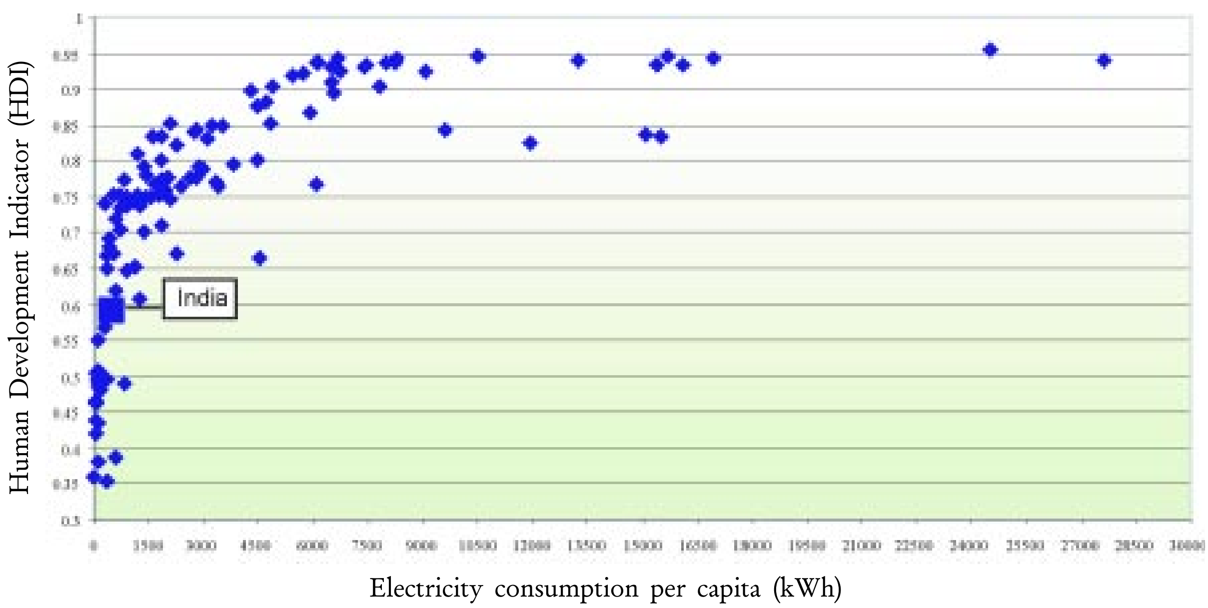
1 Inverters charge batteries when power is available and when power go out convert the DC power of batteries to supply AC power.

Figure 1.2
Kilo Watt hours of Electricity Consumption Per Capita (2003) vs. GDP Per Capita (PPP US$2000)



Source: IEA (2005)

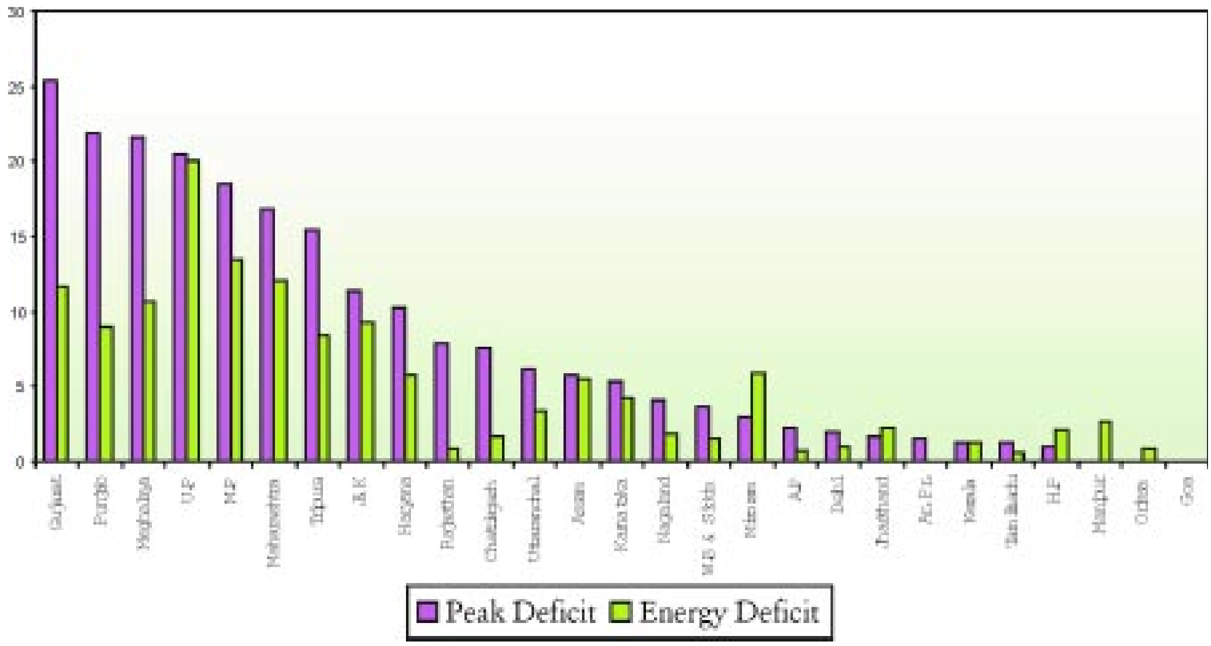
Figure 1.3
Human Development Index (HDI) vs. Electricity Consumption Per Capita in 2002



Note: HDI for India 0.595 and Electricity consumption per capita 553 kWh.
Source: United Nations Development Programme (UNDP-2004) and IEA (2004)

tide over power outages are ubiquitous in city homes. Equipment often gets damaged. Motors, compressors and pumps get burnt out often. Added to these is the cost of idle manpower and loss in production when power supply is interrupted. The extent of power shortage varies from state to state. In 2004-05, the peak shortage varied from 0 to 25.4% with an all-India average of 11.7%. Similarly, energy shortage also varied from 0 to 20.1% with an all-India average of

Figure 1.4
Peak Power and Energy Shortages in States/UTs. 2004-05



Source: Central Electricity Authority (CEA), 2005

7.3% (*Figure 1.4*). These shortages include scheduled cuts, reported load shedding and frequency corrections. However, unscheduled outages are not included.

6. Availability based tariffs (ABT) and unscheduled interchange charges for power introduced in 2003 for inter-state sale of power have reduced voltage and frequency fluctuations. The latter are still, however, not as stable as one would like. In all regions, except the Northern one, frequency was within the normal band (49.0-50.50 Hz) for more than 98% of the time in 2004-05, up from 55% in 2000. Frequency falls when demand exceeds available supply on the grid.

7. Power capacity has risen at the rate of 5.87% per annum over the last 25 years. The total supply of electrical energy has risen at the rate of 7.2% per annum over the same period. This reflects a gradual improvement in the average Plant Load Factor (PLF) of thermal plants (which stood at 74.8% in 2004-05) as well as a decline in the share of hydro in the power generation mix. However, consumption is still constrained as supply and power shortages continue to plague the country. Shortages and the poor quality of power are the outcome of inadequate investments in distribution and transmission. Increasing generation capacity has attracted the bulk of investment both at the centre and the state levels. Aggregate Technical and Commercial (AT&C) losses which include theft, non-billing, incorrect billing, inefficiency in collection, and transmission and distribution losses, exceed 40% for the country as a whole. Consequently the State Electricity Boards (SEBs), remain financially sick and hence unable either to adequately meet their investment needs on their own or attract private capital to do so.

8. The Ministry of Power has set a target of adding 1,00,000 MW of generation capacity between 2002-2012. This programme includes the 41,110 MW capacity additions proposed in the 10th Plan to ensure the availability of reliable and quality power as well as the creation of an adequate reserve margin. Historically, plan targets have never been met, and even in the 10th Plan, the likely capacity addition will actually be under 28,000 MW. Further, the generation capacity created does not have the desired mix of peaking, intermediate and base load stations. Finally, the history of emphasis

on investment in power generation results in loading more and more power on an inadequate transmission and distribution (T&D) network. Since T&D investments have not kept pace with investments in generation, power cannot be easily moved from surplus to deficit areas. Industrial and commercial establishments have been forced to seek captive and standby generation to meet demand or provide quality supply on a 24X7 basis to support critical processes and provide peaking support. There is good reason to believe that some 50,000 MW of such captive and standby capacity is in place. Those in the household sector who can afford it manage with the help of inverters.

9. The sector is dominated by large state monopolies at both central and state levels. Over 88% of utility-based generation is in the public sector, which also, almost entirely, controls transmission. Private distribution is limited to Orissa, Delhi and some parts of West Bengal, Maharashtra, Gujarat and U.P. An uneven playing field permeates the market place wherein the Central Power Sector PSUs get guaranteed post-tax returns of 14-16% with full payment backed by the GOI. State Power Sector Utilities (SPSUs) are given zero or low returns by Regulators who are under constant pressure not to raise tariffs, which are already among the highest in the world in PPP terms for industrial, commercial and household consumers. For example, in 2002, industries in India paid 47 US cents per unit as opposed to 20 cents in China, 17 cents in Brazil, 12 cents in Japan, 5.5 cents in US and 5 cents in Germany in terms of PPP. Financially sick state sector utilities are unable to invest on their own and remain a poor credit risk for private suppliers of energy. This reality has led to a growth driven by Central Power Sector PSUs, which is clearly unsustainable in the long run since their only customer is bankrupt. Even the massive investments required in distribution are unlikely to yield adequate returns in the current set-up. Nevertheless, such investments to strengthen distribution system, irrespective of public or private ownership must be made. The GOI and the Regulators have to struggle to put an enabling environment and a regulatory framework in place that will nurture competition in each element of the electricity value chain, bring in the needed investments and yield the necessary efficiency gains through such competition.

10. The Accelerated Power Development and Reforms Programme (APDRP) is aimed at supporting distribution reforms through investments and incentives by strengthening sub-transmission and distribution networks in the states so as to reduce the aggregate AT&C loss levels and encourage efficiency improvements in metering, billing and collection. The performance of the APDRP, thus far, has fallen short of the promise with an investment of only Rs.9,200 crore realised in the first three years against a target of Rs.20,000 crores for the 5 years of the 10th Plan. The programme has to be restructured to an outcome-driven programme based on monitorable targets against established baselines. Privatisation of distribution has also been tried in Orissa and Delhi as an alternative but the results are, at best, mixed.

11. Power tariffs are structured on the basis of industrial and commercial users cross-subsidising agricultural and domestic power consumption. The agricultural sector is supplied un-metered power in almost all states and the farmers pay a highly subsidised lump sum based on the declared horse power of their pumps. This leads to a zero marginal cost of power which promotes, inefficient use and over exploitation of ground water. The domestic sector also has a range of subsidies based on the level of consumption including heavily subsidised power for the poorest segment wherein households pay a low lump sum monthly charge. With the rising cost of supply, the burden of these cross-subsidies has increased and is disproportionately loaded on the paying industrial, commercial and large household consumers. Additionally, the tariff structure has created incentives for high paying consumers to pilfer power under the cover provided by unmetered power. The habit of stealing power is now widespread. A vested interest lobby has been created and what are euphemistically called AT&C losses remain stubbornly high. While some state governments partially compensate the SEBs for subsidies given to farmers and other specified consumers,

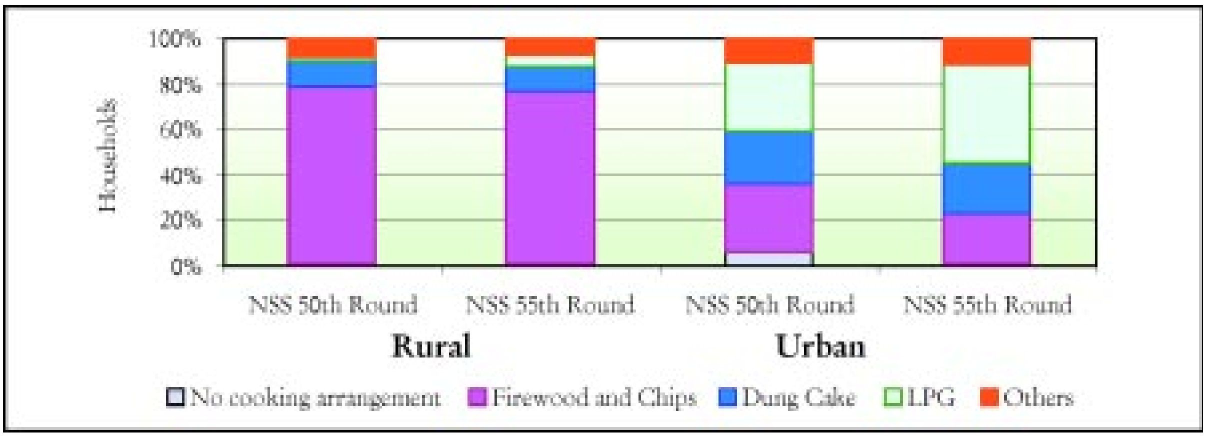
AT&C losses have to be borne by SEBs. Even if such practices could have been justified in the formative years of these companies, necessary corrective measures should have been taken on the basis of the experience gathered over subsequent years of operation. The development of an effective way to subsidise farmers and certain other consumption categories that gives them incentives to both use power efficiently and arrest pilferage, is very critical for a healthy power sector. The process of power sector reforms was started in 1992 and continues to date. Despite some progress, the sector has a long way to go before becoming competitive and efficient at meeting demand with quality power and being able to attract the needed investment to keep up with growing demand on commercially viable terms.

12. A majority of India's people use traditional fuels such as dung, agricultural wastes and firewood for cooking food. These fuels cause indoor pollution. The 1999-2000 55th round of the National Sample Survey (NSS) revealed that for 86% of rural households the primary source of cooking energy was firewood and woodchips or dung cakes. In urban areas as well, more than 20% of all households relied mainly on firewood and chips. Only 5% of the households in rural areas and 44% in urban areas used LPG. Kerosene was used by 22% of urban households and only 2.7% of rural households. Other primary sources of cooking energy used by urban and rural households include coke, charcoal, gobar gas (cow dung gas), electricity and other fuels.

13. *Figure 1.5* shows that not much change has taken place in rural areas since the 50th round of NSS (1994-95) though in urban households use of LPG has nearly doubled.

14. The use of traditional fuels for cooking with the attendant pollution and the cost of gathering them imposes a heavy burden on people, particularly women and girls. The need to gather fuels may deprive a young girl of her schooling. Over time, the use of such fuels increases the risks of eye infections and respiratory diseases. Lack of access to clean and convenient sources of energy impact the health of women and girls disproportionately as they spend more time indoors and are primarily responsible for cooking. Women's micro-enterprises (an important factor in household income, as well as in women's welfare and empowerment), are heat-intensive (food processing), labour-intensive, and/or light-intensive (home industries with work in evenings). The lack of adequate energy supply—and other coordinated support—affects women's abilities to use these micro-enterprises profitably and safely. Furthermore, women often face additional barriers in making the best use of

Figure 1.5
Distribution of Households by Primary Source of EnergyUsed for Cooking- India



Source: NSSO (2001): *Energy used by Indian Households 1999-2000*. NSS 55th Round, Report No. 464 (55/1.0/6), National Sample Survey Organisation (NSSO), Govt. of India, August, 2001.

available opportunities and obtaining improved energy services. There are social and practical constraints related to ownership and control over productive resources, and women are typically excluded/marginalised from decision-making vis-à-vis the use of these resources. This is worsened by barriers related to illiteracy, lack of exposure to information and training. Thus, the economic burden of traditional fuels is around Rs.300 billion (*see BOX 1.1*). An energy policy that seeks to be responsive to social welfare must address this fact. It is estimated that in rural North India, 30 billion hours are spent in gathering fuel wood and other traditional fuels annually.

15. The total quantities of traditional fuels used are substantial. *Table 1.2* presents the data on household energy use. Biomass based fuels dominate particularly in rural areas, where they are used by households in all consumer expenditure categories (*see Figure 1.6*). This implies that their use would not reduce even with economic growth and rising incomes in rural areas.

BOX 1.1

The Burden of Traditional Fuels in Rural India

A study based on an integrated survey covering 15,293 rural households from 148 villages in three states of rural North India and one state in South India shows the importance of clean fuels. Symptoms of diseases related to air and water pollution, expenditure on health and person days lost, demographic and socio-economic information, measurements of air quality in the kitchen, outside the kitchen and the home were collected. Indicators for respiratory functions (Peak Expiratory Flow) were measured for most of the adults present at the time of the survey. The doctors examined a sub-sample of individuals for confirmation of diseases.

The study estimated that

- 96% of households use ***biomass energy,*** *11*% use ***kerosene*** and 5% use ***LPG*** for cooking. Most of them use multiple fuels.
- Forests contribute 39% of the fuel wood need.
- 314 Mt of bio-fuels are ***gathered*** annually.
- 85 million households spend 30 billion hours annually in fuel wood gathering.
- Respiratory symptoms are prevalent among 24 million adults of which 17 million have serious symptoms.
- 5% of adults suffer from Bronchial asthma, 16% from Bronchitis, 8.2% from Pulmonary TB and 7% from Chest infection.
- Risk of contracting respiratory diseases and eye diseases increases with longer duration of use of bio-fuels.

Total economic burden of dirty biomass fuel was estimated to be Rs.299 billion using a wage rate of Rs.60 per day, comprising of opportunity cost of gathering fuel, working days lost due to eye infections and respiratory diseases, and the cost of medicine.

As women are the primary sufferers of the adverse impact of use of biomass fuels, there is a close linkage between gender and energy. Gender and energy issues have remained on the periphery of energy policy, and require greater attention and backing.

Source: Parikh Jyoti et al (2005)[2]

[2] Parikh Jyoti K. et al "Lack of Energy, Water and Sanitation and its Impact on Rural India" in Parikh Kirit S. and R. Radhakrishna (eds.), *India Development Report 2004-2005*, Oxford University Press, New Delhi.

Table 1.2
Household Energy Consumption in India (July 1999 – June 2000)

Fuel Type	Physical Units			Mtoe		
	Rural	Urban	Total	Rural	Urban	Total
Fire Wood & Chips (Mt)	158.87	18.08	176.95	71.49	8.13	79.62
Electricity (BkWh)	40.76	57.26	98.02	3.51	4.92	8.43
Dung Cake (Mt)	132.95	8.03	140.98	27.92	1.69	29.61
Kerosene (ML)	7.38	4.51	11.89	6.25	3.82	10.07
Coal (Mt)	1.20	1.54	2.74	0.49	0.63	1.12
L.P.G. (Mt)	1.25	4.43	5.68	1.41	5.00	6.41

Source: Derived from NSS 55th Round, (July 1999-June 2000) data, National Sample Survey Organisation, Ministry of Statistics and Programme Implementation, Government of India

Figure 1.6
Pattern of Household Energy Consumption
Figure 1.6(a): Monthly Per Capita Household Consumption Pattern Urban India, 2000

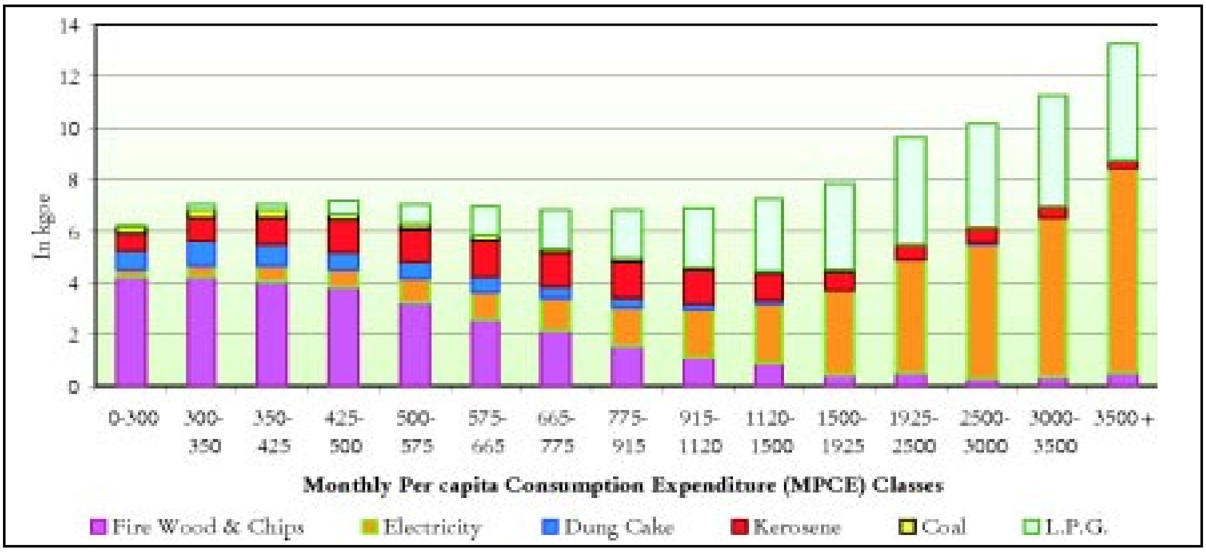
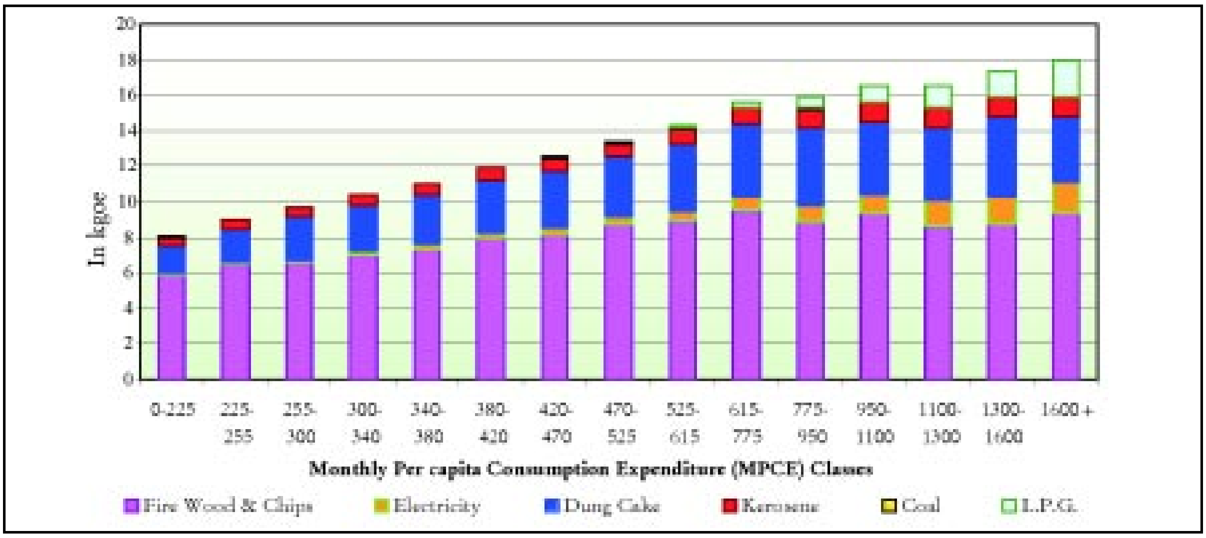


Figure 1.6(b): Monthly Per Cpita Household Consumption Pattern Rural India, 2000

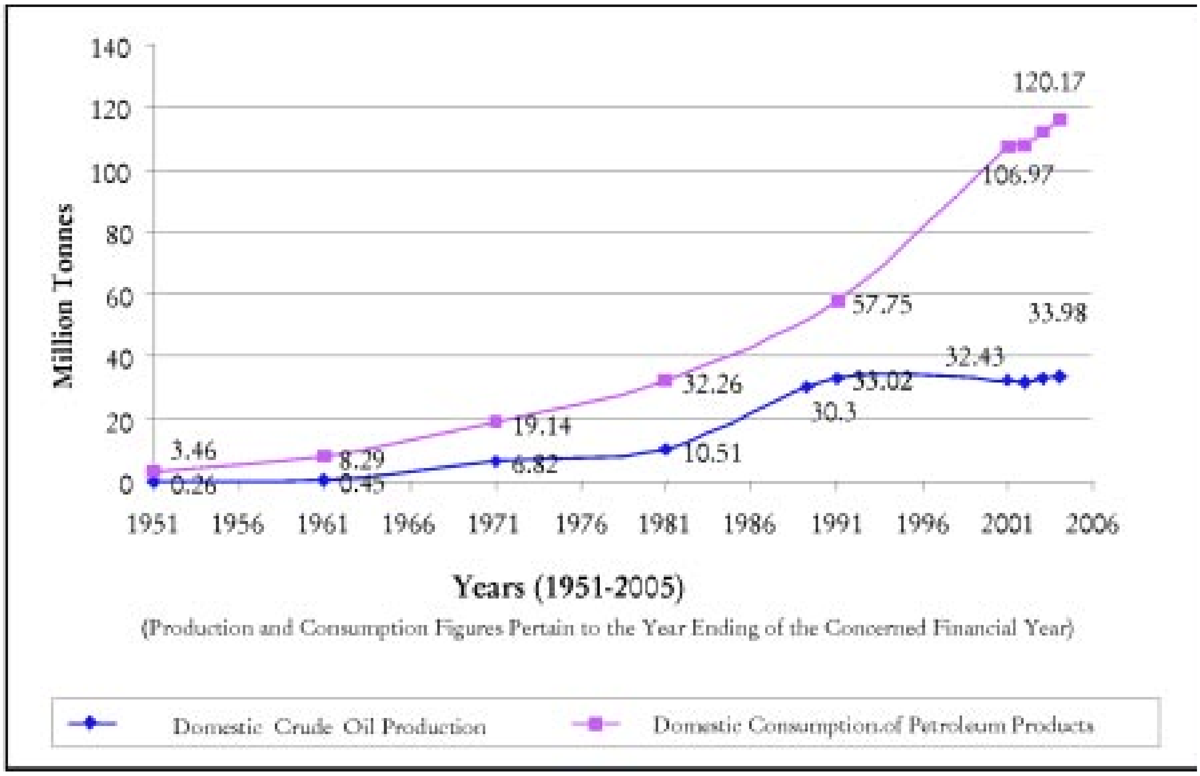


Source: NSS 55th Round, (July 1999-June 2000), National Sample Survey Organisation, Ministry of Statistics and Programme Implementation, Government of India

16. In 2004-05, net of exports, India consumed 120.17 Mt of crude oil products including refinery fuel. Domestic production of crude oil has been between 30.3 Mt to 33.98 Mt during 1990-2005 (*see Figure 1.7*). Not only has domestic production stagnated, oil reserves hovered between 700 Mt and 750 Mt during this period. The total oil reserves were 739 Mt in 1990-91 and were estimated to be 786 Mt in 2004-05. The proved reserves to production (R/P) ratio was 23 in 2004-05. We now import 72% of our consumption and our import dependence is growing rapidly. This raises serious concerns about India's energy security, our ability to obtain the oil we need and the impact of constrained supply and the consequent increase in oil prices on our economy.

17. Till 1997, oil and gas exploration was mainly done by public sector firms. Progressive liberalisation of exploration and the licensing policy has attracted some private and foreign firms. The success of these explorations has been marginal in enhancing oil reserves. However, some sizeable gas reserves amounting to 680 Mtoe [320 Mtoe claimed by Reliance and 360 Mtoe claimed by Gujarat State Petroleum Corporation (GSPC)] have been reported recently which is yet to be confirmed by DGH. More work is needed to estimate the total extractable potential. Despite one of the most liberal exploration licensing regimes, India has failed to attract any oil majors to explore in India. This might be an indication of the oil major's assessment of the exploration potential in the Indian Sedimentary basins since typically such firms prefer to work in large fields. In the latest round of bidding for exploration under the new exploration licensing policy (NELP), oil majors have shown interest. Given the rising preference for gas as a fuel and feedstock, India is also seeking to significantly raise gas imports through LNG and Trans-National gas pipelines. Oil diplomacy is currently seen as a major tool for ensuring India's energy security along with the acquisition of equity oil and gas from overseas.

Figure 1.7
Domestic Consumption and Production of Crude Oil

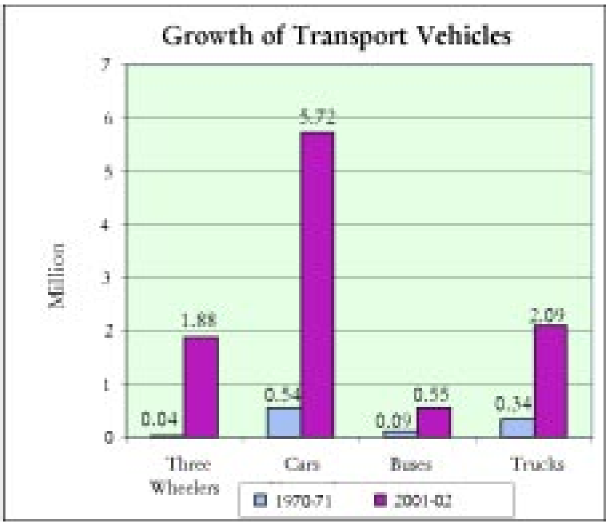


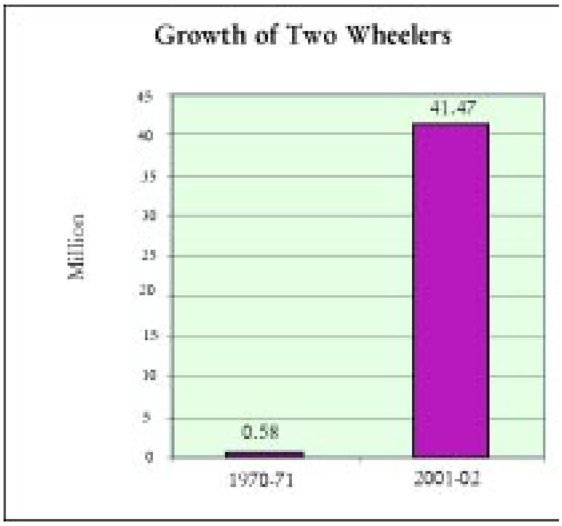
Source: Ministry of Petroleum & Natural Gas

18. The total consumption of petroleum products grew at the rate of 5.7% per annum between 1980-81 and 2003-04. However, growth in consumption has moderated to 2.95% per annum over the last four years (2000-01 to 2004-05). Consumption for petrol and diesel grew at 7.3% and 5.8% per annum respectively between 1980-81 and 2004-05. This was the outcome of the growth of personal motorised transport and the rise in share of road haulage. The numbers of two-wheelers rose from 5,75,893 to 4,14,78,136, three-wheelers from 36,765 to 18,81,085, cars from 5,39,475 to 57,17,456, buses from 93,907 to 5,52,899 and trucks from 3,43,000 to 20,88,918 between 1970-71 and 2001-02 (*Figure 1.8*). The vehicle population continues to grow at higher than historical rates. However, in the last 5 years growth in consumption of petrol and diesel has been far more moderate at 6.9% and less than 1% respectively. This reflects the improved efficiency of vehicles and better road conditions. *Table 1.3* gives the decadal growth rates of motor vehicles from 1970-71 to 2001-02. In 2004-05, liquid fuel consumption in the transport sector accounted for 28% of our total petroleum products consumption.

19. Currently, the refining capacity of the country is greater than the domestic requirements, making India a net exporter of petroleum products. The projected addition to

Figure 1.8
Growth of Transport Vehicles and Two Wheelers





Source: Centre for Monitoring Indian Economy Pvt. Ltd. (CMIE)

Table 1.3
Growth of Motorised Transport Vehicles

	1970-71	1980-81	1990-91	2001-2002	Growth Rate
Two-wheelers	575893	2530441	14199858	41478136	15.3%
Three-wheelers	36765	142073	617365	1881085	14.0%
Cars	539475	900221	2266506	5717456	8.2%
Taxis	60446	100845	243748	684490	8.4%
Jeeps	82584	120475	443734	1168868	9.2%
Buses	93907	153909	331096	552899	6.1%
Trucks	343000	554000	1355953	2088918	6.2%

Source: Center for Monitoring Indian Economy Pvt. Ltd. (CMIE) refining capacity in both the public and private sectors will far exceed addition in demand and petroleum products could, therefore, become India's largest export. India's marginal advantage in becoming a refining hub for exporting products is not immediately clear.

20. The oil sector remains largely in the hands of the central Public Sector Undertakings (PSUs). The exception is refining wherein some 26% of capacity is now in private hands. Before 2002, oil product prices were set by the government under an Administered Price Mechanism (APM), which is no longer in use. The prices of inputs and the products are now determined on the basis of the import parity principle even for products wherein India is a net exporter. However, since prices are fixed collectively by the public sector oil companies, there is no price competition at the refinery gate or retail outlets. The Government of India, through the Ministry of Petroleum and Natural Gas, has frequently deviated from the import parity principle in fixing the effective price of domestic crude as well as the price of petroleum products at the retail level. Currently, there is no independent regulation of the upstream or downstream petroleum sector.

21. The above pricing methodology leads to multiple distortions when coupled with the fact that there are differential custom duties on crude oil and petroleum products, differential excise duties and central levies on products, as well as differential state taxes and a normative pooling of the transport costs. These distortions and their impact on the profitability of central PSUs and private refiners are further compounded by subsidies on LPG and kerosene, which are exclusively marketed by central PSUs that share part of the subsidy burden. Efficient cost based private refiners with no marketing obligations have thus had extraordinary advantages in this distorted market. Even public sector refineries or upstream operations such as Oil & Natural Gas Corporation (ONGC) make large profits while oil marketing companies lose money. This has restrained the growth of private sector retailers who find it simpler to sell to the public sector marketing companies at import parity prices. Other barriers to private sector's entry into retailing include a minimum investment hurdle of Rs.2000 crore and the absence of a common carrier principle in the distribution and marketing sectors. Another feature of the distorted market is the large-scale adulteration of petrol and diesel with subsidised kerosene.

22. The challenges facing the petroleum and natural gas sectors include: (a) ensuring crude oil and gas supplies in a constrained world market amidst rising prices; (b) demand management of petroleum products; (c) rational pricing of petroleum products and natural gas; (d) removal of entry barriers for private players in distribution and retail business in order to create real market competition; (e) regulation of upstream and downstream sectors; (f) improving the administration of LPG and kerosene subsidies and, finally (g) environmental management through product upgradation.

23. Coal has been the mainstay of India's energy supply for many years. Coal consumption increased from 140 Mt in 1984 to over 400 Mt in 2004 with a growth rate of 5.4%. Thermal power plants using coal today account for 57% of our total generation capacity. Indian coal has a high ash content and low calorific value – an average of 4000 kcal/kg compared to 6000 kcal/kg in imported coal. The average calorific value of coal burnt in India's power plants is only about 3500 kcal/kg. The high ash content also results in higher emission of suspended particulate matter (SPM). However, the sulphur content of Indian coal is very low, and emission of SO_2 during combustion is also low. Since SPM is comparatively easy to trap, Indian coal is relatively clean. Despite large reserves of coal domestic supply is tailored to barely meet domestic demand for thermal coal with small quantities being imported. India is not self-sufficient in metallurgical coal and over 65% of the demand is met through imports.

24. The coal sector is dominated by Public Sector Undertakings (PSUs) under the central and state governments. PSUs engaged in the production of coal and lignite contribute nearly

90% and 73% of the total production of coal and lignite respectively. The Coal sector was progressively nationalised between 1971 and 1973 after recognising the need for scientific and planned development of resources and improving the working conditions in existing mines. The objectives of 'nationalisation' have not been realised completely. The country is facing an acute shortage of coking coal supplies, the demand and supply balance of non-coking (thermal) coal is extremely tight with marginal quantities of imports required to fill the gap. More importantly, the quality of thermal coal has been deteriorating over the years. The increasing share of opencast mines is one of the contributing factors for the deterioration in quality. There has been only a marginal improvement in productivity. The level of mechanisation of underground workings and the success thereof has also not met expectations.

25. A lack of competition, the absence of suitable benchmarks for different operational parameters and the absence of an independent Regulator for the sector have constrained the growth of coal industry. Problems of land acquisition and rehabilitation, stiff legislation covering forest conservation and environment management have also, to some extent, affected the pace of development of the coal sector. Indian Coal is internationally competitive at the pithead. However, its pricing has remained non-transparent and its distribution is restricted through a complex regime of linkages based on a constrained rail infrastructure that offers little flexibility. Moreover, freight rates are exorbitant and cross subsidise passenger traffic. This makes Indian coal progressively uncompetitive as it moves away from the pitheads. In spite of low (5%) import duty on thermal coal, imports have been sluggish. This is primarily due to constraints of port capacity and the cost associated with multiple handling and inland transportation of imported coal. Unfortunately coal consumption at coastal sites is currently minimal.

26. The entry of the private sector in coal production is essential for realising efficiency gains and augmenting the domestic coal supply. Consequently, the Coal Mines Nationalisation (Amendment) Bill, 2000, was introduced in Parliament to bring about suitable legislative amendments to permit private sector entry into the coal sector. However, its passage is still awaited. Pending such amendment, the captive mining policy was formulated within the bounds of existing legislation and several coal blocks have been offered to potential entrepreneurs to exploit coal for their own consumption. Foreign Direct Investment (FDI) in coal mining has been allowed and mining by joint venture companies is permitted albeit for captive mines. Coal blocks have also been allocated to other PSUs under Central and State Governments for coal mining.

27. Large estimates of total coal resources give a false sense of security because current and foreseeable technologies convert only a small fraction of the total resource into the mineable category. The capacity of PSUs engaged in exploration has restricted the pace of proving indicated and inferred resources. This limited capacity, coupled with the economics of opencast mines versus underground mines, gives only limited incentive to explore for coal beyond 300m depth.

28. Clean coal technologies for improving the efficiency of energy conversion and limiting emissions; research and development initiatives for establishing additional sources of energy such as coal bed methane; in-situ gasification of un-mineable and deep seated coal reserves; and the liquefaction of coal are promising areas for action but are still in their infancy.

29. While we have developed indigenous technological capability in all aspects of nuclear power, our ability to develop nuclear power is restricted by the very limited availability of Uranium. In fact, the present Uranium shortage has forced us to operate even the small nuclear generation capacity that we have at a load factor below what is technically possible. The pace at which we can expand nuclear power generation using indigenous fuel sources is thus severely limited even though the eventual potential for nuclear power generation is vast.

30. There is large unexploited hydel potential in the country. Development of this

involves relatively long gestation lags. Moreover, storage schemes often involve displacement of people and submergence of land. Project affected people need to be resettled and rehabilitated. Also, storage schemes may have other environmental consequences such as adverse impact on aquatic life and downstream ecosystems. While these problems are not unsurmountable they have not been adequately attended to in the past. There is, therefore, some opposition to the development of large storage schemes. However, storage schemes help utilise water that would have otherwise gone to the seas. Run of the river schemes avoid these problems though at the cost of a much lower utilisation of the available hydro resource both in terms of water usage and its energy potential. Most importantly, run of the river schemes, typically, have much lower capacity for delivering peak power compared to storage schemes. Thus, if a river basin can support storage projects, a careful economic analysis must be done before allowing that potential to be converted to the easy-to-do run of the river schemes.

31. Given the shortage of conventional fuels, non-conventional energy sources hold a special attraction for the country. Despite many years of efforts and despite the significant growth of small-hydro and wind power, the contribution of non-conventional energy sources such as wind, solar, biogas, etc., to our total energy use has remained below 1%.

32. Environmental problems associated with energy use have become severe in many urban areas. Most of our cities have a high concentration of one or more pollutants above the safe limit. In fact, many Indian cities are among the most polluted cities in the world. The Supreme Court mandated the use of Compressed Natural Gas (CNG) for buses, taxis and three-wheelers in Delhi beginning September 2001. Other cities are following this lead. In our energy strategy environmental concerns have to be factored in to reduce emission of local pollutants as well as global pollutants to ensure that the energy strategy is ecologically sustainable.

33. The continued dependence on biomass-based fuels, which are mostly obtained from forests, raises the threat of deforestation, thinning of forests and a loss of habitat and bio-diversity.

34. Thus in summarising the energy scene we note that the immediate problems are shortages of fuels, a growing dependence on imported oil that is becoming dearer by the day, and a power sector with ill financial health that discourages growth in a country that needs energy for growth and for improving human welfare. These problems should be addressed in the context of our long-term energy requirements and the available strategic options to fulfil them so that we may not get locked into paths that we may regret later.

1.2 THE ISSUES

35. The energy scene described above raises a number of issues. We divide these into two categories: those that need to be addressed from a long-term perspective and those that are pressing problems in the short-term.

36. From a long-term perspective a number of issues need to be addressed:

(a) How much energy do we need over the long run? Given our resources, what should be our strategy to meet the growing demand?

(b) How do we promote the efficient allocation of various fuels and energy forms to different uses? What should be their relative prices?

(c) How do we address the legitimate concerns of States rich in energy resources such as coal and hydro?

(d) What institutional reforms are needed to generate competitive efficiency? How do we leverage the strength of public sector units that dominate energy sectors? How do we obtain credible, independent, transparent and consistent regulatory oversight in the energy sector?

(e) What is the role of renewables in our energy supply? How do we promote their development?

(f) How should we increase India's known energy resources? What new technologies are relevant for India's future? How do we promote their development? What should be our R&D strategy?

(g) What is the scope for increasing the energy efficiency of the system? What policies can lead to higher efficiency? How do we encourage energy conservation and energy efficiency? In particular, how do we reduce the use of petroleum fuels for transport? What policies are needed to promote fuel efficiency and alternatives in transport?

(h) How do we ensure energy security? What is the role of obtaining equity energy abroad? How do we reduce dependence on imported energy?

(i) How do we encourage an energy system that keeps air pollution within acceptable limits? The growing global concern over the threat of climate change requires that India continues to increase its energy supply in a responsible manner without compromising its economic growth imperative. India's long-term energy strategy must take this into account.

37. In the short-term, our pressing problems are:

(a) How do we deal with persistent power shortages? How do we expand capacities for generation, transmission and distribution? How to generate investible surpluses with SEBs? How do we improve the financial health of SEBs? How do we reduce AT&C losses?

(b) How do we reduce the cost of power and improve its quality? How should we do away with cost plus regime? How do we introduce competition? How can we encourage private sector participation in the power sector? How can we provide open access in a level playing field?

(c) How do we ensure fuel supply for power generation? How should we expand coal supply in a cost effective way? How can we promote investment in coal production? How do we expand production by captive mines? How do we facilitate import of coal to meet shortfalls in domestic supply and wherever imports are cost effective?

(d) How should we allocate and price domestic gas?

(e) How do we deal with the rising cost of oil in the world market? How to minimise its adverse impact on the economy?

(f) How do we provide clean cooking energy to all? How can we develop an energy system that is poverty and gender sensitive?

(g) How do we provide access to electricity for all households? Considering some consumption of electricity as a merit good that we want all to consume, how should it be financed?

(h) How do we provide subsidy for electricity and clean cooking fuels to certain consumers e.g. poor households or agricultural pumps, in ways that do not encourage wasteful use of electricity?

1.3 THE VISION

38. The broad vision behind the energy policy is to reliably meet the demand for energy services of all sectors including the lifeline energy needs of vulnerable households in all parts of the country with safe, clean and convenient energy at the least-cost. This must be done in a technically efficient, economically viable and environmentally sustainable manner using different fuels and forms of energy, both conventional and non-conventional, as well as new and emerging energy sources to ensure supply at all times with a prescribed confidence level considering that shocks and disruption can be reasonably expected. In other words, the goal of the energy policy is to provide energy security to all.

1.4 NEED FOR AN INTEGRATED POLICY

39. The need to have an integrated policy arises because different fuels can substitute for each other in both production and consumption. Alternative technologies are available and there is substantial scope for exploiting possible synergies to increase energy system efficiency and to meet requirement for energy services. If the energy system is to be efficient, our policies must be integrated. Currently with five separate ministries (Coal, Petroleum & Natural Gas, Atomic Energy, Power and Non-Conventional Energy sources), each concerned with its own turf, policies are not always consistent, opportunities for inter-linkages and synergy are missing and sub-optimal solutions are the result. We briefly look at issues that call for an integrated policy and describe some of the attributes of such a policy.

(a) **Relative Prices**

Different fuels have different calorific values. Their efficiency in use and convenience also differ. Moreover, they generate different kinds and amounts of pollution. And yet often they are substitutes for each other in specific uses. Their relative prices, therefore, have to be set in a way that the resulting inter-fuel choices are socially and economically desirable. For this, their marginal use values per rupee of fuel need to be equivalent. Thus prices of different fuels should not be set independently of each other.

(b) **Consistent Tax Structure**

Relative prices can be affected by taxes and subsidies. Excise and import duties have to be consistent across different fuels. For an optimal allocation of resources, taxes on capital goods that use different fuels to produce the same output should be consistent. The tax structure on alternate fuels may be used to promote desired policy objectives relating to environment, utilising domestic energy resources, generating employment etc.

(c) **Level Playing Field**

All players and energy projects, public or private, large or small, domestic or foreign should be treated equally if the sector is to be efficient.

(d) **Uniform Treatment of Externalities**

Different fuels may have different externalities in their production and for use. Thus for example, coal involves mining with potential to damage land while nuclear power involves a much smaller amount of mining but poses problems of hazardous waste disposal. Biomass based fuels are renewables and may not result in carbon emissions, but the air pollution caused by their use may have a severe and adverse impact on health. Our policies need to take an integrated view so that environmental objectives are attained at least-cost.

(e) **Public Infrastructure**

Many elements of the energy system constitute public infrastructure with many positive externalities and economies of scale. Some of them are natural monopolies. Ports, roads, rail roads, urban mass transport, etc., play an important role in the energy system. Transmission networks or gas pipeline networks have large economies of scale. These are often developed through public efforts or through public-private partnerships. Their development needs to be coordinated and their functioning regulated.

(f) **Long Gestation Lags, R&D and Transition Strategy**

Many energy projects involve large investments and have long gestation lags. An integrated policy needs to provide a framework of development, and a strategy of transition to the desired energy future. In particular, R&D for new technologies and new sources may be most successful with long-term commitment and support. Setting priorities among alternative R&D missions and defining an optimal

R&D strategy require an integrated perspective on the future of the energy system.

(g) **Consistent Regulation**

The energy sector requires regulatory oversight to balance consumer and producer interests, to ensure efficiency and to create a level playing field. Natural monopolies need regulation to ensure open access to all so that competitive efficiency is realised. However, regulation should be consistent across different energy sources and across regions, which requires an integrated policy.

(h) **National Priorities**

While competitive efficiency is a desirable goal, policies have to factor in national priorities. Thus if the country decides that food security is paramount and that a certain level of fertiliser self-sufficiency is required, then the energy policy needs to provide for it. If this calls for a certain quantitative allocation of natural gas, one must consider such an allocation, though one should ideally find an implementation solution that is at the least-cost.

(i) **Regionally Balanced Development**

Energy infrastructure is critical for development. For regionally balanced development, energy should be available in all regions. Freight and transmission equalisation, as practised in the past, has often caused regionally distorted development. Thus Bihar, in spite of its natural resources, has remained industrially underdeveloped. One needs to use more direct instruments where incentives are linked to outcomes. Distortion of energy prices do not often serve this purpose. As different fuels and resources are differentially distributed geographically, an integrated approach can help minimise the cost of distortions and incentives.

(j) **Energy for the Poor**

Some amount of clean cooking fuels (LPG and Kerosene) and electricity are merit goods, which justifies subsidies for these goods for the poor. These subsidies have to be consistent, progressive and implementable. Ideally, they should also be self-targeting and self-limiting. Implemented properly, they could, especially for women, relieve drudgery, reduce health impact, increase productivity and enhance livelihood options.

1.5 APPROACH

40. Traditional approach to the energy policy - of determining optimal supply strategy with quantitative targets - is no longer appropriate. We must provide policies that create an enabling environment and provide incentives to decision makers, consumers, private firms, autonomous public corporations, and government departments, to behave in ways that result in socially and economically desirable outcomes. The Committee's approach has been to identify such policies.

41. It is not necessary to compare precisely the economics of alternatives as the policy does not mandate which alternative should be used and when. Relative economics of alternatives depend on particular circumstances, relative prices of different fuels as well as technological developments. These comparisons and the resulting choices among them are best left to economic decision takers. Thus, policy recommendations have been presented as broad principles, leaving the details to be evolved, if necessary, by implementing agencies in the framework of plans and programmes at any point of time.

42. The institutional structure in the public sector that we have so assiduously built up during the last 55 years or so to promote self-sufficiency and self-reliance in energy, has led to a monopolistic market structure and led to the systemic infirmities that are inherent in cases of majority public ownership of an enterprise. However, the Committee recognises

that in a liberalised economy, the private sector is expected to play an important role in the energy sector.

43. Keeping this in mind our approach to designing an integrated energy policy is based on the following premises:

(a) Effective implementability of policies is important. Any policy that depends on the good behaviour of many people is unlikely to be effectively implementable.

(b) Informed debate based on widely disseminated and reliable data is critical for effective policy formulation.

(c) Incentive compatible policies that factor in stakeholder concerns are more likely to be acceptable and implementable.

(d) Competitive set-ups that give appropriate signals to various economic agents, such as prices, are to be preferred.

(e) Independent Regulators have critical roles to play. However, regulation is not always a substitute for competition and by itself cannot give efficient outcomes. Regulation should be complemented by an appropriate industry structure. For example, experience in electricity sector has shown that good regulation under a proper industry structure can mimic competition. It must also be noted that the mere presence of competition does not negate the need for independent regulation – it only changes the scope of regulation.

(f) Social objectives should not be sacrificed to the objective of competition but should be made consistent with it through the use of direct transfers where possible.

(g) Policy has to recognise the existing institutional structure of the energy sector and define a transition strategy of reforms.

(h) Policies should reflect externalities of energy consumption.

(i) Efficiencies across the energy chain should be improved.

44. With these principles in mind, we will now look at energy by each fuel source as well as at the power sector to address issues identified earlier. Keeping in mind the need for integration, we will underline aspects of policies that need to be integrated with other policies.

Energy Requirements

Long-term projections for energy requirements are based on assumptions vis-à-vis the growth of the economy, population growth, the pace at which "non-commercial energy" is replaced by "commercial energy", the progress of energy conservation, increase in energy efficiency as well as societal and lifestyle changes. It is not surprising, therefore, that available projections differ widely. Yet it is useful to have a set of consistent projections with clearly stated assumptions to outline the broad discussion of the challenges facing us in meeting energy needs as well as to provide a framework for policy formulation. Having said this, it is emphasised that a rigorous demand analysis has not been conducted by the Committee and the numbers here and in *Chapter III* merely establish an indicative range of likely energy demand, supply and mix. However, the policy recommendations that emerge are not affected by the lack of precision in the demand projections.

2.1 COMMERCIAL ENERGY NEEDS

2. We projected total primary commercial energy requirement on the basis of elasticity w.r.t. GDP, which gives a percentage change in commercial energy requirement for one percent change in GDP. The elasticities are obtained from time series data of India's commercial energy use. These elasticities are summarised below:

3. The elasticity for per capita primary commercial energy supply with respect to per capita GDP estimated from the time series data of India comes to 0.82 since 1990-91 which is significantly lower than 1.08 estimated for the period since 1980-81. Similarly the elasticity for per capita electricity generation is only 1.06 since 1990-91 compared to 1.30 for the period since 1980-81. We have used electricity generation rather than consumption because while losses have been rising over time, precise data is not available on technical losses and commercial losses (which includes pilferage, non-billing, and non-collection). Except for technical losses all electricity made available contributes to GDP. However, since even technical losses have been rising (current estimates are upwards of 15%) using electricity generation instead of actual consumption gives higher elasticities. Importantly though, the elasticities in India are falling over time (or with increasing GDP).

4. The energy elasticities of GDP can be reshaped by policy interventions, the relative prices of fuels, changes in technology, changes

Table 2.1
Energy Use Elasticity w.r.t. GDP
(Percent change in Commercial energy use for one percent change in GDP)

Regression Using India's Time Series			
			Per Capita
1.	TPCES w.r.t. GDP (Rs. Crores 1993-94)	1980-81—2003-04	1.08
		1990-91—2003-04	0.82
2.	Electricity Generated w.r.t. GDP (Utilities + Captive)	1980-81—2003-04	1.30
		1990-91—2003-04	1.06

TPCES = Total Primary Commercial Energy Supply

Table 2.2
Elasticities Used for Projections

(TPCES w.r.t. total GDP)

	TPCES 1 (Falling elasticities)	TPCES 2 (Constant elasticities)	Electricity (Falling elasticities)	Electricity (Constant elasticities)
2004-05 to 2011-12	0.75	0.8	0.95	0.95
2011-12 to 2021-22	0.70	0.8	0.85	0.95
2021-22 to 2031-32	0.67	0.8	0.78	0.95

in end-use efficiency of equipment, the level of the energy infrastructure and development priorities that affect the structure of the economy. Normally, overall elasticity falls over time as is corroborated by the time series data for India's commercial energy consumption. However, there is also a feeling that, for India, the energy elasticity of GDP growth will not fall any further as rising income levels will foster life style changes that are more energy intense. Based on these alternative views two sets of elasticities were used for projecting India's commercial energy demand. The two sets of elasticities used are shown in *Table 2.2*.

5. To get a feel for how India's energy elasticities compare with other countries, we have estimated these elasticities using cross-country regression based on data of 2003. These are shown in *Table 2.3*. The elasticity for total primary energy supply, TPES, comes to 0.83 for all countries and to 0.79 for countries with a PPP GDP between $2000 and $8000 (India's GDP in PPP terms based on 2000 dollars was $2732 in 2003 and by 2031-32 might reach the upper end of the range). India's energy elasticity for commercial energy is comparable to the elasticity estimates for TPES using cross country data. The elasticity for electricity consumption comes to 1.24 for all countries and to 1.25 for PPP GDP range of $2000 to $8000. India's elasticity for electricity generation is comparable to that of countries with per capita GDP exceeding $8000 in PPP terms. Importantly, the trend of falling elasticities with rising income levels is demonstrated even by cross country data.

6. Using the above estimates, commercial energy needs have been projected for different growth scenarios using falling and constant elasticities from Table 2.2. These projections are given in Table 2.4, which also shows population projections by the Registrar of Census. It is noted, though, that the number based on constant elasticities is not used in this report for any comparison.

2.2 REQUIRED ELECTRICITY GENERATION

7. Requirement for electricity generation, (projected using the elasticities of *Table 2.2*) are shown in *Table 2.5*. Plan-wise projected electricity generation and capacity additions are shown in *Figures 2.1* and *2.2* respectively.

Table 2.3
Energy Use Elasticity w.r.t. GDP from Cross-Country Data of 2003

1.	TPES (kgoe/capita) w.r.t. per capita GDP ($ PPP 2000)	All Countries	0.83
		2000 < GDP < 8000	0.79
		GDP > 8000	0.76
2.	Electricity Consumption (kWh/capita) w.r.t. per capita GDP ($ PPP 2000)	All Countries	1.24
		2000 < GDP < 8000	1.25
		GDP > 8000	1.09

Table 2.4
Projections for Total Primary Commercial Energy Requirements
(Mt of Oil Equivalent)

Year	Population in millions	GDP (Rs. in Billion @1993-94 prices)		TPCES (Mtoe) 1 GDP Growth Rate		TPCES (Mtoe) 2 GDP Growth Rate	
		8%	9%	8%	9%	8%	9%
2006-07	1114	17839	18171	389	397	394	403
2011-12	1197	26211	27958	521	551	537	570
2016-17	1275	38513	43017	684	748	732	807
2021-22	1347	56588	66187	898	1015	998	1142
2026-27	1411	83145	101837	1166	1360	1361	1617
2031-32	1468	122170	156689	1514	1823	1856	2289

Note: 1. Projections based on falling elasticities with respect to GDP

2. Projections assuming no change in elasticities with respect to GDP

3. It is pointed out that the level of commercial energy consumption shown for 2006-07 is not expected to be achieved as the growth in demand for petroleum products in the first 4 years of the 10th Plan has only been 2.8% per annum. However, over the long-term, the projections may still be valid as incomes and access improves.

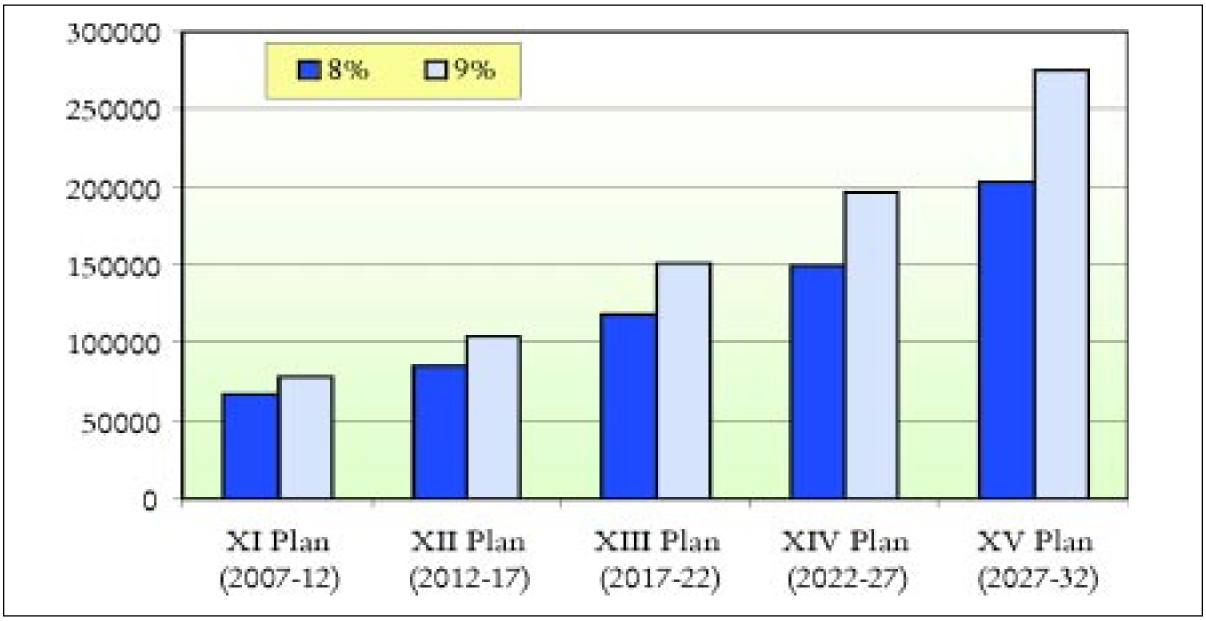
Table 2.5
Projections for Electricity Requirement
(Based on Falling Elasticities of Table 2.2)

Year	Billion kWh				Projected Peak Demand (GW)		Installed Capacity Required (GW)	
	Total Energy Requirement		Energy Required at Bus Bar		@ GDP Growth Rate		@ GDP Growth Rate	
	@ GDP Growth Rate		@ GDP Growth Rate					
	8%	9%	8%	9%	8%	9%	8%	9%
2003-04	633	633	592	592	89	89	131	131
2006-07	761	774	712	724	107	109	153	155
2011-12	1097	1167	1026	1091	158	168	220	233
2016-17	1524	1687	1425	1577	226	250	306	337
2021-22	2118	2438	1980	2280	323	372	425	488
2026-27	2866	3423	2680	3201	437	522	575	685
2031-32	3880	4806	3628	4493	592	733	778	960

Note: Electricity generation and peak demand in 2003-04 is the total of utilities and non-utilities above 1 MW size. Energy demand at bus bar is estimated assuming 6.5% auxiliary consumption. Peak demand is estimated assuming system load factor of 76% up to 2010, 74% for 2011-12 to 2015-16, 72% for 2016-17 to 2020-21 and 70% for 2021-22 and beyond. The installed capacity has been estimated keeping the ratio between total installed capacity and total energy required constant at the 2003-04 level. This assumes optimal utilisation of resources bringing down the ratio between installed capacity required to peak demand from 1.47 in 2003-04 to 1.31 in 2031-32.

Figure 2.1
Projected Electricity Generation Growth (BkWh)

Figure 2.2
Plan-wise Projected Installed Capacity Addition (MW)



8. For comparison purposes, *Table 2.6* provides projections of electricity demand made by the Ministry of Power. For the purposes of this report, however, the projections of *Table 2.5* have been used.

Table 2.6
Projections for Electricity Requirement by MOP

Year	Billion kWh		Installed Capacity (GW)	
	8%	9%	8%	9%
2006-07	700	700	140	140
2011-12	1029	1077	206	215
2016-17	1511	1657	303	331
2021-22	2221	2550	445	510
2026-27	3263	3923	655	785
2031-32	4793	6036	962	1207

9. Electricity requirements can be met by various alternative fuels. These include coal, nuclear power, hydropower, gas, oil and renewables such as biomass, wind energy, solar energy, etc. In order to understand the broad dimensions of the fuel requirements for power generation, a possible fuel mix scenario has been developed. **The projections of this scenario are summarised in *Table 2.7*. It is important to note that *Table 2.7* represents one possible scenario and it should not, in any way, be considered as the preferred scenario. Also to the extent that gas, hydro or nuclear capacity cannot be realised as projected in the scenario, coal-based generation will need to fill the gap. In reality, the choice between coal and gas will be guided by economic and commercial considerations including any policy prescriptions for pricing-in certain environmental externalities. The level of gas use projected in the scenario under *Table 2.7* is based on somewhat optimistic assumptions of gas availability and of its ability to compete with coal on price. Should these assumptions not hold true, coal dependence will increase.**

10. The projections in *Table 2.7* assume exploitation of full hydro potential of 1,50,000 MW in the country, a capacity addition of 63,000 MW from nuclear power sources and a 14,000 MW capacity from wind farms by 2031-32. These scenario assumptions in respect of hydro and nuclear may not be fully realised and are made here in order to characterise the boundaries of alternative choices. Generation from coal-based stations also includes electricity generation from lignite. The scenario also forces gas usage for power generation with gas-based electricity share rising from about 10% to 16% between 2003-04 and 2031-32. As a result of these assumptions, the share of coal-based electricity drops from 72% to 61%. The demand for oil in power sector covers consumption of petroleum products in diesel based plants as well as secondary oil consumption in coal-based plants.

2.3 INDIA'S OIL DEMAND

11. Long-term growth in demand of petroleum products depends upon a number of factors such as economic growth (GDP), elasticity of demand for petroleum products with respect to GDP growth, relative price levels of substitute products particularly LNG/CNG, saturation of LPG demand, and the impact of energy conservation measures. The demand for petrol and diesel is dependent on the growth of road infrastructure, the price of oil, the future efficiency of vehicles, the growth

Table 2.7
Sources of Electricity Generation – One Possible Scenario

Year	Electricity Generation at Bus Bar (BkWh)		Hydro (BkWh)	Nuclear (BkWh)	Renewables (BkWh)	Thermal Energy (BkWh)		Fuel Needs					
								Coal (Mt)		NG (BCM)		Oil* (Mt)	
	8%	9%				8%	9%	8%	9%	8%	9%	8%	9%
2003-04	592	592	74	17	3	498	498	318	318	11	11	6	6
2006-07	711	724	87	39	8	577	590	337	379	12	14	6	6
2011-12	1026	1091	139	64	11	812	877	463	521	19	21	8	8
2016-17	1425	1577	204	118	14	1089	1241	603	678	33	37	9	10
2021-22	1981	2280	270	172	18	1521	1820	832	936	52	59	12	12
2026-27	2680	3201	335	274	21	2050	2571	1109	1248	77	87	14	15
2031-32	3628	4493	401	375	24	2828	3693	1475	1659	119	134	17	20

*includes secondary oil consumption for coal-based generation of alternate modes of transport and the emergence of substitutes like bio-fuels and/or technologies such as hybrids. Naphtha demand is dependent on the growth plans for fertiliser and petro-chemicals and its price relative to the price and availability of natural gas. Different agencies have made various projections estimating changes in demand of petroleum products. The committee has reviewed the demand projections made by Energy Information Administration(EIA), USA, International Energy Agency(IEA), India Hydrocarbon Vision 2025, India Vision 2020, Working Group Report for the 10th Plan, Power & Energy Division and Integrated Research and Action for Development - Price Waterhouse Coopers (IRADe-PWC).

12. A summary of the projections by various agencies is given in *Table 2.8*. As the available projections by these agencies are for different years, the same have been interpolated or extrapolated to bring them to a common year to ease comparison. The projections by IEA and EIA are based on unrealistically low growth rates of GDP for India. It may be seen that the demand for the year 2025 varies from 235 Mt for the Best Case Scenario (BCS) of India Vision 2020 to 368 Mt of India Hydrocarbon Vision (IHV) 2025. The IRADe-PWC projections exclude Naphtha and their projection of 347 Mt under high growth case (HOG) is comparable to 368 Mt of India Hydrocarbon Vision.

13. It should be emphasised that most of these projections do not factor in the impact of change in prices. The world market in petroleum products has seen large swings in prices and future prices are difficult to predict. Since these projections vary a lot, we have projected oil demand by detailed sectoral end-use analysis.

2.4 INDIA'S COAL DEMAND FOR NON-POWER USE

14. Long-term projections of the demand for coal are quite complex owing to rapid changes in the relative availability and prices of different fuels as well as the technological advancements and new policies in the end-use sectors. Total demand, defined as the aggregate demand across various non-power coal consuming sectors such as steel, cement etc., is assessed by determining the outputs of each sector, which in turn are functions of GDP growth. In the last decade or so, a gradual decline in the elasticity of demand of coal against GDP has been observed. Possible reasons for this decline can be: (a) rising share of the non-energy consuming sector in the aggregate GDP; (b) substitution of coal by alternative fuels; and (c) technological innovations in coal consuming sectors leading to energy efficiency and a reduction in specific consumption.

15. The committee has reviewed the demand projections made by Energy Information Administration (EIA), International Energy Agency (IEA), India vision 2020, India Hydrocarbon Vision 2025, Coal Vision 2025, Working Group Report for the 10th Plan and the Power & Energy Division of Planning Commission. A summary of projections by various agencies is given in *Table 2.9*. Projections have been brought to a common year by interpolation/extrapolation for ease of comparison. The projections by IEA and EIA are based on low growth of GDP for India. It may be seen that the projected demand for coal in the year 2024-25 varies from 971 Mt for the "Business as Usual" scenario of India Vision 2020 to 1402 Mt in the India Hydrocarbon Vision 2025 report. The Committee decided to use the projections carried out for Coal Vision 2025 by TERI for non-power coal requirements and extrapolated them for estimating the coal requirement for non-power use in 2031-32.

2.5 INDIA'S NON-POWER NATURAL GAS DEMAND

16. Currently, the Indian gas market is supply constrained, especially since the future demand for gas appears to be strong. *Table 2.10* summarises the various long-term projections available for gas in India. As the available projections by these agencies are for different years, the same have been interpolated or extrapolated to bring them to common years and have been converted into MMscmd for the

Table 2.8
Demand Scenario for Petroleum Products - India
(By Various Agencies/Organisations)

(Mt)

Year	Projections by the Various Agencies										
	EIA (2004)			IEA (2004)	IHV-2025 (2000)	India Vision-2020 (2002)		Working Group Report of 10th Plan (2001-02)	Power & Energy Division's (Planning Commission) Projections (2003-04)	IRADe & PWC* (2005)	
	Reference Case	High Case	Low Case			BAU	BCS			BAU	HOG
Base Year	2001 (105 Mt)	2001 (105 Mt)	2001 (105 Mt)	2000 (102 Mt)	1998-99 (91 Mt)	1997 (83 Mt)		2001-02 (108 Mt)	2001-02 (108 Mt)	2003-04 (109.7 Mt)	
2004-05	119	122	115	122	132	121	112	119	124	125	127
2009-10	139	149	129	145	175	153	135	139	147	162	176
2014-15	157	194	154	171	226	193	162	164	174	191	212
2019-20	219	254	189	201	288	245	195	195	207	212	259
2024-25	264	324	204	230	368	309	235	232	240	260	347
2029-30				271				276	281	320	465

EIA - Energy Information Administration, USA
IEA - International Energy Agency
IHV - India Hydrocarbon Vision 2025
IRADe - Integrated Research and Action for Development
BAU - Business as Usual
BCS - Best Case Scenario
PWC - Price Waterhouse Coopers
HOG - High Output Growth

Note: As the available projections by the various agencies are for different years, the same have been interpolated or extrapolated to bring them to common years for comparison purposes.

Table 2.9
Demand Projection of Coal by Various Agencies in Mt

Source	Sectors/Period	Base year	06-07	2010	2011-12	2015	2016-17	2020-21	2021-22	2024-25	2025	2030
X Plan working group	Power		322		469		617					
	Captive Power		28		32		37					
	Steel		43		40		40					
	Cement		25		24		25					
	Fertiliser		4		5		5					
	Others		51		50		56					
	Total	2001-02	**473**		**620**		**780**		**981**	**1126**		
Coal Vision 2025* 7% GDP	Power		322		413		517		635	719		
	Captive Power		28		43		60		84	102		
	Fertiliser		4									
	Steel		43		53		67		84	97		
	Cement		25		38		58		88	113		
	Others		51		64		80		101	117		
	Total	2006-07	**473**		**611**		**782**		**992**	**1147**		
Coal Vision 2025* 8% GDP	Power		322		427		553		699	804		
	Captive Power		28		44		63		90	112		
	Fertiliser		4									
	Steel		43		54		69		90	105		
	Cement		25		39		61		95	123		
	Others		51		65		82		106	123		
	Total	2006-07	**473**		**630**		**828**		**1079**	**1267**		
Hydrocarbon Vision 2025		1998-99						1118		1402	1483	
India Vision 2020	Best Case Scenario	1997-98						538		659		
	Business As Usual	(311)						688		971		
EIA	High	2001		408		473		548		611	629	
	Low			374		411		447		481	490	
	Reference			390		439		493				
IEA		2000		484				623		713		817
P&E Division, Planning Comm.		2001	481		612		764	920	957			1417 (2031-32)

* Projections made by TERI for Coal Vision 2025

purpose of comparison. It may be seen that the demand for gas varies from 155 MMscmd in low case of EIA to 738 MMscmd in HOG case of IRADe-PWC for the year 2024-25. Most of these projections have not taken into account the price sensitivity of gas. The IHV 2025 states that the share of oil and gas in India's energy mix would be 25% and 20% respectively. Based on the numbers given in IHV 2025 for projected oil demand (364 Mtoe) the gas demand works out to be 291 Mtoe if the respective shares are as stated. However, IHV 2025 also states that the projected demand for gas in 2025 will be 391 Million Standard Cubic Metre Per Day (MMscmd) which translates into only 128 Mtoe. This error makes the estimates in IHV 2025 inconclusive. India Vision 2020 has estimated the demand for gas to be between 65 and 71 Billion Cubic Metres (BCM) for the year 2020. IRADe-PWC has projected demand of natural gas and natural gas equivalent of Naphtha at 243 BCM under the business-as-usual (BAU) scenario and 405.7 BCM under High Output Growth (HOG) scenario for the year 2030.

17. Natural gas can replace existing fuels in various sectors both for feedstock as well as for energy purposes. However, this substitution will depend upon the relative price of gas with respect to other fuels. Therefore, it may be stated that the demand for gas will depend upon the price of natural gas relative to that of alternatives, mainly Naphtha for fertiliser and petrochemicals and coal for power.

18. The above wide range of estimates for gas demand was considered by the Committee. It was agreed to base the demand estimate for non-power gas on the assumption that the projected fertiliser (urea) capacity by 2031-32 would be all gas-based; and non-power end-uses of gas will continue to grow at 8% or 9% per annum depending upon GDP growth. The committee considered this to be a realistic basis for estimating the use of gas for non-power use. The use of gas for power generation will depend on the availability of gas and the price relative to coal. As detailed in *Paragraph 10*, the forced gas scenario results in a 16% share for gas-based electricity generation by 2031-32. *Table 2.7* gives the gas demand for power based on this share of gas in electricity production.

2.6 TOTAL PRIMARY COMMERCIAL ENERGY REQUIREMENT

19. Putting together the various projections discussed above for coal, oil and natural gas for non-power use, the commercial fuel requirement for non-power use are summarised below in *Table 2.11*.

20. Total commercial primary energy requirements based on the scenario drawn for power in *Table 2.7* and the projections made for non-power oil, coal and gas are summarised in *Table 2.12* using the common unit of million tonnes of oil equivalent (Mtoe). It is emphasised that *Table 2.12* is merely one scenario that forces Hydro (1,50,000 MW), forces Nuclear (63,000 MW) and forces share of gas-based power generation (16%). Other scenarios based on DSM, efficiency improvements, renewables etc. will bring down the commercial energy requirements further and change the fuel mix shown in *Table 2.12*. In *Chapter III* commercial energy supply and the commercial energy mix is projected under a number of scenarios reflecting specific policy initiatives. The commercial energy supply under these scenarios varies from a low of 1351 Mtoe to a high of 1702 Mtoe. It is noted that the commercial energy requirement of 1514 Mtoe estimated on the basis of falling elasticities (*Table 2.4*) is not significantly different from the mid-point of this range (1526 Mtoe). Again, the requirement assessed in *Table 2.12* is based on assumptions that correspond to scenario 5 under *Chapter III*. The commercial energy requirement estimated in *Table 2.12* is above the mid-point of the range of commercial energy supply established by the various scenarios under *Chapter III*.

21. *Figure 2.3* shows the actual percentage shares of various commercial energy sources in 2003-04 and as projected for 2031-32 in the scenario under *Table 2.12*.

Table 2.10
Demand Scenario for Natural Gas - India
(By Various Agencies/Organisations)

(MMscmd)

Year	Projections by the Various Agencies									
	EIA (2004)			IEA (2004)	IHV-2025 (2000)	India Vision-2020 (2002)		Power & Energy Division's Projections (2003-04)	IRADe & PWC*	
	Reference Case	High Case	Low Case			BAU	BCS		BAU	HOG
Base Year	2001 (62 MMscmd)	2001 (62 MMscmd)	2001 (62 MMscmd)	2000 (67 MMscmd)	1999 - 2000 (110 MMscmd)	1997 (59 MMscmd)		2001-02 (81 MMscmd)	2003-04 (85 MMscmd)	
2004-05	74	77	74	91	195	89	87	98	93	95
2009-10	93	101	93	140	277	115	111	134	145	164
2014-15	124	132	109	189	329	149	142	183	226	285
2019-20	155	171	132	228	358	194	177	249	356	493
2024-25	195	225	155	259	391	258	226	326	488	738
2029-30				295				430	667	1111

EIA - Energy Information Administration, USA
IEA - International Energy Agency
IHV - India Hydrocarbon Vision 2025

IRADe - Integrated Research and Action for Development
BAU - Business as Usual
BCS - Best Case Scenario
PWC - Price Waterhouse Coopers
HOG - High Output Growth
* includes Natural Gas & N G equivalent of Naphtha

Note: As the available projections by the various agencies are for different years, the same have been interpolated or extrapolated to bring them to common years and have been converted into MMscmd for the purpose of comparison.

Table 2.11
Commercial Fuel Requirements for Non-Power Use in Physical Units

	Non-Power- Coal[1] Mt		Non-Power - Oil[2] Mt		Non-Power- Natural Gas[3] B.Cu.M	
	8%	9%	8%	9%	8%	9%
2003-04	91	91	113	113	20	20
2006-07	123	123	126	142	20	22
2011-12	164	170	158	178	30	32
2016-17	221	237	205	231	38	45
2021-22	299	334	266	299	56	65
2026-27	408	475	351	395	73	93
2031-32	562	684	469	528	100	133

Note: Estimated fuel requirements of coal, oil and natural gas are for non-power purposes.
[1] As explained in *Para 15*
[2] As explained in *Para 13*
[3] As explained in *Para 18*

Table 2.12
Projected Primary Commercial Energy Requirements (One Possible Scenario)

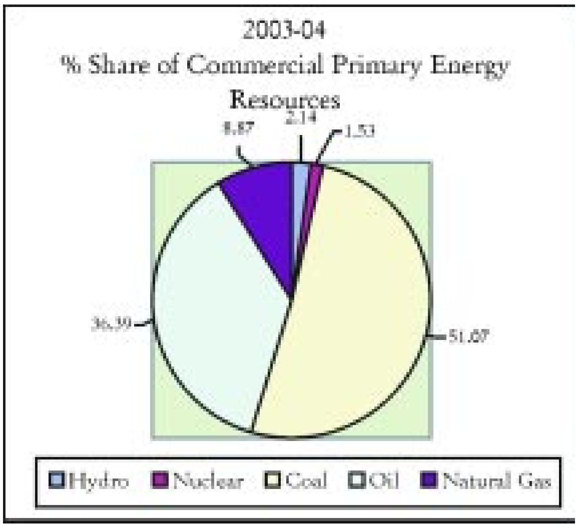
(Mtoe)

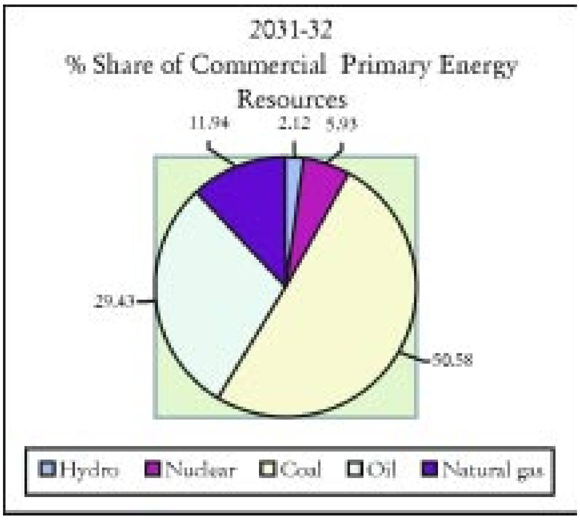
Year	Hydro	Nuclear	Coal		Oil		Natural Gas		TPCES	
			8%	9%	8%	9%	8%	9%	8%	9%
2011-12	12	17	257	283	166	186	44	48	496	546
2016-17	18	31	338	375	214	241	64	74	665	739
2021-22	23	45	464	521	278	311	97	111	907	1011
2026-27	29	71	622	706	365	410	135	162	1222	1378
2031-32	35	98	835	937	486	548	197	240	1651	1858
CAGR -% (Compounded Annual Growth Rates)	5.9	11.2	5.9	6.3	5.1	5.6	7.2	8	6	6.4
Per capita consumption In 2032 (Kgoe)	24	67	569	638	331	373	134	163	1124	1266
In 2004 (Kgoe)	6.5	4.6	157	157	111	111	27	27	306	306
Ratio 2032/2004	3.7	14.6	3.6	4.1	2.9	3.4	5.2	6.3	3.7	4.1

2.7 NON-COMMERCIAL ENERGY REQUIREMENT

22. The so-called "Non-commercial" sources of energy, including fuel wood, agricultural waste and dung, are primarily used by households for cooking energy. These are called non-commercial because a major proportion of these are simply gathered by actual users directly as opposed to being traded commercially.

Figure 2.3





23. Based on the latest data available on household energy consumption from the NSS 55th round covering the year 1999-2000, household demands are projected assuming that income distribution in rural and urban areas remain log-normal with consumption. With economic growth, the mean per capita consumption in different expenditure classes change. It is also assumed that the pattern of fuel use for a particular monthly per capita consumption expenditure class remains the same as observed in the 55th round. The projections are summarised in *Table 2.13*.

24. It should be noted that the requirement of electricity, kerosene and gas for household consumption are included in the projection given in *Table 2.12*. The impact of the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY), which targets provision of electricity to all by the year 2009-10, will alter the demand for electricity. To account for this impact, household demands are projected from 2009-10 onwards using the energy use pattern of only those households in the NSS 55th round sample, which had electricity. These are given in *Table 2.14*.

25. The differences are substantial only in 2011 and 2016, as even without the acceleration in rural electrification planned under RGGVY, most of the households will have been

Table 2.13
The Demand Scenario of Various Energy Items for Household Consumption in India

(Mtoe)

Year	Fire Wood & Chips		Electricity		Dung Cake		Kerosene		L.P.G.	
	8%	9%	8%	9%	8%	9%	8%	9%	8%	9%
2000	79.62	79.62	8.43	8.43	29.61	29.61	10.07	10.07	6.42	6.42
2006	88.64	88.78	18.17	19.26	36.97	37.33	12.68	12.77	15.85	16.87
2011	94.11	94.05	27.17	29.68	40.42	40.48	14.01	14.02	23.94	26.07
2016	98.44	98.50	38.38	42.28	41.93	41.35	14.84	14.70	33.11	35.93
2021	102.06	102.46	50.39	54.78	41.79	40.87	15.16	14.93	41.63	44.16
2026	104.64	105.07	61.37	64.95	40.95	40.28	15.17	14.93	48.11	49.63
2031	106.39	106.59	69.72	71.80	40.47	40.21	15.12	14.96	52.27	52.89

Table 2.14
The Impact of Electrification on the Demand Scenario of Various Energy Items for Household Consumption

(Mtoe)

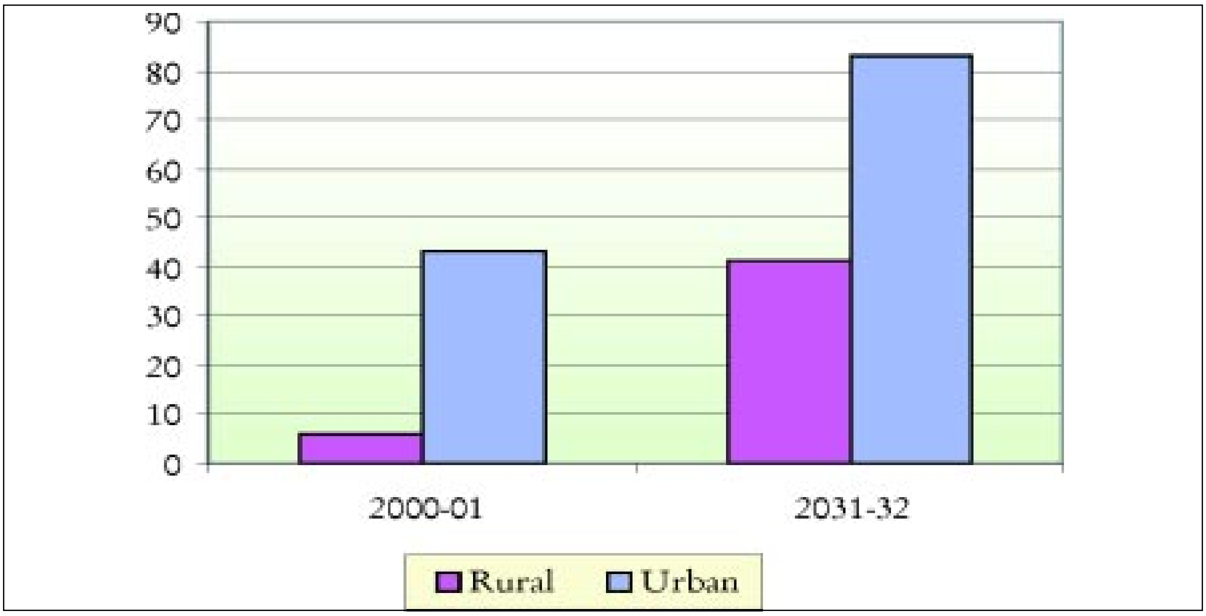
Year	Fire Wood & Chips		Electricity		Dung Cake		Kerosene		L.P.G.	
	8%	9%	8%	9%	8%	9%	8%	9%	8%	9%
2011	87.90	88.00	31.13	33.63	31.03	31.16	13.18	13.16	25.27	27.36
2016	92.59	93.02	42.58	46.51	32.21	31.53	13.82	13.64	34.30	36.95
2021	96.85	97.67	54.89	59.35	31.45	30.28	13.98	13.71	42.45	44.72
2026	100.01	100.72	66.19	69.86	30.00	29.12	13.88	13.61	48.55	49.88
2031	102.08	102.41	74.82	76.95	29.14	28.78	13.76	13.59	52.49	53.05

electrified by 2019-20. It is worth noting from a comparison of *Tables 2.13* and *2.14* that for the year 2011 electrification does not reduce kerosene consumption significantly. This is rational. As long as kerosene is available, especially subsidised kerosene, what is saved from lighting is used as fuel and the consumption of dung goes down. This substitution is more convenient and the dung saved has greater value as fertiliser. The use of LPG for cooking will increase over time. *Figure 2.4* shows this.

26. The impact of other components of Bharat Nirman is difficult to assess. If we assume that the programme will increase rural incomes by 1% every year, then the differences for the 8% and 9% growth rate column in *Table 2.14* give some idea of resulting changes in demand. In 2031, the total household requirement changes by some 3 percent (5 Mtoe) with a 1% higher growth rate.

27. It may be noted that the household demand for non-commercial energy (firewood,

Figure 2.4
Percentage of Households Using LPG



chips and dung cake) increases from around 109 Mtoe in 2000 to around 131 Mtoe in 2031. The additional requirement is expected to be met from agricultural residue and increased livestock activity that can be expected with 8-9% growth rates. In any case our goal should be to progressively substitute these traditional fuels with cleaner and more convenient fuels.

28. It is pointed out that apart from being used as household fuel, non-commercial energy is also used in the unorganised small and cottage sector for end-uses such as brick kilns, pottery, jaggery, etc. It is estimated that such consumption of non-commercial fuels was around 23.5 Mtoe in 2003-04. With easier availability of coal, gas and fuel oil growth in this segment is projected to be a sluggish 3.0% per annum. Use of non-commercial energy by the unorganised sector is thus expected to reach 54 Mtoe by 2031-32.

2.8 TOTAL PRIMARY ENERGY REQUIREMENT

29. Based on the commercial energy requirement projected in *Table 2.12* and the non-commercial energy requirement projected in *Table 2.14* together with the non-commercial energy use by small industries as detailed in *Paragraph 28*, the total primary energy is shown in *Table 2.15*. Once again, it is emphasised that this is one scenario that is above the mid-point of the range of total primary energy supply estimated in *Chapter III*. It is further noted that the 2006-07 requirement in *Table 2.15* is taken from *Table 2.4* with falling elasticities. As stated under *Table 2.4* we may not achieve this level of total primary energy consumption in 2006-07 as petroleum demand has been sluggish in the first 4 years of the 10th Plan.

2.9 SUMMING UP

30. The challenge facing the country is to ensure that the energy needed to sustain an 8 to 9% growth rate becomes available. To put the requirement in perspective, per capita energy use in other countries in 2003 is compared with India's projected needs for 2032 in *Table 2.16*. It is pointed out again that the scenario considered here is based on *Table 2.12* and *2.15* and is hence above the mid-point of the range of energy supply scenarios established in *Chapter III*.

31. India's per capita consumption of energy in its various forms in 2003-04 is well below that of developed countries and the world average in 2003. Even in 2032, the per capita consumption in India from various sources of energy will be well below the 2003 level of per capita consumption in respect of developed countries. In fact, as seen from *Table 2.16* India's projected level of per capita energy consumption in 2032, will be less than 74% of the world average in 2003.

32. One should note that these projected needs are based on past trends from the demand side based largely on the projection of income. They assume that energy prices will remain on

Table 2.15
Total Primary Energy Requirement (Mtoe)

Year	TPCES		TPNCES*		TPES	
	8%	9%	8%	9%	8%	9%
2006-07	389	397	153	153	542	550
2011-12	496	546	169	169	665	715
2016-17	665	739	177	177	842	916
2021-22	907	1011	182	181	1089	1192
2026-27	1222	1378	184	183	1406	1561
2031-32	1651	1858	185	185	1836	2043

*This includes household requirement as per *Table 2.14* and consumption by small industries as per *Para 28*.

Table 2.16
Per Capita Energy Requirements in Selected Countries (2003)

	TPES (kgoe)	Electricity Consumption (kWh)	Oil (kgoe)	Gas (Cu.m.)	Coal (Kg)	Nuclear (kWh)	Hydro (kWh)
India 2003-04	439	553	111	30	257* (375)	16	69
India 2031-32 (projected @ 8% GDP growth)**	1250	2471	331	149	925* (1388)	256	273
World Average (2003)	1688	2429	635	538	740	403	423
OECD (2003)	4668	8044	2099	1144	1651	1924	1076
U.S.A. (2003)	7840	13066	3426	2176	3410	2624	948
China (2003)	1090	1379	213	32	1073	32	215
South Korea (2003)	4272	7007	2264	627	1541	2570	101
Japan (2003)	4056	7816	2146	845	1247	1859	816

*Per capita coal consumption of India has been estimated based on the calorific value of hard coal used internationally (6000 kcal/kg) to maintain uniformity. The figures in brackets are the actual per capita consumption based on Indian coal with a calorific value of 4000 kcal/kg.

** Based on numbers estimated in *Tables 2.7, 2.12* and *2.15*.

Source: IEA (2005), *Key World Energy Statistics 2005*

the trend lines. They also assume that progress in energy efficiency and energy conservation, replacement of non-commercial energy and societal and lifestyle changes will continue as per historical trends. There are, of course, opportunities to accelerate or alter the pace of the trends. The projected energy requirements can be reduced substantially with accelerated improvement in energy efficiency and conservation, which should be considered as the most important supply options since they have the potential to reduce consumption by 20-25%. This is considered when the supply options are explored later in the report.

33. These projections and the scenarios in the next chapter provide broad guidelines to potential investors, and may supplement their own assessments of the demand levels in various energy sub-sectors.

34. What are the alternative supply options? To what extent can demand be met based on domestic resources? To what extent imports would be needed? These questions are addressed in the next chapter.

Supply Options

Strategies to meet our energy requirement are constrained by country's energy resources and import possibilities. Unfortunately, India is not well endowed with natural energy resources. Reserves of oil, gas and Uranium are meagre though we have large reserves of thorium. While coal is abundant, it is regionally concentrated and is of low calorie and high ash content, though it has the advantage of a low sulphur content. The extractable reserves, based on current extraction technology, remain limited. Hydro potential is significant, but small compared to our needs and its contribution in terms of energy is likely to remain small. Further, the need to mitigate environmental and social impact of storage schemes often delays hydro development thereby causing huge cost overruns.

3.1 INDIA'S ENERGY RESERVES

2. India's Hydro-Carbon Energy Reserves are summarised in *Table 3.1.*

Table 3.1
India's Hydrocarbon Reserves

Resources	Unit	Proved (P)	Inferred (I)	Indicated	Production in 2004-05 (Q)	Net Imports in 2004-05 (M)	Reserve/ Production Ratio P/Q	(P+I)/Q
Coal (as on 1.1.2005)	Mtoe	38114	48007	15497				
Extractable Coal**	Mtoe	13489	9600-15650		157	16	86	147-186
Lignite (as on 1.1.2005)	Mtoe	1220	3652	5772				
Extractable Lignite	Mtoe	1220			9	-	136	136
Oil (2005)	Mt	786*	-	-	34	87	23	23
Gas (2005)	Mtoe	1101*	-	-	29	3 (LNG)	38	38
Coal Bed Methane	Mtoe	765	-	1260-2340				
In-situ Coal Gasification***		?	?					

* Balance Recoverable Reserves

** Extractable coal from proved reserves has been calculated by considering 90% of geological reserve as mineable and dividing mineable reserve by Reserve to Production ratio (2.543 has been used in 'Coal Vision 2025' for CIL blocks); and range for extractable coal from prognosticated reserves has been arrived at by taking 70% of indicated and 40% of Inferred reserve as mineable and dividing mineable reserve by R:P ratios (2.543 for CIL blocks and 4.7 for non-CIL blocks as per 'Coal Vision 2025').

*** From deep seated coal (not included in extractable coal reserves)

Note: Indicated Gas resource includes 320 Mtoe claimed by Reliance Energy but excludes the 360 Mtoe of reserves indicated by GSPCL as the same have not yet been certified by DGH.

Source: Respective Line Ministries

Coal Supply Scenario

3. Proved reserves of coal, the most abundant energy resource, at the current level of consumption can last for about 80 years. If all the inferred reserves also materialise then coal and lignite can last for over 140 years at the current rate of extraction. Of course, coal and lignite consumption will increase in the future and the reserves would last for far fewer years. If domestic coal production continues to grow at 5% per year, the total (including proven, indicated and inferred) extractable coal reserves will run out in around 45 years. However, only about 45% of the potential coal bearing area has currently been covered by regional surveys. Further, it is felt that both regional as well as detailed drilling can be made more comprehensive. Covering all coal bearing areas with comprehensive regional and detailed drilling could make a significant difference to the estimated life of India's coal reserves. The problem with coal remains finding a way to raise the proportion of extractable reserves, ensure adequate production and take care of the environmental impact of production and use.

4. In-situ coal gasification can significantly increase the extractable energy from India's vast in-place coal reserves. This is so because in-situ coal gasification can tap energy from coal reserves that cannot be extracted economically based on available open cast/ underground extraction technologies. However, in-situ gasification has not yet been deployed commercially anywhere in the world. ONGC is engaged in trials to establish the feasibility and economics of this technology for Indian coal and lignite in collaboration with Russia. Neyveli Lignite Corporation has tied up with an Australian group to pursue in-situ gasification of lignite. In-situ gasification has many environmental advantages. The problems of overburden removal and ash disposal faced by conventional coal mining and use are eliminated. Gasification is the first step towards a clean coal technology since carbon can be captured from the syn-gas produced and sequestered in the mine or pumped back in oil or gas fields to enhance oil or gas recovery. In-situ coal gasification, with or without carbon sequestration could be eligible for carbon credits. Finally, using this process at abandoned coalmines might provide an economically attractive option for full extraction of energy from in-place reserves. Clearly, the potential for domestic energy supply based on in-situ coal gasification can be large but it has not yet been assessed.

Oil and Gas Supply Scenario

5. The reserves of crude oil are merely 786Mt. These can sustain the current level of production for 23 years and are less than only 7 years worth of our level of consumption in 2004-05. There has been no significant step up in crude oil reserves during the last decade in spite of large investments in exploration activities (*see Table 3.2*). The country has not had any significant oil find since the Bombay High fields, more than 28 years ago. As a result, crude oil production has stagnated and the gap between the demand and domestic availability of crude oil is widening. Import dependence will keep rising, unless dramatic new discoveries are made. Only one third of the potential oil bearing area has been explored so far. The reluctance of international majors to explore in India seen in the past, seems to have changed following the high success rate in gas discovery achieved by relatively small international players. They have shown much greater interest in the latest round of bidding for exploration blocks under the new exploration licensing policy (NELP). Also, some geologists predict vast amount of undiscovered oil in India. What it may require is development of technology to overcome geological barriers for deep drilling both above ground and under sea. In any case India's supply strategy while stepping up exploration should not rely on the possibility of finding oil domestically.

6. The situation was similar in the case of natural gas reserves till 2001-02 before the discovery of gas in Krishna-Godavari basin by Reliance. Coupled with the recent large discovery of natural gas claimed by Gujarat State Petroleum Corporation (GSPC), these finds have added to the gas reserves substantially. However, the size of the reserve

of the GSPC find is yet to be certified by the Directorate General of Hydrocarbons (DGH).

7. The Directorate General of Hydrocarbons has estimated the country's resource base for Coal Bed Methane (CBM) to be between 1400 BCM (1260 Mtoe) and 2600 BCM (2340 Mtoe). To give impetus to exploration and production, the government has formulated the CBM policy. Based on two rounds of bidding under this policy, contracts have been signed with PSUs/private companies for the exploration and production of CBM in 13 blocks. An additional three blocks have been taken up for development on the basis of nomination. The estimated investment in these blocks is about Rs.560 crore and the likely CBM resources generated is estimated as 850 BCM (765 Mtoe). ONGC maintains that commercial production of CBM from some of these blocks will start in 2007. Thus, at the very low current rate of production, the proven gas and CBM reserves, together, can last for some 50 years.

Nuclear

8. India is poorly endowed with Uranium. Available Uranium supply can fuel only 10,000 MW of the Pressurised Heavy Water Reactors (PHWR). Further, India is extracting Uranium from extremely low grade ores (as low as 0.1% Uranium) compared to ores with up to 12-14% Uranium in certain resources abroad. This makes Indian nuclear fuel 2-3 times costlier than international supplies. The substantial Thorium reserves can be used but that requires that the fertile Thorium be converted to fissile material. In this context, a three-stage nuclear power programme is envisaged. This programme consists of setting up of Pressurised Heavy Water Reactors (PHWRs) in the first stage, Fast Breeder Reactors (FBRs) in the second stage and reactors based on the Uranium 233-Thorium 232 cycle in the third stage. It is also envisaged that in the first stage of the programme, capacity addition will be supplemented by electricity generation through Light Water Reactors (LWRs), initially through imports of technology but with the long-term objective of indigenisation. PHWR technology was selected for the first stage as these reactors are efficient users of natural Uranium for yielding the plutonium fuel required for the second stage FBR programme. The FBRs will be fuelled by plutonium and will also recycle spent Uranium from the PHWR to breed more plutonium fuel for electricity generation.

Table 3.2
Reserves/Production of Crude Oil & Natural Gas

Year	Crude Oil (Mt)		Natural Gas (BCM)	
	Reserves*	Production	Reserves*	Production
1970-71	128	6.9	62	1.4
1980-81	366	10.5	351	2.4
1990-91	739	32.2	686	18.0
2000-01	703	32.4	760	29.5
2001-02	732	32.0	763	29.7
2002-03	741	33.0	751	31.4
2003-04	761	33.4	853	32.0
2004-05	739	33.9	923	31.8
2005-06(p)	786	33.2	1101	32.2
(p) Provisional				
* Reserves position as on 1st April of commencing year				

Source: Ministry of Petroleum & Natural Gas

Thorium as blanket material in FBRs will produce Uranium 233 to fire the third stage.

9. The first stage programme of PHWR technology has reached maturity, though much later than was initially expected. A beginning has been made in the introduction of LWRs with the inter-governmental agreement between India and the Russian Federation for cooperation in setting up of 2x1,000 Megawatt Electrical (MWe) LWRs at Kudankulam, Tamil Nadu. A 40 MWt Fast Breeder Test Reactor (FBTR) was set-up in 1985 at Kalpakkam to gain experience in the technology under the second phase. This has been followed by progress in the development of technology for the first Prototype Fast Breeder Reactor (PFBR) of 500 MWe capacity. Such a plant is currently under construction. Research and development on the utilisation of Thorium is also in progress.

10. FBR technology is critical to developing stage two of India's nuclear power programme. Without developing the wide-scale use of FBR technology, India will find it difficult to go beyond 10,000 MWe nuclear capacity based on known indigenous Uranium resources. Use of FBR technology would enable indigenous Uranium resources to support a 20,000 MWe nuclear power programme by the year 2020. Such a FBR programme is critical to developing the Thorium-based third stage of India's nuclear power programme. The Bhabha Atomic Research Centre (BARC) is also engaged in R&D activities to develop an Advanced Heavy Water Reactor of 300 MWe capacity that would provide industrial scale experience necessary for the Thorium-based Stage Three of India's nuclear power programme. *Table 3.3* shows the potential of nuclear energy with domestic resources in the country.

11. The pace of development of nuclear power is constrained by the rate at which plutonium can be bred and Thorium converted to fissile material. If India is able to import nuclear fuel, the process can be accelerated. Two possible growth paths of nuclear power are summarised in *Table 3.4*.

Renewable Energy Resources

12. Given the limited amount of domestic conventional energy sources, renewable energy resources gain significance in the Indian context. India's renewable energy resources are summarised in *Table 3.5*. It may be noted that many renewables require land. The potential energy generated is assessed independently for each option. If all such options are developed together the combined potential may be less than the sum due to a paucity of available land for energy generation as other competing land uses may dominate.

Hydroelectricity

13. India's hydel resources are estimated to be 84,000 MW at 60% load factor. The current utility based installed capacity is 32,326 MW and the average annual generation over the last three years (2002-05) was 74 Billion Kilowatt hours (BkWh) giving a load factor of 29%. At such a load factor an installed capacity of 1,50,000 MW including some 15,000 MW of

Table 3.3
The Approximate Potential Available From Nuclear Energy

Particulars	Amount	Thermal Energy		Electricity	
		TWh	GW-yr.	GWe-Yr.	MWe
Uranium-Metal	61,000-t				
In PHWR		7,992	913	330	10,000
In FBR		1,027,616	117,308	42,200	5,00,000
Thorium-Metal	2,25,000-t				
In Breeders		3,783,886	431,950	1,50,000	Very large

Source: Department of Atomic Energy

Table 3.4
Possible Development of Nuclear Power Installed Capacity in MW

Year	Unit	Scenario		Remarks
		Optimistic*	Pessimistic	
2010	GWe	11	9	These estimates assume that the FBR technology is successfully demonstrated by the 500 MW PFBR currently under construction, new Uranium mines are opened for providing fuel for setting up additional PHWRs, India succeeds in assimilating the LWR technology through import and develops the Advanced Heavy Water Reactor for utilising Thorium by 2020.
2020	GWe	29	21	
2030	GWe	63	48	
2040	GWe	131	104	
2050	GWe	275	208	

* It is assumed that India will be able to import 8,000 MW of Light Water Reactors with fuel over the next ten years.

Source: Department of Atomic Energy

Table 3.5
Renewable Energy Resources

Resources	Unit	Present	Potential	Basis of Accessing Potential
Hydro-power	MW	32,326	1,50,000	Total potential assessed is 84,000 MW** at 60% load factor or 1,50,000 MW at lower load factors
Biomass				
Wood	Mtoe/year	140	620*	Using 60 million Ha wasteland yielding (20) MT/Ha/year
Biogas	Mtoe/year	0.6**	4	In 12 million family sized plants
		0.1	15	In community based plants if most of the dung is put through them.
Bio-Fuels				
Bio-diesel	Mtoe/year	-	20*	Through plantation of 20* million hectares of wasteland or 7* million hectares of intensive cultivation
Ethanol	Mtoe/year	<1	10	From 1.2 million hectares of intensive cultivation with required inputs.
Solar				
Photovoltaic	Mtoe/year	-	1,200	Expected by utilising 5 million hectares wasteland at an efficiency level of 15 percent for Solar Photovoltaic Cells
Thermal	Mtoe/year		1,200	MWe scale power plants using 5 million hectares
Wind Energy	Mtoe/year	<1	10	Onshore potential of 65,000 MWe at 20 percent load factor
Small Hydro-power	Mtoe/year	<1	5	

* The availability of land and inputs for getting projected yields is a critical constraint

** based on 50 percent plants under use

Source: Respective Line Ministries

small hydel plants (size <25 MW) may be justified given the available potential hydroelectric energy. All new projects should be designed with this objective in mind. Such a strategy would ensure that hydro is maximally used for meeting peak loads. Undeveloped hydro potential is mainly concentrated in the North East, Himachal and Uttaranchal. In addition there are possibilities of importing hydropower from Nepal and Bhutan whose combined economically feasible potentials is estimated to be in excess of 55,000 MW.

14. The accelerated hydro development plan aims to build 50,000 MW of new capacity by 2025-26. Out of this, 25690 MW are to be installed in Arunachal Pradesh. Problems of environment and ecology, and the social problems of resettlement of project-affected people have delayed development of hydro projects, particularly those that involve large storage dams. Of the 50,000 MW planned, 31,000 MW shall come from run of the river (ROR) schemes where these problems are more manageable. However, the available energy varies from month to month and peaking capacity is minimal. It is estimated that 19,660 MW of ROR schemes generate 2 BkWh of energy in a lean month and 13 BkWh in a high inflow month, giving load factors of 14% to 90%.

Wind

15. Onshore wind energy potential is estimated to be around 45,000 MW. Currently, it is claimed that Indian wind farms deliver a capacity factor of about 17% on average. As a first level of approximation, this permits a grid-connected wind capacity estimate of as much as 20,000 MW at the current size of India's grid. The actual grid connected wind capacity, however, is only about 3,600 MW. This reflects both a poor exploitation of claimed potential and, perhaps, the exaggerated claims of capacity factors. Even if one goes by a wind potential of 65,000 MW (as estimated by the Wind Power Society) inclusive of off-shore potential and further assumes that technological innovations will raise capacity factors to 20%, the total contribution of wind energy to India's energy mix will remain below 10 Mtoe. Despite this, wind power, especially at the lagging ends of the grid, provides several benefits and should be pursued wherever it is viable.

Biomass, Biogas and Bio-fuels

16. Biomass is the major domestic fuel used for cooking, and consists mainly of agricultural by-products and gathered wood. Domestic biomass use in 2000 was 80 Mtoe. Along with dung cakes which provided 30 Mtoe, biomass based fuels provide 81% of domestic energy. Biomass is also used as industrial fuel by small industries in the unorganised sector and by cottage industries. Inclusive of such use biomass along with dung cakes accounts for almost a third of India's total primary energy consumption. This non-commercial energy for the domestic use is essentially managed by women without technology, or investment, and involves unsustainable practises, backbreaking drudgery, health problems especially for women and the girl child and likely environmental damage. What needs to be done to make this energy resource more sustainable is to improve the efficiency and convenience of using biomass through, for example, wood gasification or biogas plants. Rural people aspire to have clean and convenient fuel just like their urban counterparts. Though falling in its share of the total energy mix, biomass dependence shall continue to rise in absolute terms, and biomass will remain a part of India's energy supply scene till 2031-32 and beyond. As such, a technology mission for enhanced and efficient use of biomass/bio-fuels is highly desirable.

17. India has a 40 year old biogas programme. The total number of family size biogas plants installed is 3.7 million, though evaluation studies show that only half of these are in use. Community based plants can process dung from households with less than the 3-5 animals that are required for a family sized plant and can also use any excess gas available from family sized plants. Managing a community sized plant in an incentive compatible way that ensures voluntary cooperation of all stakeholders is admittedly challenging but is very much possible and worth pursuing (*Parikh and Parikh, 1977*)[3].

[3] Parikh Jyoti K. and Parikh K.S. (1977) "Mobilisation and Impacts of Biogas Technologies", Energy, Vol. 2 pp. 441-445, 1977

18. Biomass could become a major energy source if fuel wood plantations are developed. This requires land, which may have other competing uses. In fact, biomass, bio-fuels (vegetable, edible and non-edible oils and ethanol) and solar energy on sizeable scale all require large amounts of land. The potential energy generated is shown in *Table 3.5*. At appropriate relative prices, farmers may themselves decide to use their land for producing energy. Clearly, *Table 3.5* shows that wood plantations offer the best option for biomass based supply sources along with possessing a huge employment generation potential. Wood gasification or direct combustion are possible options for power generation based on such biomass. The economics would depend on actual yields from the wood plantations.

19. Bio-diesel is a natural diesel substitute. While bio-diesel from non-edible oils such as Jatropha, Karanj, Mahua etc., has attracted lot of attention recently, its economic feasibility depends largely on the yields one can get from wasteland and/or the returns one can get from good quality land with irrigation and fertiliser use compared to returns from growing other crops. A number of projects being undertaken now will provide an assessment of these comparative returns in a few years. Bio-diesel also provides decentralised local fuel, which can be used directly without esterification in stationery engines. The process of bio-diesel generation and use can also create significant employment. These benefits should be factored in while assessing the desirability of bio-diesel when the data on land productivity are available.

20. Ethanol is used extensively in Brazil as a fuel for cars. In the Indian situation of scarcity of land and water, the available quantities of ethanol, when used as feedstock for production of chemicals and potable alcohol, offer higher economic and opportunity costs to the country rather than its use as an admixture with gasoline. If technology can be developed to economically collect and convert crop residues such as rice straws (which are currently burnt) or if intensive cultivation of land for crops to produce cellulosic ethanol constitutes an attractive option to farmers, adequate quantity of ethanol could then be available to blend petrol with 10% or higher concentration of ethanol. At present ethanol as a transport fuel can make some contribution but is not likely to constitute a major option.

Solar-Energy

21. Solar energy has a large potential in the country. The average solar insolation in the country is 6 kWh/meter^2/day. This can be exploited by many direct thermal applications such as for cooking, heating or in photovoltaic cells that directly convert sunlight to electricity. The present conversion efficiency of commercially available photovoltaic cells is less than 15 percent. With this efficiency the potential of covering just 5 million hectares of land with photovoltaic cells is 1200 Mtoe/year. Photovoltaic technology is proven but expensive and the cost of electricity exceeds Rs.20/kWh at present. Potential to reduce costs and increase efficiency exists and a technology mission for this purpose is highly desirable.

22. Solar thermal generation is economical for water heating for both households and industrial use. Much of its potential has yet to be exploited. Appropriate policies need to be designed to accelerate the exploitation of this energy source. Solar thermal generation has not found acceptance globally, though the potential to use it in hybrid systems may be there.

Hydrogen

23. Hydrogen is seen as the new energy carrier. Development of Hydrogen technology is being pursued in many countries. India has also set up a Hydrogen Development Board to promote development of technologies for producing, transporting, storing and distributing hydrogen as well as to explore the field of fuel cells for efficient end-use of hydrogen. Hydrogen can also be burnt directly in internal combustion engines. It can be produced from hydrocarbons and biomass, by splitting water with the use of solar, hydro, wind or nuclear energy, and through certain

microbial processes. The overall efficiency of the hydrogen cycle, however, remains in doubt. Hydrogen production, liquefaction or compression, transportation, storage and final dispensation, all entail huge amount of energy consumption and loss. Significant barriers relating to financial and technological viability remain in the widespread use of hydrogen in automotive or stationary applications. Metal hydrides that store hydrogen and release it for direct combustion have been developed for powering two/three-wheelers in the country but the technology has not yet been commercialised. Stationary applications or automotive applications using fuel cells are still relatively uncompetitive.

Emerging Technologies

24. Another emerging technology of interest is the liquefaction of coal. South Africa leads the world in this technology based on the Sasol process. Some 6 tonnes of relatively high quality (5500+ kcal/kg) coal is required to produce one tonne of liquid fuel. The technology was commercially proven in South Africa and has been in use there for a number of decades. At current prices of oil, this technology may be viable even for Indian coals and should be pursued.

25. Among new energy resources that have yet to be proved are gas hydrates and nuclear fusion. India has large deposits of gas hydrates (methane gas trapped inside ice) off her coasts. The technology to exploit it is yet to be developed. Fusion power which requires fuels that can be obtained from sea water offers virtually unlimited power. The technology of controlled fusion with positive energy gain in an economic way is also yet to be developed. These two energy sources are not likely to be available commercially in the next 25 years.

3.2 SUPPLY SCENARIOS

26. *Table 2.12* in *Chapter II* outlines one possible energy mix scenario. This scenario assumes that electricity generation will be based on the full development of hydro and nuclear potential of the country and the use of gas to the extent of 16%. Possible fuel-wise substitution should be taken into account in considering supply options. With respect to oil for transport use, it cannot easily be replaced in significant quantities unless there are technological breakthroughs or large-scale shifts to public transport in place of personal vehicles or to freight movement by railroads in place of trucks. Other than for power generation demand for natural gas is in the production of fertilisers and chemicals where it cannot be economically substituted. With coal and natural gas there is a clear substitution possibility. Such a substitution will depend on the relative availability and price of coal/gas.

27. To explore the consequences of different alternatives and their quantitative significance a number of scenarios have been developed using a multi-sectoral, multi period optimising linear programming model[4]. These scenarios are described in *Table 3.6*. They are designed to assess the importance of critical policy options for meeting energy requirements. **These scenarios are designed to map out extreme points of feasible options and none of them should be looked upon as a preferred scenario.**

28. The linear programming model used above obtains the least-cost solution subject to constraints over ten 5-year periods from 2000 till 2050. It also has sub-periods characterising peak, intermediate and base load during summer and winter seasons. Power demand is characterised for three regions: (a) near coal mines, (b) distant coastal regions and (c) the rest. Options at distant coastal regions include transmission from pithead plants and load centre based generation using domestic coal or imported coal. The amount of pithead generation is restricted due to environmental reasons. In the case of hydro, India's full potential of 1,50,000 MW is taken as exploited by 2031-32. Nuclear capacity of 63,000 MW is assumed to be realised by 2031-32. As regards

4 The model developed by Observer Research Foundation (ORF) was upgraded and the scenarios developed under the guidance of Dr. Kirit Parikh by a team from ORF.

Table 3.6
Some Energy Supply Scenarios for 8% GDP Growth

	Scenario	Description
1.	Coal-Based Development	Most electricity generation by the most economical option – which turns out to be primarily coal.
2.	Maximise Nuclear	Assumes nuclear development as per the optimistic scenario of *Table 3.4.*
3.	Forced Hydro	Development of the entire (1,50,000 MW) domestic hydro potential by 2031-32.
4.	Maximise Hydro & Nuclear	Both nuclear and hydro as in 2 and 3.
5.	'4' plus forced Natural Gas	16% of electricity generation from gas. This is comparable to the scenario of *Table 2.7 & 2.12.*
6.	'5' plus Demand Side Management	Demand side management reduces electricity demand by 15 percent.
7.	'5' plus Higher Coal Power Plant Efficiency	*Thermal Efficiency of future coal power plants increased to 38-40 percent for super critical boilers. from 36 percent for the present 500 MW
8.	'6' plus Coal Power Plant Efficiency	Both DSM and coal efficiency together.
9.	'8' plus higher freight share of Railways	Railways freight share increased from 32 percent to 50 percent.
10.	'9' plus vehicle efficiency increased	Fuel efficiency of all motorised vehicles increased by 50 percent.
11.	'10' plus renewables	30,000 MW wind power, 10,000 MW of solar power, 50,000 MW of biomass power, 10 Mt of bio-diesel, and 5 Mt of ethanol by 2031-32.

* Thermal efficiency of coal-based plants refers to gross thermal efficiency based on gross generation and is equal to the ratio of gross heat output to gross heat input.

gas, the model is forced to have a 16% share for gas-based power generation by 2031-32. A model scenario critically depends on the set of assumptions, parameters and constraints, and in particular on the relative costs and prices of the alternatives available, the discount rate and the projected requirements. Requirements have been specified in terms of billion units of electricity, billion tonne-kilometre of freight traffic, and billion passenger-kilometre of passenger traffic. The freight and passenger traffic projections have been made using elasticities with respect to GDP of 1.0 and 0.8, estimated using time series data from 1930 to 2000. The "optimality" of the solution is contingent on the various inputs/assumptions detailed herein. The importance of the model is that each solution provides a consistent scenario. It should be noted that the model does not suggest preferred scenarios. They are in fact extreme options to define the feasible space for alternate policy choices. Thus when 1,50,000 MW of hydel by 2031-32 is estimated, it does not mean that given the various social, political and environmental constraints we will in fact fully develop our hydel resources to reach this estimate. The scenario does, however, show what the implications are for energy supply if we were able to develop the full hydro potential. *Table 3.7* summarises the results of the scenarios. *Figure 3.1* shows this graphically. Period-wise details for three selected scenarios are given in *Figures 3.2 to 3.4.*

3.3 IMPLICATIONS OF THE RESULTS OF THE SCENARIOS

29. The results provide us insights on aggregate energy needs and required imports, energy supply options, the importance of energy efficiency and demand side management, the range of carbon emissions, and investment needs. We look at these in turn.

Figure 3.1
Fuel Mix Comparison in Year 2031-32

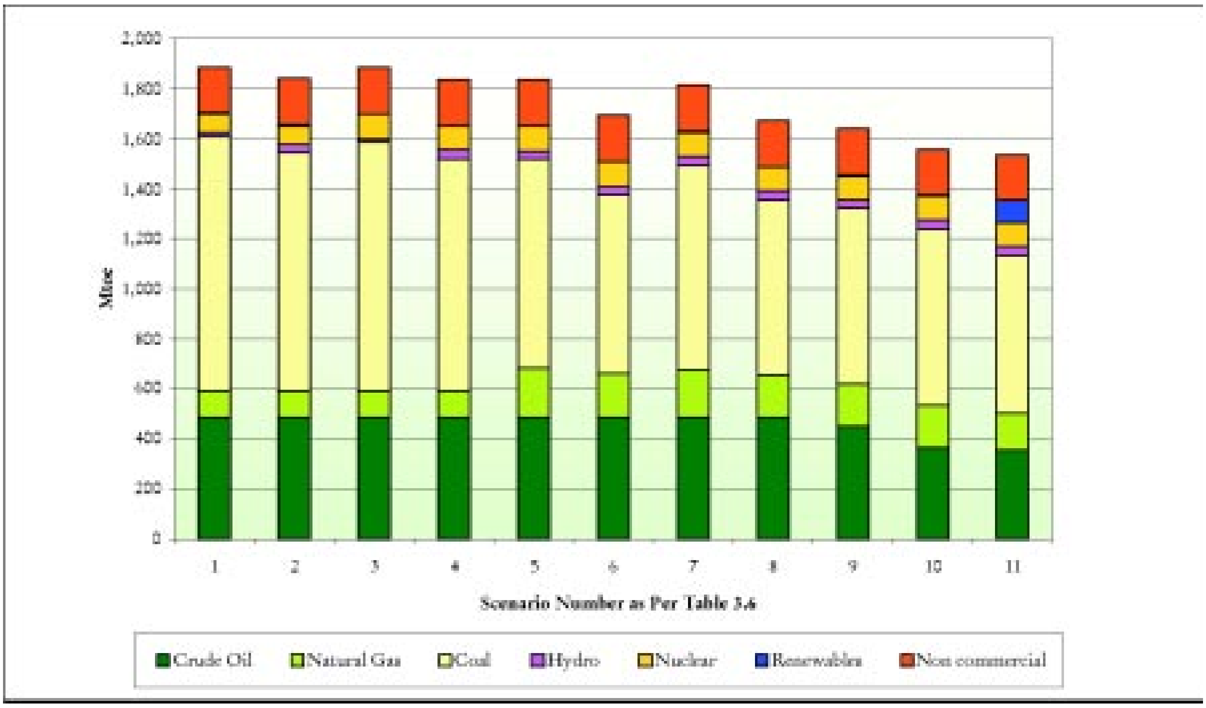


Figure 3.2
Coal Dominant Scenario 1 - Fuel Mix Year-Wise

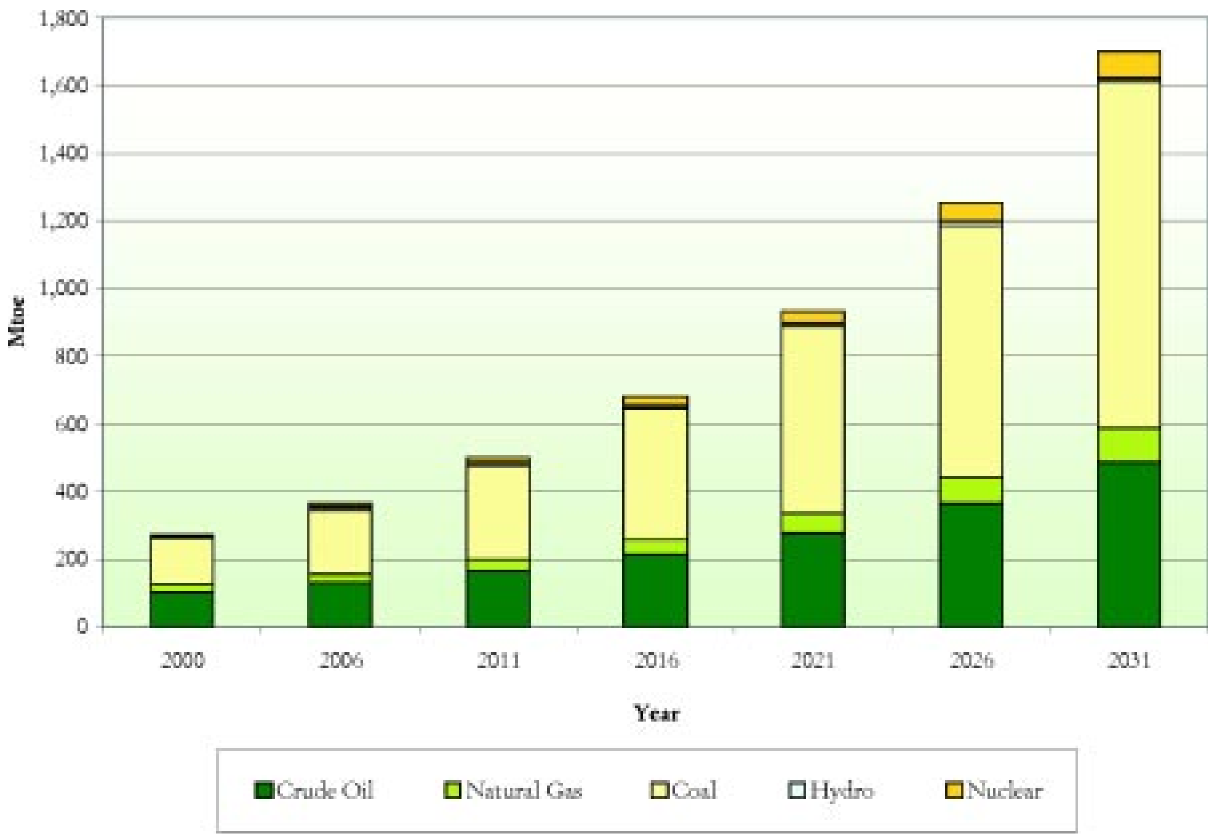


Figure 3.3
Forced Hydro, Nuclear and Gas Scenario 5 - Fuel Mix Year-Wise

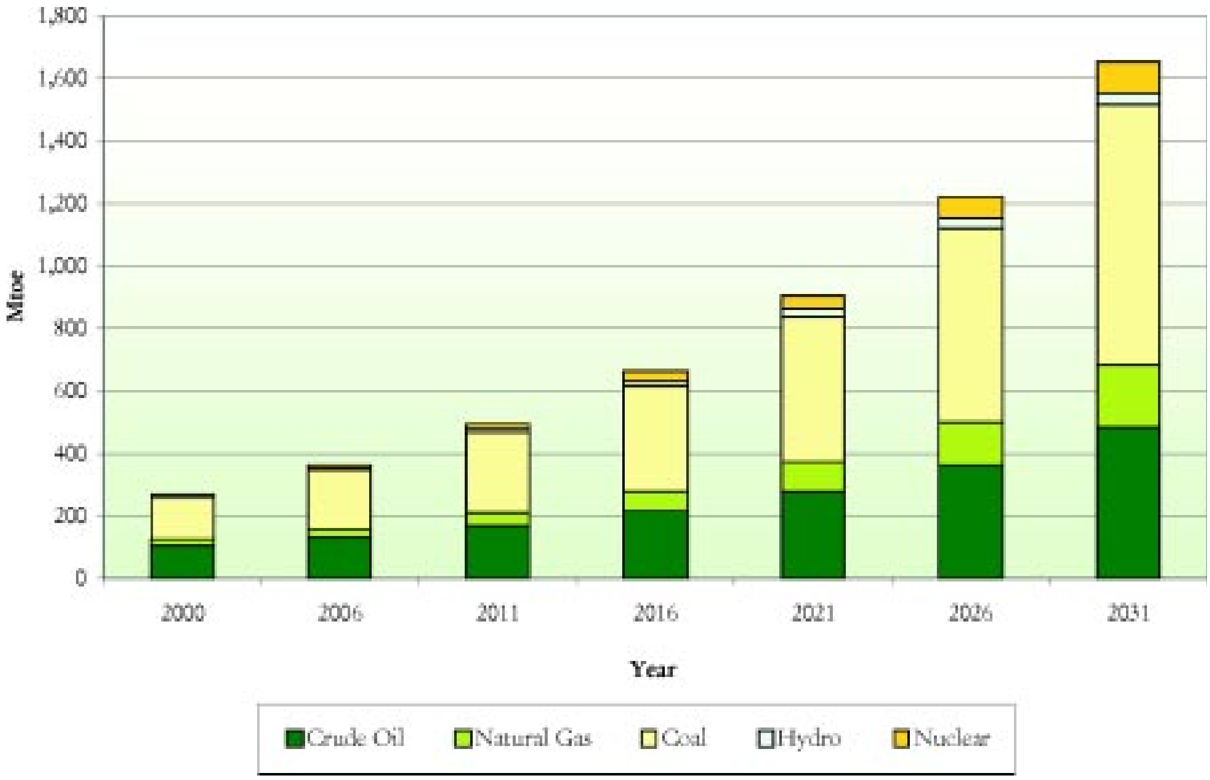


Figure 3.4
Forced Renewables Scenario 11 - Fuel Mix Year Wise

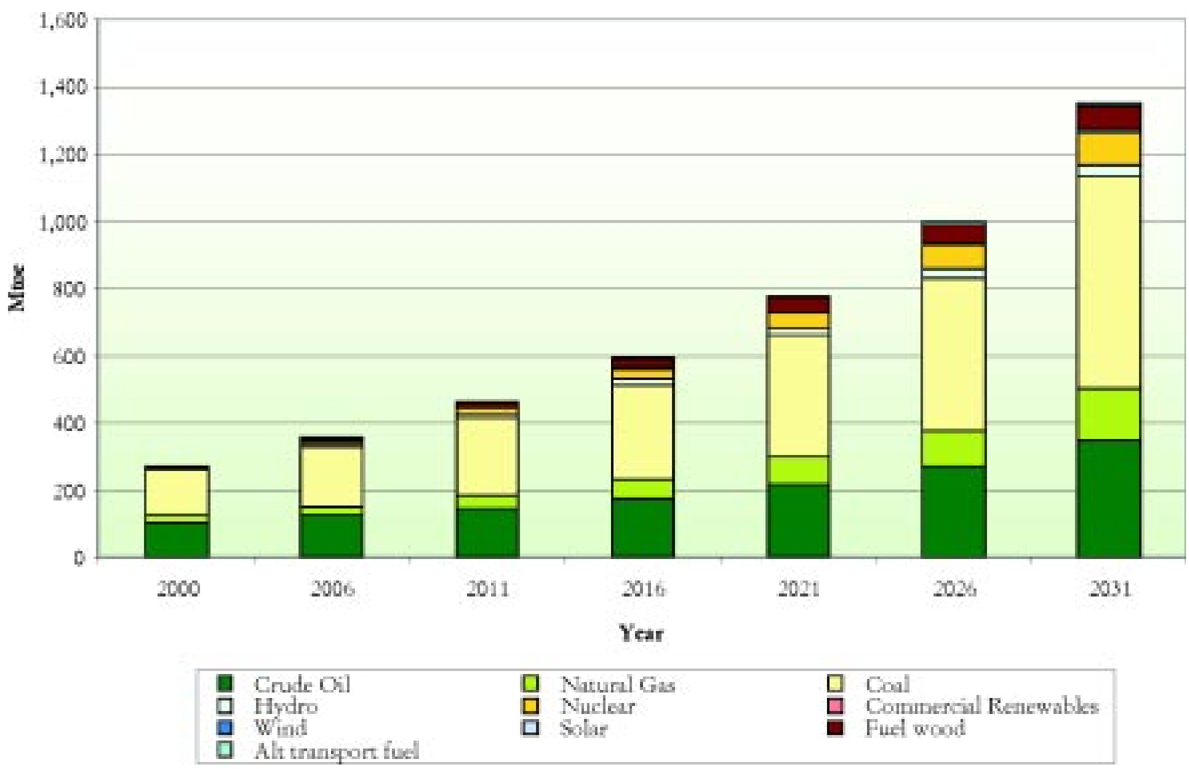


Table 3.7
Scenario Summaries for 8% GDP Growth — Fuel Mix in Year 2031-32

Mt of Oil Equivalent (Mtoe)

Scenario No.	1	2	3	4	5	6	7	8	9	10	11
Scenario Description	Coal Dominant Case	Forced Hydro	Forced Nuclear	Forced Nuclear+ Hydro	Forced Nuc+Hyd + GAS	Forced Nuc+Hyd+ GAS+ DSM	Forced Nuc+Hyd+ GAS+ Coal eff.	Forced Nuc+Hyd+ GAS+ DSM+ Coal eff.	Forced Nuc+ Hyd+GAS+ DSM+ Coal eff.+ Rail share up	Forced Nuc+Hyd+ GAS+DSM +Coal eff. +Rail share up+Transport eff.	Scenario 10+Forced Renewables
Crude Oil	486	485	486	485	486	486	485	485	447	361	350
Natural Gas	104	105	104	105	197	174	191	171	171	171	150
Coal	1,022	953	998	929	835	715	818	698	701	707	632
Hydro	13	35	13	35	35	35	35	35	35	35	35
Nuclear	76	76	98	98	98	98	98	98	98	98	98
Renewables	2	2	2	2	2	2	2	2	2	2	87
Non-commercial	185	185	185	185	185	185	185	185	185	185	185
Total	**1,887**	**1,840**	**1,885**	**1,839**	**1,837**	**1,695**	**1,813**	**1,673**	**1,639**	**1,558**	**1,536**
Total without Non-Commercial	**1,702**	**1,655**	**1,700**	**1,654**	**1,652**	**1,510**	**1,628**	**1,488**	**1,454**	**1,373**	**1,351**
Crude Oil	25.7%	26.4%	25.8%	26.4%	26.4%	28.7%	26.8%	29.0%	27.3%	23.2%	22.8%
Natural Gas	5.5%	5.7%	5.5%	5.7%	10.7%	10.3%	10.5%	10.2%	10.5%	11.0%	9.8%
Coal	54.1%	51.8%	52.9%	50.5%	45.5%	42.2%	45.1%	41.7%	42.8%	45.4%	41.1%
Hydro	0.7%	1.9%	0.7%	1.9%	1.9%	2.0%	1.9%	2.1%	2.1%	2.2%	2.2%
Nuclear	4.0%	4.1%	5.2%	5.3%	5.3%	5.8%	5.4%	5.9%	6.0%	6.3%	6.4%
Renewables	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	5.6%
Non-Commercial	9.8%	10.1%	9.8%	10.1%	10.1%	10.9%	10.2%	11.1%	11.3%	11.9%	12.0%
Total	100	100	100	100	100	100	100	100	100	100	100

3.3.1 Aggregate Energy Needs and Imports Dependence

30. Based on the various scenarios developed the total commercial energy requirement for India in 2031-32 varies from a low of 1351 Mtoe to a high of 1702 Mtoe. This level of commercial energy requirement entails an annual growth of 5.2% to 6.1% over the commercial energy supply level in 2003-04 to sustain an 8% growth rate of GDP. The total primary energy requirement in 2031-32 varies from a low of 1536 Mtoe to a high of 1887 Mtoe. This yields an annual growth in total primary energy requirement of 4.3% to 5.1% over the 2003-04 level to sustain a GDP growth of 8% per annum.

31. The modelled scenarios help us in assessing the significance of various options. They also suggest our likely dependence on energy imports. The level of imports depend on the level of domestic production. Given our resources shown in *Table 3.1*, domestic production of oil and gas will depend critically on new finds. If we don't make major new discoveries, our production can increase only marginally. We can only guess what the production will be and be ready for the worst. Thus we assume that we can produce by 2031-32 only 35 Mtoe of oil per year and around 100 Mtoe of natural gas including coal bed methane. Our production of coal is constrained by our ability to successfully use our ample domestic resources. The main hurdle could be an inability to expand production at the needed pace, environmental constraints due to attendant deforestation and the social problem of resettlement of project affected people. At a modest growth rate of production of 5.5 percent per year - a rate slightly higher than what has been achieved over the previous 25 years - the production of coal and lignite by 2031-32 will be around 1400 Mt. Based on these assumptions, our import needs for the various scenarios will be as shown in *Table 3.8*. Thus, with an 8% GDP growth rate an import dependence for energy in 2031-32 could be as low as 29 percent and as high as 59 percent. Increasing coal production and associated infrastructure of transport, as well as improving energy use efficiency in generation and use are critical if we are to reduce our dependence on imported energy.

3.3.2 Energy Supply Options

32. The major choices are use of alternative fuels in the power sector and in modes of transport. *Table 3.9* shows the generation capacities in scenario 11 (renewables scenario) from different sources and the load factor for each type of plants for the year 2031-32. This is an extreme scenario where all options for power generation other than coal, are pushed to their limits. We have also assumed high

Table 3.8
Ranges of Commercial Energy Requirement, Domestic Production and Imports for 8 percent Growth for year 2031-32

Fuel	Range of Requirement in Scenarios (R)	Assumed Domestic Production (P)	Range of Imports* (I)	Import (Percent) (I/R)
Oil (Mt)	350–486	35	315–451	90–93
Natural Gas (Mtoe) including CBM	100–197	100	0-97	0-49
Coal (Mtoe)	632-1022	560	72-462	11-45
TCPES	1351-1702	—	387-1010	29-59
*Range of imports is calculated across all scenarios as follows:				
Lower bound =Minimum requirement – Maximum domestic production				
Upper bound = Maximum requirement – Minimum domestic production				

Table 3.9
Generation Capacities and Load Factors in Scenario 11

Source	Capacity (MW)	Plant Load Factor (%)
Coal	269997	67
Natural Gas	69815	27
Coal Bed Methane	27778	36
In-situ Coal Gas	22222	36
Nuclear	63060	68
Hydro	150153	30
IGCC Pet coke	3137	68
Wind – Onshore	32141	20
Wind – Off-shore	1200	25
Biomass Gasification	1200	75
Biomass combustion	50000	70
Solar	10000	17.5
Total	700703	50

plant load factors for biomass gasification and combustion, and somewhat lower factors for conventional plants. It gives the minimum coal requirement.

33. It is seen that even under scenario 11, coal is the dominant fuel with a share of 51% in electricity generation and a share of over 41% in the energy mix. Gas-based generation constitutes only 11% of electricity generation capacity in scenario 11. The capacity factor of gas plants remains 31% showing that they are mainly used for peaking. Scenarios were also generated with alternative prices of natural gas and it is found that natural gas is not selected when the gas price is US$ 4.5 per MMBtu or higher even for peaking power as long as the coal price remains at or below US$ 2.27 per MMBtu (i.e. $45 per tonne of imported coal with 6000 kcal/kg). The low load factor for hydro plants is an outcome of the limited availability of hydro energy.

34. The results of the scenarios in the context of the brief review of energy resources show the following:

(a) Any supply strategy over the coming decades will have to emphasise India's major resource, i.e. coal. Coal is the most abundant domestically available primary energy resource other than thorium and solar insolation. In the "coal-based development" scenario, the total demand for coal increases from 172 Mtoe in 2004-05 to 1022 Mtoe in 2031-32. Measured in Mt of Indian coal with 4000 kcal/kg, the requirement of coal will thus increase from 406 Mt in 2004-05 to 2555 Mt in 2031-32. The quality of Indian coal is deteriorating progressively. A 5% deterioration over the next 25 years would raise the coal requirement to 2689 Mt by 2031-32 in terms of Indian coal. This order of increase may call for a massive rise in coal imports unless domestic production increases correspondingly. This would increase our energy dependency on imports. Additionally, since use of coal is associated with the environmental problems of mining and local air pollution, apart from CO_2 emission; coal use must be accompanied by appropriate environmental measures and use of clean coal technologies. Even under the least coal intensive option, domestic coal production would need to rise to 1580 Million Tonnes.

(b) A massive effort is clearly needed to expand domestic coal production. Given that, at present, coal mines take 8 years to develop and Coal India suffers from several problems, it is doubtful that Coal India can meet this need. Opening up the coal sector to private mining and use of the best technology are unavoidable. Captive mining as permitted at present alone will not suffice. We must build a consensus to allow changes in the coal sector to happen sooner rather than later. In any event, massive investments would be needed to enhance the rail infrastructure to move large quantities of domestic coal. Alternate coastal/ river transportation of coal may also have to be pursued aggressively.

(c) As seen from *Table 3.8* high quality coal (6000 kcal/kg) import needs could range from 120 million tonnes to 770 million tonnes by 2031-32. To put this in perspective, currently less than a billion tonnes of high quality coal equivalent is traded internationally out of a production of about 4.8 billion tonnes of equivalent high quality coal. This will require the development of appropriate port infrastructure as well as the development of end-use (power, steel and cement) at coastal locations to avoid double handling and inland transportation of imported coal.

(d) Development of hydropower as a clean power source has to be given due priority. Full development of hydro potential while technically feasible, will require timely resolution of issues of water rights, resettlement of project affected people and environmental concerns. These issues can be and must be resolved satisfactorily. The irrigation and flood control benefits of hydro-power and its operational flexibility can justify the higher costs of hydel plants. It is pointed out that India needs to create water storage capacity. Its storage per capita at 207m^3/capita is one of the lowest in the world and compares poorly with the corresponding levels of 1964 m^3/capita and 1111 m^3/capita in the US and China respectively.

(e) States that are well endowed with coal and/or hydro resources have been increasingly demanding a greater share of the benefits to the nation from exploiting these resources. This is an urgent issue and must be taken up at the National Development Council (NDC) level to avoid delays and additional costs in fully exploiting these domestic energy resources.

(f) Though nuclear energy can make only a modest contribution over the next 25 years, longer term consideration of even a modest degree of energy self-sufficiency suggests the need to pursue the development of nuclear power using Thorium. Despite the many delays and disappointments in achieving set targets of nuclear energy development in the past, this is an option we cannot afford not to pursue. Today the PHWR is economically competitive with coal-based plants at certain locations.

(g) If the import of 6,000 MWe of LWR reactors does not materialise, the installed nuclear capacity by 2031-32 will be 48,000 MW instead of 63,000 MW. The impact on the various scenarios will, however, be marginal and none of the policy conclusion would be affected. We have not depended on large scale import of LWRs due to the uncertainties involved. Imported LWRs could be an important option if the FBR and Thorium reactor routes not materialise or are found to be uneconomical. Energy security concerns may leave us no option other than full pursuit of the FBR and Thorium routes.

(h) The optimistic nuclear development scenario as envisaged is contingent on 6,000 MW of additional import of LWRs whose plutonium could be used in FBRs along with the plutonium from the 10,000 MWe reactors using our own Uranium. Import of the additional 6,000 MW of LWRs (and associated fuel) depends upon the handful of countries constituting the Nuclear Suppliers' Group (NSG). If the sanctions by the NSG are removed and India is able to import Uranium and nuclear power plants, nuclear power can play a much bigger role in the power sector. The capacity growth then would not be constrained by *Table 3.4*. However, if energy security concerns are our primary driver towards nuclear, then import of LWRs, even though more economical, may have to be limited to restrict our dependence on energy imports.

(i) Full development of hydro potential and realisation of the optimistic nuclear scenario by 2031-32 reduce coal requirement by some 93 Mtoe (232 Mt of Indian coal) from the level of 1022 Mtoe projected in the coal dominant scenario. This scenario implies total electricity generation capacity of 7,75,500 MW in 2031-32 of which hydro capacity will be 1,50,000 MW, and nuclear capacity will need to expand from the present 3,660 MW to 63,000 MW.

(j) If we assume no dramatic new finds of oil occur in the country, our oil imports will be around 315 to 451 Mt in 2031-32. This is about four to five times of what we import today. Assuming that world trade over this period will grow from 2.4 billion tonne (Bt) today to 4 Bt by that time, India's imports will constitute 7.9 to 11.3 percent of global trade.

(k) Gas does not emerge as a major fuel in any of the scenarios. The share of gas in the energy mix remains below 11%. Even when gas is pushed for power generation, only 16% of the power generated comes from gas. This is so despite the scenarios assuming that domestic natural gas supplies will be supplemented with coal-bed methane and in-situ gasification of coal as well as with imported LNG.

(l) A disturbing fact that emerges from the study of various scenario is that even if India somehow succeeds in raising the contribution of renewable energy by over 40 times by 2031-32 inclusive of a renewable power capacity of 1,00,000 MW (compared to 6,161 MW as on March 2005); the contribution of renewables to our energy mix will not go beyond 5.6% of total energy required in 2031-32. This is consistent with various projections worldwide that shows that the fossil fuel dependence of the world as a whole will continue to rise till 2031-32.

3.3.3 Energy Efficiency and Demand Side Management

35. India's conventional energy reserves are limited and we must develop all available and economic alternatives. Simultaneously, a major stress must be laid on energy efficiency and conservation, with particular emphasis on efficiency of electricity generation, transmission, distribution and end-use. Clearly, over the next 25 years energy efficiency and conservation are the most important virtual energy supply sources that India possesses.

(a) India cannot deliver sustained 8% growth over the next 25 years without energy and water, and these two together shall, in turn, pose the biggest constraints to India's growth. The energy intensity of our growth has been falling and is about half what it used to be in the early seventies but there is significant room to improve. In 2003 India consumed 0.16 kilogram of oil equivalent per dollar of GDP expressed in purchasing parity terms. This compares to 0.23 in China, 0.22 in US and a world average of 0.21. However there are several countries in Europe and Japan at or below 0.15. One should note that cross country comparisons are full of pitfalls. For example, if the share of hydel energy is higher in the total energy mix, energy intensity would be lower. Even then, these comparisons do show that energy intensity can be brought down by 20% in India with commercially viable technologies currently available and in use in the developed countries.

(b) The most energy efficient scenario from our model shows an aggregate energy requirement of 1536 Mtoe in 2031. This scenario is 19% more efficient than the most energy intensive scenario. With a projected population of 1.468 billion, the per capita total primary energy supply (TPES) in the most energy efficient scenario comes to 1046 kgoe/year. This is comparable to China's per capita TPES in 2003. Even in the most energy intensive scenario the per capita TPES in 2031-32 is only 1285 kgoe. This compares with the 2003 world average per capita energy consumption of 1688 kgoe. Thus while the projected total energy requirement may look large, it is perhaps not large enough for the GDP growth assumed.

(c) Efficiency of coal power plants themselves can be improved substantially. The average gross efficiency of generation from coal power plants is 30.5%. The best plants in the world operate with super critical boilers and get gross efficiency of 42%. Germany is even claiming gross conversion efficiency of 46%. It should be possible to get gross efficiency of 38-40% at an economically attractive cost for all new coal-based plants. This alone can reduce coal requirement by 111 Mtoe of coal (278 Mt of Indian coal). Thus a very high priority should be given to developing or obtaining the technology for coal-based plants of high efficiency.

(d) If Demand Side Management (DSM) options are pursued to reduce demand for electricity through energy efficient processes, equipment, lighting and buildings so that electricity demand is reduced by 15% by 2031-32, a reduction of 152 Mtoe (381 Mt of Indian coal) in coal requirement takes place. Studies have shown that economically attractive options of DSM exist to attain such reductions. Energy efficiency and DSM should have a very high priority. Policies to promote these are described in *Chapter VI*.

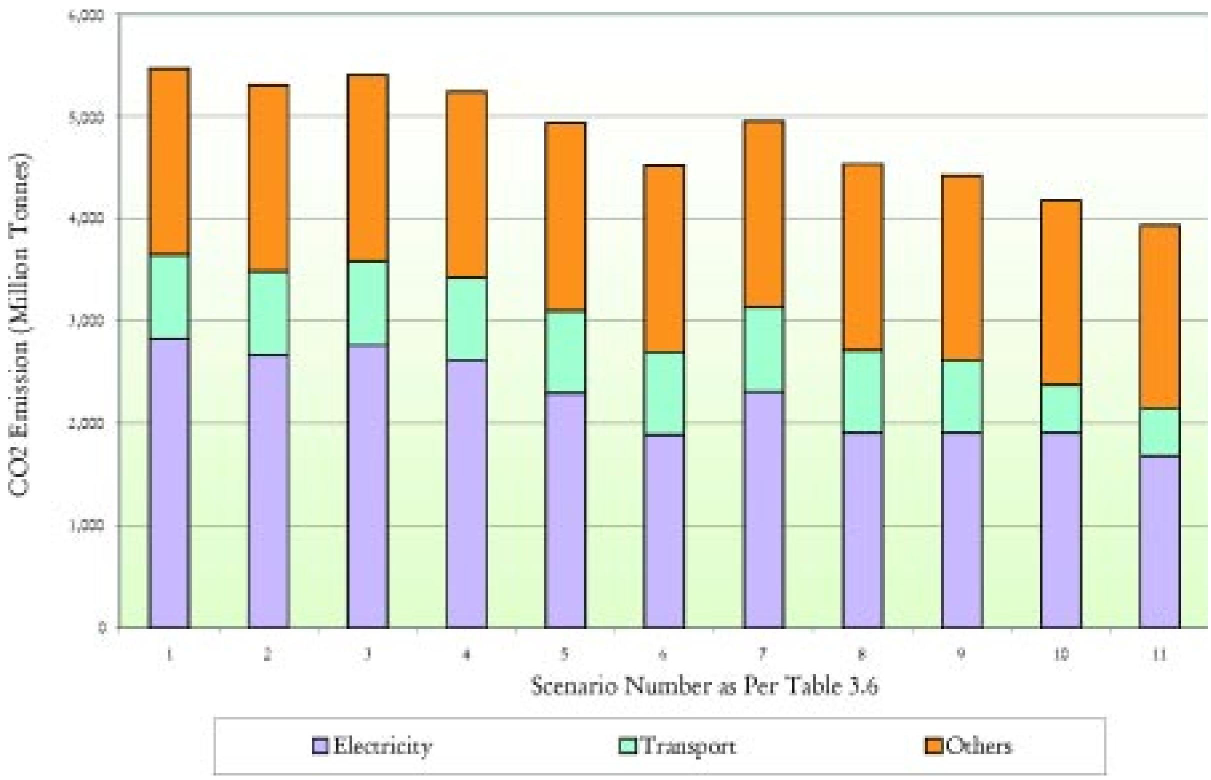
(e) Since domestic oil supply has stagnated at a low level and requirements are growing, oil use efficiency, conservation and substitution by other forms of energy are major options to reduce oil imports. The same is true of gas, though the prospects of finding gas look somewhat brighter. Since no economic substitutes are obvious for the transport sector at least till 2031-32, energy efficiency of vehicles and use of mass transport have to have high priority. If the energy efficiency of all motorised transport vehicles is increased by 50%, (an efficiency level that is already achieved in the world today) our oil requirement will go down by some 86 Mt by 2031-32. If on the other hand railways are able to win back the freight traffic they have lost to trucks and manage to carry 50 percent of freight billion tonne kilometre (Bt-km), then oil requirement can go down by 38 Mt. These two initiatives in the transport sector can, together, reduce our oil requirement by over 25% from the most oil intensive scenario in 2031-32.

(f) Urban mass transport is much more fuel efficient per passenger kilometre compared to private vehicles. Mass transport also reduces road congestion and air pollution. Thus development of urban mass transport systems of quality and convenience that can attract passengers will contribute significantly to energy conservation.

(g) If both energy efficiency of coal generation and DSM are pursued together along with higher freight share by Railways and a push for renewables, coal demand could come down by over 38% from the coal dominant scenario to 632 Mtoe (1580 Mt of Indian coal).

36. All of the above recommendations,

Figure 3.5
CO2 Generation Comparison in year 2031-32



resulting from an analysis of the scenarios studied, are technologically viable. Pursuing them can lower our energy demand by over 19%. Failure to deliver on these recommendations could push India into the international market for coal with a potential demand equal to over 75% of the current level of trade. The short to medium term impact of such an eventuality on coal prices could be disastrous. That being said, there are indications that over the medium term world output of coal and coal trade is set to increase significantly.

3.3.4 Carbon Emissions

37. Estimates of CO_2 generated from energy use in different scenarios are shown in *Figure 3.5*. Between Scenarios 1 (coal dominant scenario) and scenario 11 (with all efficiency and DSM measures and renewables) the difference is nearly 35%.

38. The carbon emission implications of our scenarios are therefore significant. Annual CO_2 emissions could rise from 1 billion tonne at present to 5.5 billion tonnes per year by 2031-32 in the high coal use scenario and 3.9 billion tonnes in the low coal and renewable dominant scenario. In the US, emissions today are in excess of 5.5 billion tonnes of CO_2. In per capita terms, however, India's carbon emissions in 2031-32 will be 2.6 to 3.6 tonnes of CO_2 compared to the 2004 level of over 20 tonnes in US and a global average of 4.5 tonnes in 2004.

3.3.5 Implications for Investment Needs

39. Apart from the challenges of physically supplying different forms of energy discussed above, the investment requirement also show a need for purposive action. The electricity generation, transmission and distribution sector alone is estimated to require an investment of at least Rs.60 trillion in 2005 rupees. The total energy sector investment could well amount to Rs.100-110 trillion in 2005 rupees inclusive of related infrastructure.

40. An economy growing at 8% should have little difficulty in mobilising the needed resources particularly with public private partnerships. The main challenge, however, is to create efficient and financially viable energy

sub sectors so that investors have the incentives to invest in a competitive set up where consumers interests are simultaneously protected.

3.3.6 The Main Actions Recommended

41. Comparisons of energy requirements and our resource base suggest that our hydrocarbon resources would be grossly inadequate to meet our needs. From a longer term perspective we need to take a number of actions:

- Relentlessly pursue energy efficiency and energy conservation as the most important virtual source of domestic energy.
- Institute policies that maximise domestic coal production.
- Create coastal infrastructure for import and use of coal.
- Develop coal transportation infrastructure including alternatives such as coastal and river movement.
- Develop fully the nuclear and hydro option.
- Mount R&D efforts to develop commercially viable in-situ coal gasification technology.
- Redouble exploration efforts for oil, gas and coal.
- Raise the level of diplomacy to access hydrocarbon reserves overseas and gas pipelines to India.
- Undertake a technology mission on carbon sequestration.
- Undertake pilot projects to assess the economics and social benefits of biomass plantations and bio-fuels
- Undertake a solar technology mission to make solar power using photovoltaics or solar thermal economically attractive.
- Undertake R&D for exploiting gas-hydrates.
- Undertake R&D for fusion to keep open that option for unlimited power.
- Assess off-shore wind power potential.

3.4 ENERGY INDEPENDENCE IN AN ENERGY SCARCE WORLD

42. World energy supplies are becoming increasingly constrained. India needs to grow its energy share in a market with sluggish growth in supply and rising prices. It is assumed that the world's fossil fuel supplies grow by 2% per annum. Then India's share of world supplies of fossil fuels in 2031-32 would rise from a level of 3.7% to a low of 7.6% in the most energy efficient scenario to 10.9% in the most energy intensive scenario.

43. President Kalam in his Independence Day address to the nation in 2005 has called for achieving energy independence. While energy security is a major concern for the next 25 years, from a longer term perspective energy independence becomes important. What does an energy independence scenario look like? The main challenges are to augment total domestic energy supply.

44. *Table 3.10* shows the energy supply by sources for the year 2003-04. The following options exist to substitute oil:

- Industrial use of Naphtha, Fuel Oil (FO) and High Speed Diesel Oil (HSDO) and domestic use of LPG and Kerosene can all be replaced by natural gas. Domestic availability of gas, today, looks more promising than oil. Gas should be used for power generation only after it meets the above demand.
- Produce bio-diesel in a decentralised manner and substitute all agricultural use of HSDO/LSHS/fuel oil with bio-diesel.
- Encourage blending of ethanol with petrol.
- Provide adequate quality power to reduce the need for diesel used for standby generators and diesel pumps.
- Expand electrification of railways to reduce diesel needs.
- Improve railways' freight service so that all long distance goods traffic prefer railways thereby substantially reducing HSDO used for transport.

- Promote urban mass transport to reduce demand for petrol for personal motorised vehicles.
- Improve fuel efficiency of motorised vehicles by a factor of two through better vehicle design.
- Encourage hybrid vehicles which are now available commercially on cost competitive terms.

45. Under President Kalam's vision for energy independence, India could eliminate its

Table 3.10
Primary Energy Supply Sources (2003-04)

(All figures in Mtoe)

Source		Domestic	Import#	Total
Coal & Lignite	Coal	145.00	14.00	167.00
	Lignite	8.00	-	
Oil & Products	LPG	12.44	0	12.44
	Kerosene	10.69	0.84	11.53
	HSD	40.31	-6.29	34.02
	LDO	1.21	0.00	1.21
	FO	8.36	-0.35	8.01
	LSHS	4.60	0.00	4.60
	MS	8.59	-3.19	5.40
	ATF	2.66	-1.77	0.89
	NAPHTHA	13.59	0.21	13.80
	Bitumen	3.24	0.00	3.24
	Pet Coke	2.80	0.00	2.80
	Lubes etc	1.37	1.53	2.90
	Others*	18.01	0.15	18.16
	TOTAL	127.87	-8.87	119.00
Gas	Gas	29.00	-	29.00
Electricity	Hydel	7.00	-	7.00
	Nuclear	5.00	-	5.00
	TOTAL	12.00	-	12.00
TOTAL COMMERCIAL ENERGY				327.00
Non Commercial	Fuel wood Agro Waste	110.00	-	110.00
	Dung Cake	32.00	-	32.00
	Biogas	1.00	-	1.00
	TOTAL	143.00	-	143.00
TOTAL ENERGY				470.00

* Others include refinery fuel of about 9 Mt
\# Net of exports

oil dependence over the next 40-50 years by:

- ❑ Developing cheap batteries with high storage density for hybrids/electric vehicles.
- ❑ Developing solar power. As suggested by President Kalam, if efficiency of solar photovoltaics can be increased from the current 15% to 50%, without increasing the cost, we can have all the power we need at competitive costs by covering a small fraction of our land (the land required can be further reduced by putting photovoltaic cells on all roof tops). The surplus solar power during day time can be used to split water to produce hydrogen that can provide electricity at night and can also be used to run motor vehicles using fuel cells.
- ❑ Developing nuclear power based on Thorium.

46. A focussed research effort in the direction suggested by President Kalam needs to be initiated now as the sooner these technologies are available, the better it will be for the country's energy security and independence.

Energy Security

4.1. WHAT IS ENERGY SECURITY?

Obtaining a secure and adequate supply of a traded commodity, be it food or fuel, is generally a problem prevalent amongst poor people, poor regions or poor nations. With the power to pay the price the rich often find willing suppliers for what they want. 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". This definition needs to be modified to better reflect our situation.

2. We define energy security as follows:

"We are energy secure when we can supply lifeline energy to all our citizens irrespective of their ability to pay for it as well as meet their effective demand for safe and convenient energy to satisfy their various needs at competitive prices, at all times and with a prescribed confidence level considering shocks and disruptions that can be reasonably expected".

The various elements of this definition that may be noted are: "all her citizens", "lifeline energy", "effective demand", "safe and convenient energy", "at competitive prices", "at all times", "various needs", "prescribed confidence level", "shocks and disruptions" and "reasonably expected".

These are motivated by the following considerations:

(a) It is important that energy is supplied to all citizens. When the energy needs of only some citizens are met, it cannot be a sustainable situation.

(b) It is necessary to provide "lifeline" energy to all citizens irrespective of their paying capacity. Energy up to a certain level is a basic necessity and whether the state supplies it or not, people will procure it in any way possible. If the state does not provide such lifeline energy, environmental degradation can be expected. Lifeline energy consumption for those who cannot afford energy at market price has to be made good through subsidies that, preferably, target the intended beneficiaries directly. Energy security requires that the lifeline energy needs of the Nation are met in full.

(c) Effective demand, i.e. demand backed by the ability to pay at market determined prices, should be met fully. If it is not, the rich will get what they desire but the poorer classes won't.

(d) If demand is not met at competitive prices the competitiveness of the Indian economy would be compromised.

(e) Safe and convenient energy is desirable as use of traditional fuels such as wood or dung cakes causes indoor air pollution and leads to adverse impact on health, particularly that of women and children.

(f) Energy is required in different forms to meet different needs. Energy in one form cannot be easily substituted by other forms. Often such substitution involves cost or loss in the quality of service. For example, kerosene can replace electricity for lighting but at a cost and a loss in quality of service. Fuel cells or batteries could replace IC engines using petrol or diesel but at a cost.

(g) Energy should be available at all times. Interruptions in energy availability can impose high costs on the economy and also on human well-being.

(h) To ensure energy security at all times, shocks and disruptions that can be reasonably expected must be anticipated. Ability to withstand such shocks and disruptions is essential for energy security. However, one cannot guard against all possible shocks at affordable costs. The surety of energy supply cannot be 100 percent. One can ensure supply only within a certain prescribed confidence level.

4.2 THE NATURE OF THE PROBLEM

3. Energy security has become a growing concern because India's energy needs are growing with rising income levels and a growing population. At the same time, our dependence on imported energy has increased. Up from 17.85% of Total Primary Commercial Energy Supply (TPCES) in 1991, imports accounted for 30% of our TPCES in 2004-05. What is of particular concern is that imports comprise largely of oil and during 2004-05, oil imports constituted 72% of our total oil consumption.

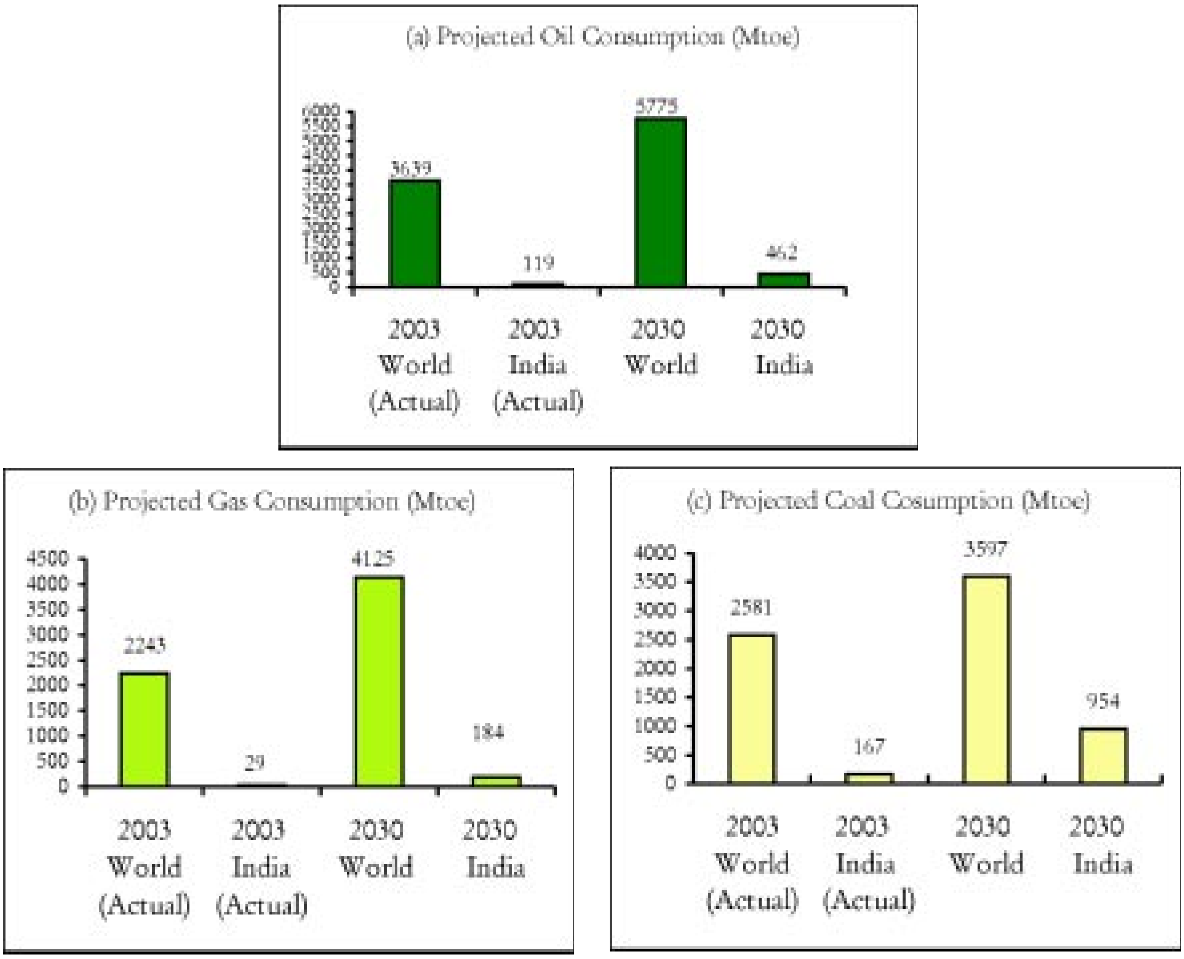
4. Our projected energy requirement and various supply options show the country's growing dependence on import of energy. Not only oil and gas but also coal imports are likely to grow substantially over time. Energy security, thus is an important concern for India's energy policy.

5. The growing dependence on energy import raises several concerns. India's requirements of fossil fuels for the year 2030 based on the scenarios of *Table 3.7* (which gives requirements for 2031-32) are projected to be 337 to 462 Mt of oil, 99 to 184 Mtoe of gas and 602 to 954 Mtoe of coal. If the global fossil fuel supply increases by only 1.7%, as projected by IEA, then India's share in 2030 would range from 5.8% to 8.0% for oil, 2.4% to 4.5% for natural gas and 16.7% to 26.5% for coal (*see Figure 4.1*). Will we get all the energy that we need even when we are willing and able to pay the price? What will we do if supply is disrupted due to events outside our control? Wars, strikes, and political upheavals in the oil exporting countries can suddenly and drastically reduce global oil supply. Also in a situation of conflict, an oil blockage may be imposed against India. One can think of many such eventualities. How do we keep our economy going in such a situation? How do we deal with this supply risk? The threat to energy security arises not just from the uncertainty of availability and price of imported energy, but also from the possible disruption or shortfalls in domestic production. Supply risk from domestic sources, such as from a strike in Coal India or Railways, also needs to be addressed.

6. The second concern is not disruption of supply but the market risk of a sudden increase in oil price. While we may be able to pay for imports, a high oil price can cause inflation, slow down the economy and impose hardship on our people. Given that world oil prices have fluctuated substantially over the years (*see Figure 4.2*), the adverse impact on the economy of sudden and large increases in oil price is perhaps a more likely risk than supply disruption.

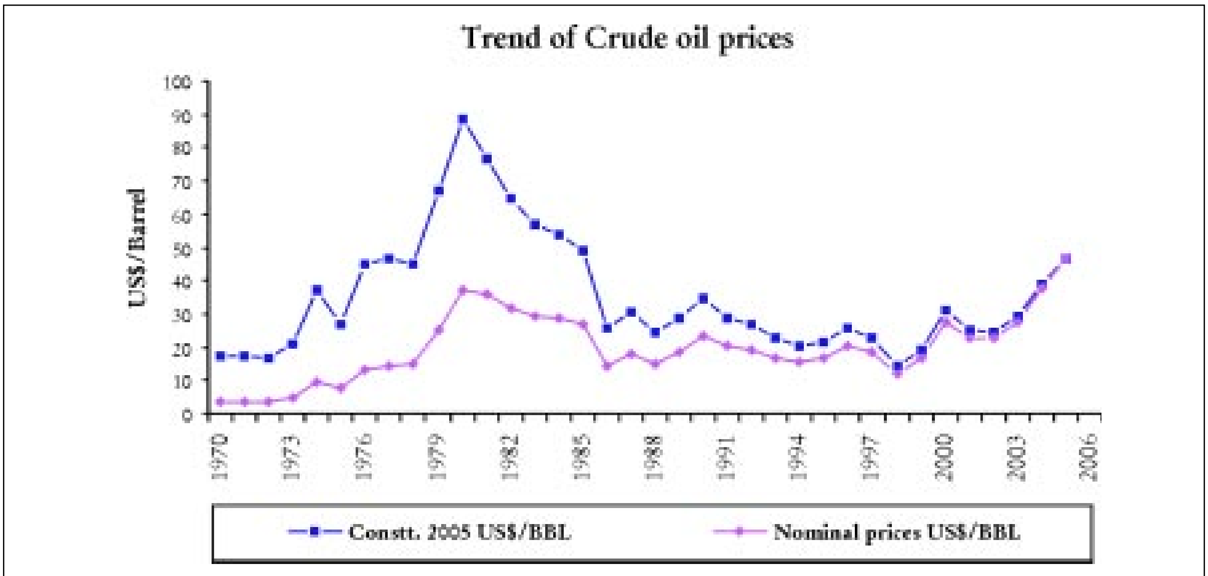
7. Any disruption in access to energy can be very expensive in welfare terms as energy is critical not only for economic growth but also for human survival and well-being. For example, if an increase in the price of oil, a disruption of oil supply or erratic power supply forces farmers to reduce the use of their pumps and tractors, the consequent reduction in agricultural output and employment can have a serious and adverse impact on the poor. Thus, a government may choose not to immediately transmit a sudden large increase in the international price of imported energy to consumers. To be able to insulate consumers against such sudden price increase, governments may have to bear the burden of this price rise for some time. This requires a certain resilience in the government finances. Of course, if the price increase persists, it has to be transmitted to the consumers sooner or later since oil imports constitute a large part of India's oil consumption and the subsequent import bill is sizeable. Thus, India is exposed to price fluctuations in the world market and we have to accept this reality.

Figure 4.1
India's Growing Share in Global Energy Consumption
(Higher Projections)



Source: Projections are based on the scenarios of *Table 3.7* reflecting a GDP Growth Rate of 8% for India and for World they are 2030 numbers from IEA, 2005

Figure 4.2
World Oil Prices



8. Even when the country has adequate energy resources, technical failures may disrupt the supply of energy to some people. Generators may fail, transmission lines could trip or oil pipelines may spring leaks. There may be many such accidents that disrupt the supply of energy. One needs to provide security against such technical risks.

4.3 POLICY OPTIONS FOR ENERGY SECURITY

9. The effectiveness of measures to enhance energy security depends on the nature of the disruption. The costs of the various measures also differ. One wants to minimise the expected cost for a desired level of confidence. Such measures include: reduction in the need for energy and the consequent reduction in energy imports; diversification of supply sources; maintenance of strategic reserve; and obtaining equity oil or gas abroad that could, under some cases, help in reducing the consequences of both supply and market risks.

10. Actions to improve energy security can be classified broadly into two groups, one that reduces risks and another that deals with the risks after they occur. The major policy options are:

(a) Reducing Risks

- Reduce the requirement of energy by increasing efficiency in production and use of energy;
- Reduce import dependence by substituting imported fuels by domestic fuels;
- Diversify fuel choices and supply sources;
- Expand domestic energy resource base.

(b) Dealing with Risks

- Increase ability to withstand supply shocks;
- Increase ability to import energy and face market risk;
- Increase redundancy to deal with technical risk.

4.3.1 Reduce Energy Requirements

11. Major opportunities exist in reducing energy requirements without reducing energy services. Improvement in energy efficiency or conservation is akin to creating a new domestic energy resource base. Such efficiency improvements can be made in energy extraction, conversion, transmission, distribution and end-use of energy. All of these efficiency improvements can come using currently available commercial technologies. Some examples are detailed below:

(a) The efficiency of extracting fossil fuels in India as well as other mining activities can easily be improved by some 10%. For fossil fuels this would mean a lower level of energy spent per unit of energy extracted.

(b) Fuel efficiency of Coal Power Plants: The average fuel conversion efficiency of Indian power plants is just about 30.5% though the new 500 MW plants have efficiency of 36%. State of the art super critical pulverised fuel fired boilers can reach an efficiency level of 46% depending on plant location. Under Indian conditions an efficiency level of 38-40% should be attainable. Considering our large dependence on coal-based power plants, obtaining this technology for all new power plants should be our first target. Possible policies to achieve this target are:

   (i) Purchase technology, if available at reasonable price otherwise set-up a technology mission to develop it independently.

   (ii) Offer to buy 20 plants of a standard size, say 700 MW from any firm that first commercialises 42% efficiency coal fired boiler for Indian coals at a price prescribed in advance.

(c) Another major option is provided by freight traffic. The share of railways in total tonne kilometre (t-km) of goods traffic has come down from 70% in 1970-71 to 39% in 2003-04. If the railway carried 70% of the goods traffic today, it would carry 300 Bt-km of additional traffic. Assuming that all of this goods traffic would have been carried by Railways using diesel, the diesel saved in year 2003-04 would have been around 5 Mt out of a total consumption of 40 Mt. If all of the goods traffic was carried by Railways using electric traction, the diesel saved would have been around 8 Mt in 2003-04. Thus a significant saving of diesel is possible if Railway operations can be upgraded to win back the haulage lost to road traffic. The needed policies are:

(i) The monopoly of Container Corporation (CONCOR) for the container traffic on railways should be ended.

(ii) Freight rates should be rationalised and the cross subsidy to passenger traffic should be reduced, if not eliminated.

(iii) Timely delivery of goods should be guaranteed, preferably by operating scheduled goods trains between large cities.

(iv) Dedicated corridors for goods traffic should be developed, preferably on electric traction, between metro cities.

(d) Energy efficiency and demand side management also have a large scope to reduce energy requirement. These include the use of energy efficient appliances and automobiles, hybrid cars, energy efficient buildings, efficient lighting, cogeneration, distributed generation with Combined Heat and Power (CHP) use, energy efficient and well-maintained irrigation pumps, smokeless improved woodstoves, etc. The needed specific policy initiatives are discussed in *Chapter VI*.

(e) In the long-term, promotion of public transport in urban areas can significantly reduce energy consumption particularly the need for imported oil and gas. Some advance actions that can be taken now are as follows:

(i) Develop effective and attractive mass transport such as underground, elevated trains, light rail, monorail or dedicated bus lanes in existing metros.

(ii) For medium size cities, make plans for efficient public transport corridors to serve future population and acquire the right of way. Public transport can then be further developed as the city develops. Development of city infrastructure can be financed by gradually increasing permissible built up area or Floor Space Index (FSI) and auctioning the right to build. Even existing land owners should be required to purchase the additional right to build, if they want to extend their buildings.

(iii) Congestion charges and parking fees should be levied in city centres to discourage the use of private cars.

4.3.2 Substitute Imported Energy by Domestic Alternatives

12. Energy security can be increased by reducing the need for imported energy by substituting it with other forms of energy. Though this does not reduce the need for total energy, it reduces import dependence. If the domestic substitutes increase dependence on one particular fuel, however, it can increase domestic supply risk. Conversely, if substitutes diversify the domestic energy mix, they can also reduce supply risk particularly if the substitutes are local renewables. Some important options include:

(a) Electrification of railways can replace diesel trains. Of course this calls for investment in electrification of tracks, electric locomotives and electricity generation. However, with crude oil at US$70 a barrel, electric traction can be economically attractive on routes with lower traffic density than before. Such electrification can lead to the substitution of imported diesel with domestic coal.

(b) Wood plantations with a potential of yielding up to 20 tonnes of wood per hectare per year in a sustainable way could significantly expand the domestic energy resource base. Wood can be burned directly or gasified for power generation. This would reduce the need for future gas/coal imports.

(c) Bio-diesel and Ethanol can substitute diesel and petrol. Bio-diesel becomes particularly attractive when it is derived from inedible oilseeds from trees that need little water and fertiliser and can thus grow without care on wasteland.

Table 4.1
Sources of India's Oil Imports – 2004-05

	Country	Oil Imports (Mt)	% of Total Imports
Middle East Region	Iran	9.61	10.03
	Iraq	8.33	8.69
	Kuwait	11.36	11.85
	Neutral Zone	0.15	0.15
	Oman	0.14	0.14
	Qatar	1.19	1.24
	Saudi Arabia	23.93	24.96
	UAE	6.43	6.71
	Yemen	3.51	3.66
	Sub Total	**64.64**	**67.43**
Other Regions	Angola	2.44	2.55
	Brazil	0.29	0.30
	Brunei	0.81	0.84
	Cameroon	0.35	0.36
	Congo	0.14	0.14
	Egypt	2.12	2.21
	Equador	0.15	0.16
	Equitorial Guinea	1.66	1.73
	Gabon	0.28	0.29
	Libya	1.47	1.53
	Malaysia	3.43	3.58
	Mexico	2.28	2.38
	Nigeria	15.08	15.73
	Russia	0.16	0.16
	Sudan	0.33	0.34
	Thailand	0.27	0.28
	Sub Total	**31.23**	**32.57**
Total		**95.86**	**100.00**

Ethanol can be obtained from molasses, which may have other economically more paying uses. Ethanol can also be obtained from other starchy crops and from cellulosic plant matter. The competition for using limited land resources and availability of water pose the main challenges to increasing the production of ethanol.

(d) Use of hybrid vehicles and/or of electric vehicles, cars, scooters and motorbikes can significantly reduce requirements of petrol. This requires development of low weight, high density batteries. An advantage of such vehicles is that individuals can adopt this technology without the development of a supporting fuel supply network as would be required by hydrogen or fuel cell based vehicles.

(e) If hydrogen can be produced as a by-product of industry or with locally available energy sources, hydrogen based vehicles could provide an option to reduce dependence on oil imports.

(f) Coal can be converted into oil as is done in South Africa. The technology is well-developed and in use for years. Sasol is routinely available at filling stations along with petro and diesel in South Africa.

4.3.3 Diversify Supply Sources

13. The impact of a short-term disruption in the normal source of supply will depend on how important that source is in our total import mix. Thus the first measure for increasing security is to diversify our sources of supply both domestically as well as for the import of oil or gas. India currently imports oil from many different countries as can be seen from *Table 4.1*. While we import oil from 25 different countries, nearly two-thirds of our imports are from four countries, i.e. Saudi Arabia, Nigeria, Kuwait and Iran.

14. Energy security can be increased not only by diversifying sources of import of a particular fuel but also by diversifying the energy mix by using different types of fuels. An economy that uses coal, oil, gas, nuclear, hydro and renewables of various kinds is naturally less dependent on one particular fuel, and hence less vulnerable to supply disruptions of either domestic or imported energy sources. The security provided by such diversification is enhanced when the ability of the users to switch among fuels increases. One should assess the uses in which different fuels or energy forms can substitute each other. In an emergency if rationing of a particular fuel is needed, this process can be made less costly by encouraging the use of substitutes by specific users. This can also have a bearing on the size of the strategic reserve that one needs.

15. Apart from sourcing oil or LNG imports from different countries, supply risks can also be reduced by policy coordination among importing and exporting countries, by importing gas through pipelines, or getting hydropower from neighbouring countries. Many countries in India's neighbourhood have very large resources of natural gas. Among these are Iran, Turkmenistan, Bangladesh and Myanmar. Turkmenistan's gas can be augmented by gas from Uzbekistan, Kazakhstan, Azerbaijan and the Astrakhan littoral on the Russian shore of Caspian sea. Developing such a supply chain poses geo-political challenges. Payoffs are large and attempts must be made to overcome such obstacles. However, gas imports through trans-national pipelines raise their own issues concerning energy security.

(a) **Policy Coordination:** Not only importers but also exporters benefit from stable prices. Major Asian oil importers like India, China, Japan, Republic of Korea and major Asian suppliers like Saudi Arabia, UAE, Kuwait, Iran, Qatar and Oman all have a stake in securing oil supply and demand. A cooperative relationship - perhaps under an Asian Energy Association - can help in reducing fluctuations in oil supply and prices.

(b) **Import of Gas Through Pipelines:** Gas imports from, say, Iran through Pakistan, or from Central Asia through Afghanistan and Pakistan or from

Myanmar through Bangladesh do provide a higher degree of energy security compared to equity oil or gas. This is so because of the security of such supply. The supplying country typically invests in the pipeline and hence has a stake in maintaining the supply. Also, if supply to India is stopped, alternate buyers along the route may be difficult to find and the pipeline cannot be easily diverted like, for example, a LNG ship. Thus the risk of disruption from the supplier is relatively smaller. There is, however, the risk of sabotage of the pipeline as it transits through different countries. This can be guarded against by the following:

(i) Create an interest in the pipeline for all countries through which it transits. For example, a common pipeline shared by India and Pakistan will have substantial gains for Pakistan too. There are economies of scale that reduce costs for Pakistan over the alternative of obtaining gas through a pipeline of its own. Also Pakistan would earn transit fees. With this, a disruption should it occur, would likely be of a short duration.

(ii) Get multilateral agencies to invest in the project by way of equity and debt.

(iii) Enlarge the domestic buffer stock of LNG, have redundancy in regasification facilities and ensure that, in the case of a disruption, the supplier would be obligated to provide compensatory supply in the form of LNG. Such additional buffer stock can only be justified as cost of energy security.

(c) **Import of LNG:** Importing LNG through long-term contracts provides a flexible alternative to pipelines. Since the global gas market has developed and LNG trade has increased, the price of natural gas is likely to match the opportunity cost of selling it as LNG. Thus, the cost advantage of piped gas is not likely to be very large and has to be balanced against the risks of pipeline discussed above.

(d) **Import of Hydro-Power Through Nepal/Bhutan:** Substantial scope exists for import of hydro-power from Nepal and Bhutan. Their combined potential is estimated to be in excess of 55,000 MW. This could enhance energy security as hydro-power (which is particularly suited for meeting peak power demand) can replace natural gas-based generators which are also used for peaking purposes. The problem of arriving at an agreement on the price of power needs to be resolved. The development of a market for power trading in the country provides a benchmark that should make this task simpler. Nepal and Bhutan may be given the right to sell power to anyone on the market to ease this process.

4.3.4 Expand Resource Base and Develop Alternative Energy Sources

16. Our resource base can be expanded in many ways: enhance recovery from existing resource bases; explore to find new reserves; obtain equity energy abroad; and develop new sources of energy through R&D.

(a) **Enhanced Recovery:** Enhanced oil, gas and coal recovery from existing fields is an obvious option. India's recovery of in-place reserves can improve easily by 5-10 percentage points. Better mine design and the use of technologically advanced mining techniques are valid options. In the case of oil and gas, Improved Oil Recovery (IOR) and Enhanced Oil Recovery (EOR) techniques can improve exploitation of in-place reserves. Recovery of oil and gas from abandoned and/or marginal fields may also be taken up. However, the cost of such recovery should be balanced against the total amount of oil or gas that may be recovered from the field.

(b) **In-situ Coal Gasification:** Similarly for coalfields, in-situ gasification may permit much higher recovery of coal than can be economically mined by conventional techniques. Technology development for in-situ gasification should be vigorously pursued and entry barriers for gasification removed.

(c) **Coal Bed Methane:** Methane is adsorbed in coal seams. This Coal Bed Methane (CBM) usually escapes into the atmosphere when coal is mined. Tapping and utilising the CBM as a source of commercial energy has been in vogue in the US and Australia for several years. The estimated potential of CBM in India is in the range of 1400-2600 billion cu. metres (BCM) (1260-2340 Mtoe). The Government formulated a CBM policy in 1997 and the development of CBM is a concurrent responsibility of the Ministry of Petroleum and Natural Gas and the Ministry of Coal. So far, 13 blocks have been awarded through competitive bidding and 3 blocks by nomination to various PSUs/private companies for exploration and production of CBM. The estimated CBM resources in these blocks are 850 bcm (765 Mtoe) and a total production of about 23 MMscmd at peak production level is expected from these blocks. In addition to this, the Ministry of Coal - with the assistance of UNDP/ GEF - is implementing a CBM Recovery and Utilisation Demonstration Project in the Jharia coalfields under the Coal Science & Technology programme. Promotion of CBM exploration and production is essential to expanding the domestic resource base in the short to medium-term.

(d) **Exploration:** Efforts can be stepped up to find new reserves. Recent success by private as well as public sector companies such as Reliance and Gujarat State Petroleum Corporation Ltd. in finding gas shows the need to attract more players in exploration in the country. Exploration for all energy resources - coal, oil, gas and Uranium - should be stepped up. Offshore wind energy potential should also be mapped.

(e) **Equity Oil, Gas, Coal from Other Countries:** Obtaining equity oil abroad does not particularly increase oil security beyond diversification, if any, of supply sources. The political risk of disruption of the supply of equity oil through embargos or nationalisation etc., would be similar to risk entailed in oil import from the same country. It also provides a right to a resource for a period that is typically longer than that provided by options and futures contracts. To the extent that India owns that oil abroad, whether it is brought to India or sold in the international market, the value remains the same. Thus obtaining equity oil abroad should be mainly looked upon as a commercial investment decision. If the amount of money invested in obtaining equity oil were to earn a higher return in an alternate investment, then such investment provides a better level of comfort for accessing oil at even higher prices in the future. Equity oil, however, does increase the country's access to imports in the same way as a long-term supply commitment. Thus we should explore and seize economically attractive opportunities for equity energy abroad. However, such investments must factor in all country, political and logistic risks. A simple way to ensure an independent oversight of the techno-economic viability of a new investment would be to require that it raises at least two-thirds of the funding required through off-shore commercial loans/ equity on a stand-alone basis without recourse to sovereign guarantees and without recourse to the balance sheets of India's national energy companies.

(f) **Using Energy Abroad:** In case India can get access to cheap gas in gas surplus countries, it could consider setting up captive energy intensive units such as fertiliser plants in these countries.

Alternatively, India could set up captive liquefaction plants to bring LNG into the country.

(g) **Coal to Oil:** Rising oil prices in the world market makes conversion of coal to oil economically attractive. Sasol claims that its technology for converting South African coal to liquids is viable if crude oil stays above US$45/ barrel. India should establish the viability of Sasol technology with domestic coal and establish the break-even price at which coal to liquids would make sense for Indian coal. Another step in this direction would be the inclusion of coal to oil conversion in the list of captive use under Section 3(3) of the Coal Mines (Nationalisation) Act, 1973, so that dedicated coal blocks could be allocated for this purpose.

(h) **Gas to Liquid (GTL):** In addition to sourcing piped natural gas and LNG, natural gas liquids may be another option. Major investments are being planned for conversion of gas to liquid in countries with large gas reserves viz., Qatar, Nigeria and Australia. India, with strong political ties with Russia and CIS countries, can consider setting up GTL plants in these countries under long-term arrangements wherein India gets a share of the produced liquids. However, a comprehensive study to evaluate technology, available resources and the economics involved is necessary prior to entering into any collaborative arrangement.

(i) **New Domestic Sources:** The domestic resource base can also be expanded through developing hitherto poorly developed or new sources of energy. Some of these resources may require R&D to make them economical. Among these are:

(i) **Nuclear Power:** With meagre availability of Uranium in the country and vast resources of Thorium, any long-term nuclear strategy has to be based on Thorium. The three stage strategy of development of nuclear power from pressurised heavy water based reactors to fast breeder reactors to Thorium based reactors requires a sustained R&D effort. Success in these efforts could deliver some 2,50,000 MW of nuclear power by 2050 and much more thereafter. Given the limited resources of oil, gas and Uranium, solar energy and Thorium based nuclear option are the only two sizeable sources (apart from fusion) of energy for the country. Thus, the Thorium option must be pursued. Failure to economically develop India's Thorium based nuclear potential to the fullest will significantly increase India's dependence on domestic and imported coal. Nuclear power will not only enhance energy security but also yield rich dividends by reducing carbon emissions.

(ii) **Gas Hydrates:** Very large reserves exist in Indian waters and have the potential to provide vast amount of gas. Technology to exploit these economically in ecologically safe ways is yet to be developed. However, the potential size of the resource makes it critical to vigorously pursue R&D.

(iii) **Wind:** The potential for onshore wind power has been assessed to be 45,000 MW. The Wind Energy Society of India claims it to be as high as 65,000 MW. However, given that the average capacity factor realised by India's wind farms is only about 17%, the total contribution to energy from these plants would be relatively small. Thus while wind power may be pursued for environmental and economic reasons, its contribution to energy security will remain very limited. Off-shore wind power potential has not yet been assessed. As mentioned above such assessments should be taken up immediately.

(iv) **Solar:** Solar energy, if it can be economically exploited constitutes a major energy resource for the country. Solar electricity generated through either the thermal route or using photovoltaic cells provides comparable amounts of electricity per unit of collector area. Both methods currently provide about 15% conversion efficiency. While it is clear that the ratio of capital cost to the efficiency of energy conversion needs to be brought down significantly, solar thermal and solar photovoltaic routes to electricity generation remain attractive alternatives to enhance India's energy security. Nano-technology holds the hope for making a major breakthrough in solar photovoltaic technology. It is stressed here that solar water heating is cost effective for India even today and can reduce India's demand for oil, gas and coal if pursued to meet the hot water demand in industry and households.

(v) **Energy Plantations:** Growing fuel wood for running power plants either directly or after gasification can save the coal or gas used for generating power. Since the country's energy needs are growing, imports of coal and LNG are also likely to grow. Fuel wood plantations can help improve energy security. The scope for such plantations is substantial. For example, if 10 million hectares of wasteland can be converted to fuel wood plantations with a sustained yield of 200 Mt of wood per year, it would obviate the need for some 200 Mt of domestic coal. Moreover since wood is a renewable fuel, no net carbon emission takes place. Thus all compensatory afforestation should be made in the form of energy plantations to improve India's energy security.

4.3.5 Increase Ability to Withstand Supply Shocks

17. Once imports are minimised and diversified, the shortage due to disruption of supply from any one country will be small and can be dealt with by maintaining a strategic reserve. A stock of oil can be kept either in storage tanks or in the form of ability to get higher output from existing wells at short notice.

18. If the supply disruption is total, such as might occur through a blockade in a situation of conflict, the size of the buffer stock needed would depend on the expected length of supply disruption. In today's world local wars are not likely to last beyond a few weeks often due to the interventions by the world community. Thus the size of the buffer stock need not be very large. Pachauri (2005)[5] argues as follows:

> "Strategic reserves of crude oil and petroleum products were first recognised as a policy tool in the aftermath of first oil shock in 1973. Major industrialised 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 draw down 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 Mt of crude oil at Rajkot (2.5), Mangalore (1.5) and Vishakhapatnam (1.0) are Rs.1225.2 crores with a mixture of

[5] Pachauri, R.K. (2005): *Addressing the Challenge of Energy Security.* A report prepared for the Asian Development Bank by The Energy and Resources Institute (TERI), New Delhi.

concrete tanks and rock caverns. The maintenance cost of these facilities is calculated as 29.3 crores. This excludes the cost of crude". (At $70/barrel 5 Mt of crude equivalent to about 14 days of net imports is estimated to cost Rs.11,545 crore)

"No extensive exercise has been done evaluating the benefits of Strategic Petroleum Reserve (SPR) for India. APEC (APEC, 2000) concluded "emergency oil stocks could be the most effective means for minimising 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".

"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".

19. These arguments suggest a strategic oil reserve of around 30 days at most. However, an oil reserve of 90 days is maintained by many countries, which they also use as a buffer stock against price fluctuations. We might use that as a thumb rule for our strategic plus buffer stock reserve. Such a reserve can also provide enough room to curtail domestic needs by switching over to alternate fuels, rationing to restrict some uses and promoting thrift thereby making it possible to manage a longer supply disruption. The effectiveness of such a reserve can be increased if it is a part of regional reserve or is cooperatively operated with reserves of other countries such as the IEA member countries.

4.3.6 Increase Ability to Import Energy and Face Market Risks

20. To guard against the market risk of a sudden price increase, we need to keep our energy import bill within a certain proportion of our foreign exchange earnings or maintain a stock of foreign exchange to address volatility.

21. Options contracts and the futures market can be used to reduce the risk of price volatility. If the energy market is competitive then managers can be expected to use these instruments to reduce their risk. Even then, for public sector management, special schemes may have to be designed to provide incentives to minimise import costs. However, options and futures may not be available over a long duration. Equity oil or gas holdings abroad may provide better security against sudden price increases.

22. A buffer stock can also help in reducing the impact of short-term volatility in prices. As pointed out above its effectiveness increases when it is worked cooperatively with reserves of other countries.

4.3.7 Increase Redundancy to Deal with Technical Risk

23. The obvious solution against technical risks is to provide redundancy. For example, electrical networks minimise probability of a loss of load by providing alternate routes. Similarly, power plants carry standby capacity or a spinning reserve to address the technical

risk of same station going off the grid or of a sudden increase in demand. Some redundancy must be built into the design of all energy installations to address such technical risks.

4.4 ENERGY SECURITY FOR THE POOR

24. Even when the country has adequate energy and even when there are no technical failures, the poor may not get clean energy. The issues and policies for providing energy security to the poor are discussed later in *Chapter VIII*.

4.5 POLICIES AND INITIATIVES FOR ENERGY SECURITY

25. India's energy security concerns have, thus far, been largely defined by a narrow focus on supply disruptions and the consequent need to increase redundancy in our stocks of crude oil and petroleum products through the creation of a strategic storage. In reality, India's energy security concerns go well beyond a narrow focus on a likely supply disruption in our crude oil imports. India's energy security, at its broadest level, has to do with the continuous availability of primary commercial energy at a competitive price to fuel our economic growth and to provide reliable access to modern forms of primary and secondary energy and energy services needed for lifeline support to over 50% of our population which lacks access to any form of commercial energy barring the unreliable and often costly supply of PDS kerosene primarily for lighting. Again, energy security requires that such access to lifeline energy be ensured even if it requires directed subsidies.

26. We have discussed how to reduce risk to our energy security by way of policies aimed at reducing our energy requirements and import dependence (through efficient production, transmission, distribution and use of energy, development of efficient energy markets, instituting well-targeted "lifeline" entitlements, and diversifying/expanding the domestic resource base using commercial or near-commercial technologies). India's ability to effectively manage such risks can only grow with her rising economic and political stature in the World economy. Yet, there are certain additional policies that can be instituted to enhance our energy security. These are:

- A legal claim to energy resources abroad can marginally enhance India's energy security to the extent that such a claim increases the diversity of supply sources. Equity oil and gas abroad are being currently pursued. The Planning Commission, recognising the looming coal import requirements, has been, emphasising equity coal for the past three years in order to further increase the diversity of supply of fuels. Nonetheless, these acquisitions should be primarily assessed as commercial investments. Thus, while the Government must aggressively support acquisition of energy assets overseas, companies active in this field must be forced to securitise the assets with international funding instead of the current practice of acquisitions based on 100% equity. The process of securitisation essentially creates an interest of other investors in the cash flow anticipated from the asset being acquired. This will not only provide independent oversight on the quality of such acquisitions but also strengthen our legal claim over these assets under extreme situations.
- Another mitigating policy could be to diversify imported fuels as well as the sources of such imports. Today, almost 100% of our energy import is in the form of crude oil with 67% being sourced from the Middle East. A strategy to import larger quantities of Gas, LNG, coal, ore emulsion, ethanol etc, as additional energy sources should be considered. Further, imports from other countries can be enhanced for strategic diversification of supply sources.
- Power plants at coastal locations should be set up with captive jetties to run on imported coal.
- If and when the gas pipeline from Iran

materialises, we may have a sudden increase in supply of natural gas of nearly 30 Mtoe a year. After meeting the feedstock requirement for fertiliser and chemical plants, the temptation will be to use this increased supply for power generation. Advance planning should be done to use this gas in more appropriate ways such as in distributed generation and CHP applications where we can get an efficiency of 80% or more.

- India currently has stocks equal to about 85 days of requirement excluding line-pack and the strategic stocks for the defence department that are maintained by Indian oil. However, these stocks are more in the nature of raw material and finished good inventories (for which facilities had been built during the comfortable cost plus regime) and not in the nature of strategic reserves. Internationally, a 90-day strategic reserve is considered adequate for providing security against short-term supply disruption and/or extreme price spikes. India could earmark part of the available storage capacity with oil companies as strategic reserve controlled by the Government. Japan follows this practice and requires its oil companies to carry and maintain a strategic reserve. Additional strategic storage may also be built to supplement such mandated strategic reserves. 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.

Energy Policy Options/Initiatives

India has to depend on a mix of different fuels to meet its energy requirement. The opportunities and economics for substitution vary with place, time and application. To ensure that options selected by individuals and firms lead to an efficient strategy for the country, appropriate policies need to be followed within an integrated framework and in the context of the emerging backdrop detailed below.

5.1 THE EMERGING BACKDROP

2. **Energy for Growth:** The discussion in *Chapters I through IV* provides the necessary backdrop to the Energy Policy Options/ Initiatives that India needs to pursue. India has committed herself to eradicating poverty and empowering its people with education and health. Given that the population is expected to reach 1.47 billion by 2031-32, and the fact that sizeable part of India's population, today, is living below the poverty line, rapid growth rates of around 8% per annum over the next 25 years are essential for attaining these goals. To fuel a sustained 8% annual growth, our energy scenario faces major challenges. Even a conservative projection of India's energy needs to fuel this level of economic growth requires that basic capacities in the energy sector and related physical infrastructure such as rail, ports, roads and water grow by factors of 3 to 7 times by 2031-32 alongside a 20-fold increase in nuclear and a 40-fold increase in renewable energy. If we cannot assure supply at even the conservatively projected levels of commercial energy (1.35 to 1.70 billion tonne oil equivalent by 2031-32 compared to the 2003-04 level of 327 Mtoe), we will not be able to grow at 8% per annum. This level of commercial energy consumption yields a growth in total energy consumption that ranges from 4.3% per annum to 5.1% per annum over the 2003-04 level of consumption. However, to supply the energy needed, it is essential that India, once again gives energy the same importance it was given in the first 30 years of its planned development. With the current emphasis on market driven growth, this implies that India must make a deliberate effort to create an enabling environment that attracts the required investments into energy and related infrastructure, and an environment that exploits the synergy of public private partnership.

3. **"Lifeline" Energy for All:** Access to safe, clean, convenient and reliable energy is vital for people's well-being. Clean cooking energy is essential for freeing women and girls from the burden of indoor air pollution and the drudgery of long hours spent in gathering fuel wood and dung. Clean cooking energy is thus also a tool for empowering girls and women to pursue education and enriched livelihoods. Again, a minimum amount of electricity is essential to remove darkness, extend working hours and raise productivity. However, even when safe, clean and convenient energy is available, the poor may not be able to pay for it at market prices. No progressive government can ignore its responsibility to provide a "lifeline" level of energy inputs in the form of electricity and clean cooking fuel. Such lifeline consumption is an essential part of energy security for India's people. Further, such lifeline consumption would need to be subsidised for some consumers till income levels rise to make such consumption affordable for all households. The good news is that such lifeline consumption does not require more than 75-80 billion kilowatt hours of electricity (BkWh) (about 12-13% of net electricity generation in 2004-05) and some 16-17 Mtoe of LPG (about 4.5 to 5.0% of the 2004-05 level of commercial energy consumption). Further, it can be said that currently not more than 75% of the lifeline consumption of electricity (60

BkWh) and some 85% of LPG (13 Mtoe) needs to be subsidised to varying degrees. These percentages will fall relative to our total consumption over time. However, in absolute amounts, these numbers are not likely to exceed these levels of magnitude as consistent growth at 8% should reduce poverty levels and raise capacity to pay to effectively negate the impact of population growth. What is essential, though, is efficient targeting which ensures that: (a) only lifeline level consumption is subsidised; and (b) the subsidy is enjoyed only by those who cannot afford to pay for such lifeline consumption at market prices. However, even with full electrification and targeted subsidies on commercial fuels for cooking, India's reliance on traditional non-commercial energy sources will rise in absolute terms to some 185 Mtoe in 2031-32 from the current level of about 150 Mtoe even as the share of total primary non-commercial energy consumption falls from about 30% to 10-12%. If we succeed in providing clean commercial fuels to households as proposed, this bio-mass would increasingly get diverted for industrial use and/ or power generation.

4. **Role of Different Fuels:** Given India's limited resources of oil, gas, Uranium and hydro-power, it needs to develop all economically viable sources of energy. The integrated analysis of various energy resources and supply options reveals that even under aggressive growth assumptions for hydro (5 times current levels) and nuclear (20 times current levels), the contributions from the two together cannot exceed 8-10% of commercial energy supply in 2031-32. However, both hydro and nuclear remain strategically important; hydro for providing much needed peaking support and storage capacity for water and nuclear to work towards India's energy independence in the long-run based on Thorium. Renewable energy, even when it rises to 40 times its current level will, at best, meet only about 5 to 6% of India's commercial energy demand by 2031-32. Despite this, renewables remain important from the point of view of increasing our domestic resource base. Fossil fuels maintain their domination in India just as in other parts of the world. The share of coal varies between 41% and 54% and that of oil and gas together between 32% and 41% of total energy. Abundant Thorium and solar resources might become important sources for India beyond 2050 provided we promote R&D now to be able to realise this potential in the future. Under the most optimistic scenarios for hydro, renewable and nuclear growth, and domestic supply levels for coal (3.8 times current levels), oil (3 times current levels) and gas (more than 5 times current levels), India's import dependence for commercial energy, in 2031-32, would range from a low of about 29% in the most energy efficient scenario to about 59% in the most energy intensive scenario. Realistically speaking, it is likely that India would need to import some 40-45% of its commercial energy requirement compared to the current level of under 30%. Domestic commercial energy supplies will then need to rise four times in aggregate over the next 25 years if import dependence for commercial energy is not to exceed 40%.

5. **India's Energy Intensity:** The energy intensity of India's growth has been falling and though it is currently about half what it used to be in the early seventies, there remains significant room to improve. Improvement in energy intensity creates a virtual source of energy by reducing the total energy needed to sustain a given level of growth. While differences in the structures of different economies may result in different energy intensities, available data clearly shows that energy intensity can be brought down significantly in India with commercial technologies that are currently available. The country must endeavour to do so at the earliest.

6. **India's Energy Demand in the Global Context:** Putting India's likely energy demand in 2031-32 in a global perspective, one sees that China's current energy consumption is 1100-1200 Mtoe and USA's current consumption is 2400-2500 Mtoe. In comparison, India consumed about 348 Mtoe of commercial energy in 2004-05. With a projected population of just under 1.47 billion in 2031-32, India's per capita energy consumption (based on the mid point of the range of scenarios developed in *Chapter III*) will be marginally above China's current per capita consumption or be about

one seventh of the current US per capita consumption. What this means is that India on per capita basis, currently consumes under 6% of what the US consumes and under 41% of what China consumes and will, by 2031-32, consume just under 15% of current US consumption levels and equal China's current per capita consumption. More importantly, India's per capita energy consumption that is less than 27% of 2003-04 level of global average energy consumption, shall in 2031-32 also remain just about 74% of the current global average. On simple considerations of equity alone, therefore, India cannot be denied this level of energy consumption by 2031-32.

7. On an incremental basis, assuming the world's fossil fuel supply grows at about 2%, India's incremental fossil fuel demand will account for 21% of the incremental world supply of fossil based commercial energy by 2031-32 in the most fossil fuel intensive scenario. In the least fossil fuel intensive scenario, India's incremental share of the incremental world supply of fossil fuel based commercial energy will be 13% by 2031-32. India's share of world supplies of fossil fuels in 2031-32 would rise from a level of 3.7% to a low of 7.6% in the most energy efficient scenario and 10.9% in the most energy intensive scenario. It is pointed out that it is this incremental demand from India when coupled with the much higher incremental demand from China that is cited as putting pressure on fuel prices and is raising apprehensions in the world community. The fact is that the incremental US demand for oil was twice that of India and China's was twice that of US over 2000 to 2004. The real issue is not the incremental demand from India but the dire need to curb consumption and realise life style changes in the developed world. If India is to be denied even the modest levels of energy consumption cited in *Paragraph 6* even in 2031-32 then we can forget about eradicating poverty or meeting the millennium development goals. Further, if the energy consumption levels in the developed world are not brought down significantly the climate change goals shall never be met irrespective of the growth in Indian demand. Finally, the 8% GDP growth trajectory is as important to reducing poverty in India as it is to enable India to absorb technologies and policies that lower its energy intensity.

8. **Growth in a Constrained Energy Market:** Irrespective of the final level of demand, India's growing demand for commercial energy supply has to be seen in the context of a tightening global energy market with rising prices and stagnant outputs. The world oil demand is expected to grow from the current level of 81-82 million barrels per day to 110 million barrels a day by 2020 at a growth rate of 1.8% per annum. Nearly 65% of crude oil is traded across borders. The world gas production is expected to rise from 2420 Mtoe to 3418 Mtoe by 2020 at a growth rate of 2.2% per annum. However, less than 25% of gas is traded across borders either through pipelines (natural gas) or to a lesser extent as LNG (30% of the total gas trade). The US production of oil peaked in 1970 and North American gas production is widely believed to have peaked in 2000. The world oil and gas production are expected to peak in the 2010-15 and 2015-2020 time frames respectively. The growth in the demand of primary energies, over time, has not lead in the past to an exhaustion of reserves because the right price signals lead to new, more competitive, sources of energy that take their place. Nevertheless, the uncertainties of energy markets, particularly in moving supplies to where they are needed, coupled with the long lead times of new investments in developing new and alternate reserves/sources of primary energy and adding corresponding refining/liquefaction/ transportation capacities reinforce the view that the supply-demand balance for oil and gas is likely to remain tight for the foreseeable future. Even if this is considered to be a pessimistic outlook, India should be prepared for it.

9. The common belief that current prices of oil are high is only true in nominal terms. If one looks at historical oil prices in constant 2005 dollars then the recent average of about $55-60 per barrel is comparable to the average price of US$53.50 that prevailed between 1974-1985. In fact, in comparable 2003 dollars oil prices were at an all time high of $80 a barrel in 1980 and were at $72 a barrel during the four year period 1979-1982. These facts are

behind the low impact that currently nominally high oil prices are having on global inflation and the predictions of higher prices to come.

10. It is thus of utmost importance that alternatives to oil which are based on domestic resources are pushed. Energy efficiency, energy conservation, development of substitutes and R&D to make them economically viable should get high priority. Some of the possibilities are identified in Section 3.4.

11. **Coal Remains India's Most Important Energy Source, Gas Share Remains Low:** Coal emerges as the most important energy source for India accounting for not less than 41% of our energy mix under any scenario and potentially reaching 54% of the energy mix under certain scenarios. Even at the 41% level, India will need 1.6 billion tonnes (about 4 times the current production). At the higher share requirement could rise to 2.5 billion tonnes (over 6 times the current production) of coal from domestic sources. The additional coal requirement from domestic sources will be even higher if the past trend of falling domestic coal quality is not arrested. India could also import 250 to 500 Mt of superior coal to reduce local coal requirement by 375 to 750 Mt per annum. It is pointed out, however, that currently only about 700-800 Mt of coal is internationally traded. Associated port and rail handling would have to rise in capacity to achieve any of the above scenarios. Gas under various scenarios is seen to account for only 5.5% to 11% of our energy mix in 2031-32. Achieving a gas share in the 10-11% range in India's energy mix presumes successful development of the Krishna-Godawari (KG) basin potential, exploitation of coal bed methane and success with trans-national gas pipelines and LNG imports. Clearly India's policy framework must recognise the pre-eminence of coal and the importance of getting the required technology to maximally exploit the large in-place reserves of coal.

12. **Development of New Sources:** Depending upon the level of increase in domestic coal production to meet growing demand, India's currently known reserves of extractable coal will not last beyond 45 years. Thus, we have to stretch out our energy resources as much as we can by promoting energy efficiency and conservation. To augment our energy resources, we should also promote the development of new sources of energy.

13. **Energy Coordination Committee:** The above backdrop and the discussions in the previous four chapters establish: (i) the inescapable dependence of growth across all sectors of the economy (including social sectors) on the assured availability of energy supplies at competitive prices; (ii) the existence of cross cutting issues impacting various sub-sectors of energy and the related infrastructure for its production and delivery; (iii) the massive investment needs of the sector for increasing domestic supply and ensuring energy security for all; (iv) the need to raise technology levels and mounting specific R&D efforts under mission mode; and (v) instituting targeted subsidies for lifeline energy needs. These features and the need for rational pricing & taxation to promote inter-fuel substitutions, cost reduction and efficiency gains etc. underline the need for an integrated energy policy. They also provide the basis for the Integrated Energy Policy Committee to support the Planning Commission's 10th Plan proposal for ***"Creation of an Apex Body on Energy under the chairmanship of the Prime Minister".*** Such a body at the highest level of government is essential for operationalising the kind of policy decisions enumerated below. An "Energy Coordination Committee", under the Chairmanship of the Prime Minister, has already been created to review and approve policies for the energy sector as a whole.

5.2 POLICIES COVERING ENERGY MARKETS, REGULATION, PRICING, TAXATION, SUBSIDIES, EXTERNALITIES AND INSTITUTIONS

14. **Meeting Growing Energy Needs in a Cost-Effective Way:** To meet growing energy needs in an efficient, cost-effective way requires a policy framework that realises efficiency in production, transmission, distribution and consumption of all available types of energy, and that provides incentives to supply required

energy. *Promoting transparent and competitive markets for all forms of energy supplies/services is the first policy initiative that the government must take as part of its integrated energy policy. Such competitive markets provide the best means to extract efficiency gains from the sector.*

15. Having said this, it is also recognised that in some sectors within the energy sector (especially power) truly competitive markets may be difficult and costly to realise. Efficient, strong and independent regulation can, however, address this concern effectively. Transparent and competitive markets that offer a level playing field to all participants, and are independently regulated, are essential to the creation of an enabling environment for domestic and foreign investment flows from public and private sources to the energy sector. Energy efficiency in extraction, conversion, transmission, distribution and consumption requires that all players and all energy projects, public or private, mega projects or micro projects, domestic or foreign, are treated equally under a consistent policy framework. Moreover, appropriate pricing of various energy sources and services is needed to realise efficient choice across fuels. The policies to achieve competitive and transparent markets must recognise the dominance of large public sector units in most energy sub-sectors. Many of these PSUs are financially strong but their strength has been acquired in a protected public sector environment. The presence and strength of dominant and efficient public sector units can be an asset in the transition to a competitive set-up as they, through their participation could provide a starting benchmark that the markets must better. Some key specific initiatives needed to support such an overall policy commitment across the energy sector, and for each of the energy sub-sectors, are described below.

16. **Independent Regulation:** Independent regulation is critical to attaining competitive efficiency in the energy sector since the sector is characterised by large economies of scale and has natural monopoly characteristics in sub-sectors such as transportation and distribution networks. It is important that all sub-sectors of the energy sector are regulated and done so in a consistent manner. Today, only the power sector has a regulatory framework. A Regulator for the petroleum sector is being established. A Regulator for coal is also needed. The regulatory framework must ensure the following:

- To provide genuinely independent regulation across each sub-sector of the energy value chain, the regulatory responsibility/functions of the State must be separated from the Ministries that control the PSUs that dominate the energy sector and are the principal owners of over 75% of India's energy assets and related infrastructure.
- Since domain knowledge is important, a common Regulator is not recommended for all energy sub-sectors. However, to provide cohesion and consistency of regulation across all energy sub-sectors, the Regulators should meet regularly and arrive at the common principles that emerge from this Integrated Policy.
- There should be a common appellate tribunal for all the energy sub-sectors.
- The functioning of regulatory institutions must be improved by:
  - Creating an autonomous Regulatory Academy
  - Institutionalising the selection of Regulators and their impact assessment under the Regulatory Academy
  - Mandating training for all Regulators
  - Granting financial autonomy to regulatory institutions
  - Limiting the quasi-judicial role of Regulators to tariff setting and dispute resolution
  - Providing a system that makes Regulators accountable to Parliament
  - Mandating annual reports from all Regulators that detail progress under and compliance with the various provisions of the Act they are regulating
- In order to give independent regulation a fair chance of success, the government

should create the enabling policy environment for competitive and transparent markets by eliminating barriers to entry and removing pro-public sector biases.

- It should also be recognised that regulation and competitive markets are not substitutes for one another. Similarly ownership is no guarantee for efficiency and replacing a public monopoly by a private one is unlikely to yield efficiency gains. Privatisation of dominant public sector enterprises in the energy sector is likely to be effective only if a well-regulated and a competitive market exists/results.

17. **Relative Prices for Efficiency:** Relative prices play the most important role in choice of fuel and energy form. They are thus the most vital aspect of an Integrated Energy Policy that promotes efficient fuel choices and facilitates fuel substitution towards specific objectives. In a competitive set-up, if the marginal use value of different fuels which are substitutes for one another are equal at a given place and time, and if the prices of different fuels at different places do not differ by more than the cost of transporting the fuels, then the resulting inter-fuel choices will be efficient. Prices of different fuels cannot be set independently of each other. However, this is the current practice and the domestic energy prices are not only uncompetitive but suffer from a number of distortions as detailed in *Paragraph 19* below.

18. In perfect markets the relative prices of different energy supplies and services yield the most optimal fuel mixes, investment flows and economic outcomes. At the margin, competing energy sources providing the same end service are priced identically per unit of such service delivered. However, such perfect energy markets do not exist in most countries. Supply/resource constraints, priority of domestic energy resources over imported energy resources, lack of substitutability, externalities such as ease of use, differences in achievable levels of efficiency, differences in specific investment levels per unit of energy, differences in environmental impact etc. – all combine to thwart rational markets for energy. Add to this mix policies that look upon energy supplies/services selectively and differently for purposes such as raising fiscal resources and providing subsidies; – or politically different perceptions of what constitutes a long-term "social good" and what is best for the "national interest" and what one gets is a recipe for ad-hoc policies that are, more often than not, inconsistent. To obtain competitive efficiency in this environment requires continuous engagement by policy makers at the senior-most administrative and political levels and a set of dedicated and fiercely independent Regulators to achieve near optimal market behaviour.

19. **The Distortions in Pricing Energy in India:** As pointed out earlier, based on purchasing power parity comparisons, the Indian consumer pays one of the highest tariffs in the world[6], for energy supplies/services. At present in most energy sub-sectors there is virtually no competition. Despite the dismantling of the Administered Price Mechanism in the petroleum sector and price controls in the coal sector, Government controls hydrocarbon pricing. The current policy is to price petroleum products at international parity without any competition among incumbents. However, this policy is not being followed. Further, prices are loaded with taxes and levies that are not uniform and lack consistent policy drivers. Access to petroleum products including subsidised kerosene meant for the Public Distribution System is limited. There is a need to examine: (a) why the so called import parity price is used for oil products wherein India is a net exporter; (b) why trade parity prices are not used; (c) what is the basis on which import parity is calculated; (d) the practice of burdening oil marketing with kerosene and LPG subsidies

[6] Based on country reports we have calculated that in 2002 the average purchasing power parity price in US cents per kWh was 30.8 in India, 7.7 in US, 9.5 in Germany, 15.3 in Japan, 20.6 in China and 27.6 in Brazil.

and the leakages in these subsidised products; and (e) the practice of making upstream companies share the subsidy burden of oil marketing companies. Serious entry barriers remain for new entrants to import products and market the same freely. Natural gas supplies are well below current demand levels and multiple prices prevail in the market. Coal has been deregulated under a monopoly supplier, even though the import and transportation infrastructure for moving coal remains both deficient and largely in the hand of Government monopolies. Again there are serious entry barriers for new entrants wishing to mine coal. Supplies of coal barely match demand. Power, a secondary form of commercial energy, is grossly overpriced (for the paying industrial, commercial and large domestic consumers) since over 40% of the energy through put is either not paid for or bills for it are not collected by the State utilities. Uranium fuel used in India's nuclear plants costs at least three times the prevailing international prices due to very poor deposits. Wind power in India delivers only about 17% capacity factor on average, India's hydro sector has been plagued with significant delays and cost over-runs, and the Himalayan geology makes siltation a major issue in hydro development and the realisation of our full hydro potential thereby affecting costs of hydro-power. Non-commercial energy is considered to be practically free since opportunity costs of labour spent in collecting firewood or cow dung and preparing the same are rarely factored in. Taxes on petroleum products are a key source of government revenue but not uniform across products and, finally, differential state taxes and custom duties on crude and petroleum products introduce further distortions in energy pricing in India.

20. While keeping energy prices high has helped limit demand, it has definitely made Indian industry, agriculture and commerce less competitive and has constrained consumption, both of which subdue economic growth. High energy prices are akin to a tax burden on the consumer and the economy. Given India's energy supply constraints and its energy security concerns, national priorities will require that all available energy resources be optimally exploited. Rational pricing of energy supplies and services must ensure that: (i) distortions are removed across all energy and energy service sub-sectors; (ii) appropriate priority is given to the development of local energy resources and related infrastructure; (iii) energy conservation and energy efficiency are encouraged; (iv) India's competitiveness is raised; and (v) economic growth is spurred. Key policy principles and initiatives in pricing energy supplies and services that cut across all energy sub-sectors of India are enumerated below.

- As a general rule, all commercial primary energy sources must be priced at trade parity prices at the point of sale. This should be particularly so for the oil sector where imported crude provides over 70 percent of domestic consumption of petroleum products. Even when the global oil market dominated by Organisation of the Petroleum Exporting Countries (OPEC) is not a competitive market, the trade parity prices reflect India's opportunity costs. However, the domestic economy may have to be protected against short-term volatility in the International market caused by speculators and manipulators. The government can do this by adjusting taxes and duties in a revenue neutral way. An alternative could be to allow price adjustments based on lagging 1-3 month average prices, thereby forcing oil companies to use short-term hedging. Another alternative would be to use long-term supply contracts linked to a variety of more stable energy price indices. Of course any persistent price change that cannot be absorbed by change in taxes and duties, should be passed on to the domestic consumers. Several arguments are made to maintain the status quo of import parity pricing in the oil sector. However, the only legitimate alternative to trade parity prices is full price competition at refinery gate and retail levels in a competitive environment with low entry barriers and multiple players. Once full price competition is permitted on the inputs as well as the outputs at all levels and the Government stops interfering in price setting, trade parity prices will prevail and the need for building up costs on a normative basis with possibilities of padding up, as is currently being done, will be obviated and efficiency gains will emerge in procurement and marketing. Prices of petroleum products will also vary across the country reflecting actual costs and relative regional strengths of the oil companies.

- While the above idea works for traded goods, non-traded goods have to be handled differently. Prices of non-traded commercial energy supplies can be determined through competition among different producers (this presumes multiple sources, low entry barriers, and a competitive supply-demand balance) or independently regulated on a cost plus basis including reasonable returns (where competing supply sources are absent, entry barriers are high and demand exceeds available supply). The cost plus regulation must take into account any realisation that is achieved out of by-products priced and sold on competitive terms. To illustrate this point, the cost plus regime pricing natural gas in India does not take the full credit for by-products as it continues to price the C_2/C_3 components of natural gas well below their traded or competitive prices.
- To trade natural gas either through trans-national pipelines or as liquefied natural gas (LNG) requires a large investment in pipelines or gasification/regasification facilities (in small quantities natural gas is nearly non-tradable). If sufficient gas is available such investments may be worthwhile but carry risks related to long-term price for LNG. In a competitive set up, the producers of associated and non-associated natural gas have the option of liquefying the gas and transforming it into a tradable commodity or, alternatively, piping it to an export market. Either option adds cost (inclusive of return on capital employed) to transform the non-tradable natural gas to a tradable commodity based on investments. The net-back-realisation by the gas producer would thus be the price of gas at the landfall point which makes it possible for the gas producer to incur the extra cost of making it tradable and yet compete effectively in the end market with other suppliers of natural gas, LNG or alternate energy forms. This net-back-price should then become the minimum price for the domestic user of such natural gas. At this net-back-price the gas supplier has the choice of selling gas domestically or taking the investment risk and exporting the same through a pipeline or by conversion to LNG.
- Given limited production of natural gas in India, economic considerations may well require that domestically available gas be made available first to those end-uses that best extract its economic value among competing end-uses. Such end-uses in India could, for example, be fertiliser, petrochemicals CNG vehicles and power in that order. All of these end-users could compete for the natural gas available from domestic sources with a floor price that would be equivalent to the net-back-price that the producer could have obtained as described above. Under such a scenario natural gas would first meet the fertiliser, CNG & petrochemical demand in full before reaching the power sector. In reality this situation is complicated by the fertiliser subsidy regime and the power pricing regime both of which allow pass through of feedstock/fuel costs. Again gas use may be considered economically more justified for peaking power that must be priced differently but it is not. There is also a Supreme Court order that requires preferential allocation of gas for CNG vehicles.

Unless these ground realities change gas may need to be allocated under a cost plus regulation.

- However, with limited availability of natural gas, domestic prices in a competitive set up would reach the price of imported regasified LNG price or even exceed it if LNG import facilities do not exist. Since some of the priority uses of gas have externalities (e.g. the lower air pollution due to CNG buses) in a situation of limited domestic availability, such a user would be willing to pay a CNG premium over diesel, the alternate fuel. To avoid such distortions, till such time that a better demand-supply balance emerges, some allocation of gas to specific uses along with restraints on the price of natural gas may be needed. Once adequate natural gas is available either through LNG or piped gas imports or domestic natural gas, the marginal use in India would likely be power generation where natural gas will have to compete with domestic or imported coal. Of course, a gas-based power plant can be a peaking plant in which case it will have to compete against alternative sources of peaking power. The market determined price of natural gas would be one at which power generated using natural gas would have the same cost as power generated through the cheapest alternative which would most likely be a coal-based plant. New domestic gas developments and the Joint Venture fields developed under New Exploration Licensing Policy (NELP) rounds would need to take the foregoing pricing policies into account.
- How should one allocate natural gas in a shortage? If there were no other distortions, a competitive market would be the ideal mechanism. However, given that a certain degree of self-sufficiency is considered desirable for domestic fertiliser production, allocation of natural gas to fertiliser plants on a priority basis may be required to ensure adequate domestic production. Also, as long as fertiliser producers have feedstock cost as a pass through gas price determined through competition would be distorted. The case for allocating compressed natural gas to the transport sector is also strong as long as the Supreme Court's mandate continues to require the use of CNG by buses, taxis and auto-rickshaws. In the long-run, however, air pollution should be controlled by stipulating emission standards and not by mandating a particular fuel, since air pollution can also be controlled by use of clean diesel. There would then be no need to allocate gas for transport sector.
- It must be recognised that the bulk of Indian coal cannot be easily traded. The Power Sector consumes about 80% of the domestic coal production. With an ash content of over 40% and a calorific value averaging only 3500 kcal/kg., most of the coal sold to the power sector would have to be "prepared" to be made tradable. This would entail both cost and additional investment. In international trade, shipping and handling of coal typically accounts for 30-35% of the cost of coal with an average calorific value of about 6000 kcal/kg. In India transport and handling costs can reach 200% to 300% of the pit head price of coal when moved to Tamil Nadu, Karnataka, Maharashtra, Goa, Gujarat, Rajasthan, Delhi, Haryana, Punjab and parts of UP. This reinforces the need for washing and preparation of coal by the coal supplier since high grade energy used for traction is used to transport a low grade fuel and useless ash. Further, it brings into focus the need to gradually decrease cross subsidies in railways since the rail freight for coal and other commodities is higher than what can be economically justified. Eliminating cross subsidy surcharges on the movement of primary energy sources and other bulk freight items will not only make energy prices more

competitive but will also shift freight traffic from the far less energy efficient road sector to the railways. Offering open access to rail lines for private movers may be another way to make rail movements more efficient. As a result of high freight rates imported coal is competitive at coastal locations all along India's Western Coast and parts of Tamil Nadu.

- The price of coal should vary with quality and its calorific content. Cost of production varies with the scale and technique of production as well as with geological conditions. A central planner is highly unlikely to have the needed information to set prices in a rational manner. Only a competitive free market can do an efficient job of price determination. A competitive market requires that there is also competition on the supply side, i.e. that there are many producers and no entry barriers to new producers. Entry of new players in coal mining should be facilitated, trading of coal should be made completely free and coal prices should be left to the market once competing suppliers come into the market.
- Would this make coal expensive? As long as there is also competition on the supply side, coal prices will remain near the cost of production, including a reasonable return on investment. New entrants would whittle away any excess profits. Even when domestic producers take time to augment production, competition from imports will keep the price in check. At the ports domestic coal has to compete with imported coal and the delivered price of coal calorie cannot exceed the landed cost of imported coal calorie. This also puts a natural constraint on coal prices at mine mouths since they have to be below the landed cost of imports minus the transportation cost from mine to port. If coal is exported, the mine mouth price cannot exceed FOB price minus the transport cost.
- Given current ground realities coal prices cannot be determined in a competitive market open to all users as long as there is a single dominant supplier and the largest coal consuming sector, i.e. power, operates on a cost-plus regime making it indifferent to coal prices. Under the prevailing conditions, a strategy for competitive price discovery is possible as follows:

(i) High quality coking and non-coking coal which is exportable may be sold at trade parity prices as determined by the import parity price at the nearest port minus 15%. This practise is currently being adopted for supply of good quality coking coal to the steel industry.

(ii) Twenty percent of the production may be sold through e-auctions. Quantities to be sold through e-auctions from different mines must be determined annually with an independently monitored monthly mine-wise schedule that is enforced by an independent coal Regulator.

(iii) The remaining coal should be sold under long-term Fuel Supply and Transport Agreements (FSTAs). Regulated utilities should be allowed upto 100% of their certified requirements through FSTAs. Other bulk consumers may have to be given partial FSTAs based on coal availability. Any shortfalls should be met through e-auction supplies or imports.

(iv) The pithead price of coal under FSTAs will have to be revised annually by a coal regulator on a basis that *inter-alia* takes into account prices obtained through e-auctions, the FOB price of imported coal (both adjusted for quality) and the production cost inclusive of return based on efficiency standards.

(v) Coal prices should be made fully variable based on Gross Calorific Value (GCV) and other quality parameters.

- A competitive coal market is important for setting a proper price of natural gas. This is so because in a market that does not have any constraints in gas supply, the marginal use of gas will be power generation which places it in competition with coal.
- Entry barriers for new mining companies must be dismantled, and time taken for awarding blocks, granting clearances and opening mines reduced significantly. India also needs to invest in port facilities and create coast based power generation capacities based on imported coal. These steps would facilitate trade and benefit from the discipline of competition that trade provides. Improved port capacities and coastal power plants with dedicated jetties will not only yield competitive efficiency through imports but can also facilitate movement of domestic coal through coastal shipping, thereby providing a competitive alternative to the stretched bulk freight capacity of railways.
- All secondary energy resources should be priced based on competitive procurements by the service provider. Regulators must facilitate multiple suppliers for all secondary energy resources and energy services. Where the service is provided by a natural monopoly such as a pipeline or a distribution network, rents must be independently regulated and, where possible, competitively procured under normative and regulated caps. All such natural monopolies must be pure common carriers and service providers with no interest in the content.

21. A competitive price regime can be established in the power sector once tariff based bidding becomes the norm during the 11th Plan period. Similarly, prices of petroleum products at the refinery gate can be freed and competitively set. However, coal and gas prices cannot be left to the market till a number of coal suppliers emerge, gas availability improves, or till fertiliser prices are deregulated. Thus, Regulators are necessary for these sectors to set prices that will mimic markets as outlined above.

22. **Consistency of Taxes Across Fuels:** Currently Central & State taxes on various forms of primary and secondary energy are a significant part of the final price. More importantly, these taxes are not applied consistently, thereby resulting in significant price distortions. Taxes are essential to raising revenues but the following policies are essential to ensure that they minimally affect energy choices:

- Central and State taxes on commercial energy supplies need to be rationalised so as to become neutral to fuel choices and investment decisions. Relative prices of fuels can be distorted if taxes and subsidies are not equivalent across fuels. In other words, taxes and subsidies should be such that producer and consumer choices as to which fuel and which technology to use are not affected by them.
- The equivalence of taxes across competing fuels should be uniform with respect to energy service delivered duly adjusted for prevailing overall energy efficiency levels and any other specific externality relevant to specific fuels. This would result in the least distortion as it would take into account effective calories and the conversion efficiencies of alternate fuels.
- Making the energy sector fully "Vatable" or rationalising taxes and eliminating differential taxation by State Governments can reduce distortions.
- Eliminating custom duty differentials on crude and petroleum products, differential levies on alternate fuels, removing or applying a uniform low custom duty on all imports for energy sector projects/investments/supplies are other measures critical to rationalising taxes in order to minimise distortions in energy markets. This can be done in a revenue neutral way.

- Removal of misplaced incentives such as those available to Mega Power Projects is needed. While the rest of the world is recognising the higher efficiency of distributed generating facilities, India is providing incentives to Mega Projects. Consequently, State Governments opt for Mega projects that claim the incentives and then swap power among themselves to meet the guidelines of the Mega power policy thereby creating unnecessary transmission capacity and movement of power back and forth. There should be no discrimination in available incentives based on size or type of technology or fuel used.
- In fact, incentives should be similar for each of the energy sub-sectors so that balanced development takes place. Any tax concession or duty exemption provided should be available to all energy sub-sectors unless it supports a well-documented economic benefit.

23. **Dealing with Externalities:** While taxes to raise revenues should be levied in a way that least affect fuel/energy choices, environmental taxes and subsidies can be used to actually affect fuel/energy choices. Some options available to deal with environmental externalities could be:

- A consistent application of the "polluter pays" principle or "consumer pays" principle should be made to attain environmental objectives at least-cost where prescribed environmental norms are either not applied consistently or not being adhered to. Methodologies need to be developed to do this consistently.
- Using incentives, cross subsidies, tax breaks for public investments to maximise the more energy efficient rail freight, electrification of railways, building double decked freight trains, improved mass transportation options, R&D for efficient engines or fuel alternatives etc., could also help mitigate environmental concerns.
- Certain conservation objectives may be better served through appropriate regulations such as minimum vehicle occupancy ratios, minimum fuel efficiency norms, or even allowing odd and even numbered vehicles on road on alternate days etc.
- Taxes and subsidies to create differential pricing and achieve the above objectives run the risk of creating perverse incentives. As an example, lower taxation of diesel to boost public transport has several negative outcomes such as adulteration, less emphasis on efficiency in road transport carriage, agricultural and off-road applications, a negative environmental impact and the spawning of diesel passenger vehicles enhancing all of the foregoing negatives. Thus care should be exercised in using taxes and subsidies.

24. Environment is not the only externality that can be managed through differential tax rates. Differences in taxes may be justified based on documented benefits from exploitation of domestic resources, maintaining international competitiveness, creation of employment or similar objectives.

25. **Subsidies for the Weaker Sections:** Subsidies designed to benefit weaker sections of the society remain poorly targeted and result in serious price distortions and malpractices. Most of the LPG subsidy is actually benefiting the rich and the upper middle classes. A large part of the PDS kerosene is used for adulterating diesel and burned in standby generating sets. Agriculture and household subsidies on electricity provide the basis for theft of power by industrial and commercial consumers. The following policy options exist to address this concern:

- Moving the prevailing subsidies and cross subsidies in the energy sector designed for the weaker sections of the economy to the Central and State Budgets will go a long way in removing price distortions, providing optimal price signals and eliminating malpractices.

- Subsidies that cannot be targeted in a fool-proof manner should be made available as minimal entitlements to everyone. Consumption in excess of the minimum should be charged at full cost of supply. Further, entitlements should be made tradable if not consumed by requiring the service provider to cash the entitlement at the full marginal cost of supplying the underlying energy resource or service.
- Another way to provide subsidies efficiently is to make service providers bid for making the entitlements available to the beneficiaries at least-cost to the State.

26. **Institutional Reforms for Competitive Efficiency:** Neither appropriate pricing nor independent regulation by themselves, can lead to competitive efficiency if dominance by one or two large public or private sector units continues and if the public sector remains handicapped by lack of authority to take commercial decisions. Ease of entry for other players from both public and private sectors and competition from the world market will create incentives to be efficient.

27. **Public Sector Autonomy to Ensure a Commercial Culture:** All public sector companies must be managed by independent boards with no more than two government nominated Directors including just one from the incumbent Ministry. All other Directors should be nominated independently with necessary sitting fees and consequent responsibilities under the Companies Act. No Director should have a direct or indirect beneficial interest in the company exceeding a prescribed monetary equivalent of say Rs.2 lakhs, in any financial year.

28. **The Dismantling of Entry Barriers:** Entry of other firms from within the central, state or private sectors into all sub-sectors of energy should be facilitated. Thus, open access to distribution networks, the removal of restrictions on captive coal mines, allocations for coal, oil and gas blocks in competitive and transparent ways and creating a level playing field for all players must be undertaken to generate competition.

29. **Developing Long-Term Debt Markets:** The Central and State Governments as well as term lending institutions must seed the market for long-term (20 years plus) debt. This should be available to finance all infrastructure, particularly energy infrastructure. Options could include one or more of the following:

(a) capital market based instruments;

(b) debt structures with 20 year repayment schedules including bullets at the end of years 10-12 along with undertakings for take-out financing of the bullets as they fall due;

(c) guarantees for later maturities;

(d) twenty year repayment terms with built-in refinancing every 5 years;

(e) partial risk guarantees and other similar structures that effectively provide 20 year plus funding for the energy sector.

Policy for Energy Efficiency and Demand Side Management

6.1 LARGE POTENTIAL FOR SAVING ENERGY

The importance of energy efficiency and demand side management (DSM) has clearly emerged from the various supply scenarios and is further underlined by rising energy prices. Efficiency can be increased in energy extraction, conversion, transportation, as well as in consumption. Further, the same level of service can be provided by alternate means that require less energy. The major areas where efficiency in energy use can make a substantial impact are mining, electricity generation, electricity transmission, electricity distribution, pumping water, industrial production and processes, transport equipment, mass transport, building design, construction, heating ventilation and air conditioning, lighting and household appliances. It may be noted that a unit of energy saved by a user is greater than a unit produced as it saves on production, transport, transmission and distribution losses. Thus a "Negawatt" (a negative Megawatt) produced by reducing energy need saves more than a Megawatt generated.

2. In the 1990s, several studies have estimated the potential and cost effectiveness of energy efficiency and demand side management (DSM) in India[7]. Despite these potential studies, actual implementation has been sluggish. The 8th Five Year Plan made a provision of Rs.1,000 crores for energy efficiency to provide targeted energy savings of 5,000 MW and 6 Mt in the electricity and petroleum sectors respectively. There is no clear quantification of the actual costs and savings achieved. The 9th Five Year Plan proposed the passing of the Energy Conservation Act and the setting up of the Bureau of Energy Efficiency.

3. The 10th Five Year Plan proposes benchmarking of the hydrocarbon sector against the rest in the world. It also suggests demand side management specifically in the transport sector. The target for energy savings in the 10th Plan is 95,000 Million Units which is about 13% of the estimated demand of 7,19,000 Million Units in the terminal year of the 10th Plan. However, there is no specific allocation to meet the energy savings targets.

4. A study prepared for the Asian Development Bank (ADB, 2003) estimated an immediate market potential for energy saving of 54,500 million units and peak saving of 9,240 MW. Though there is some uncertainty in any aggregate estimates, it is clear that cost-effective saving potential is at least 15% of total generation through DSM. Additional savings are possible on the supply side through reduction in auxiliary consumption at

[7] Nadel, S., V. Kothari, and S. Gopinath (1991): *Opportunities for Improving End-Use Electricity Efficiency in India*, American Council for an Energy-Efficient Economy, Washington, DC.
Banerjee R., Parikh J.K. (1993): *Demand Side Management in Power Planning – An exercise for H.T. Industries in Maharashtra*, Economic and Political Weekly, August, 7-14, pp. 1659-70.
Parikh J.K., Reddy B.S., Banerjee R. (1994): *Planning for Demand Side Management in Electricity Sector*, Tata Mc-Graw Hill Company Ltd., New Delhi.
Parikh J.K., Reddy B.S., Banerjee R. & Koundinya S. (1996): *DSM Survey in India: Awareness, Barriers and Implementability*, Energy, Vol. 21, No. 10, pp. 955-966.

generating plants and lowering technical losses in transmission and distribution. At present an estimate of the total volume of the energy efficiency consulting business (audit, performance contracting, engineering, technical assistance and consultancy) is less than 1% of its potential (DSCL, 2004)[8].

5. Since Energy Efficiency (EE)/DSM schemes are often cost effective, is it necessary to have policy interventions? In actual practice there are several barriers that constrain the adoption of EE/DSM schemes including high transaction costs, lack of incentives to utilities who perceive DSM as a loss of market base,

BOX 6.1

Bureau of Energy Efficiency (BEE)

BEE was established under the Energy Conservation Act, 2001 with effect from 1st March, 2002 to meet the following objectives:

- To exert leadership and provide policy framework and direction to national energy conservation and efficiency efforts and programmes.
- To coordinate energy efficiency and conservation policies and programmes and take it to the stakeholders
- To establish systems and procedures to measure, monitor and verify energy efficiency results in individual sectors as well as at a macro level.
- To leverage multi-lateral and bi-lateral and private sector support in implementation of Energy Conservation Act and efficient use of energy and its conservation programmes.
- To demonstrate delivery of energy efficiency services as mandated in the EC Act through private-public partnerships.
- To interpret, plan and manage energy conservation programmes as envisaged in the Energy Conservation Act.

Actions taken by BEE so far are given below:

- BEE has conducted National Certificate Examinations for selection of Energy Managers and Energy Auditors.
- Energy auditing agencies for accreditation on the basis of their energy auditing capabilities and institutional set-up have been cleared by BEE.
- Draft norms for fixation of specific energy consumption in Cement and Pulp & Paper Industries have been framed and these norms are under discussion prior to finalisation.
- Task forces in 7 Energy Intensive Sectors have been set-up and best practices on energy conservation are being discussed by these task forces.
- Industries are being motivated to take up energy efficiency measures through institution of National Energy Conservation Award Scheme of Ministry of Power.
- Energy Audits for 9 Govt. buildings have been completed that include Rashtrapati Bhawan, Prime Minister's office, South Block (Defence Ministry), Rail Bhawan, Sanchar Bhawan, Shram Shakti Bhawan, Transport Bhawan, R&R Hospital, Delhi Airport and All India Institute of Medical Sciences (AIIMS) and implementation plans have been prepared.
- Energy Conservation Building Code has been prepared and is under review by the stakeholders.

[8] DSCL (2004): *Catalysing Markets Through Innovative Financing and Competitive Procurement for Energy Efficiency*, G.C. Datta Roy Presentation available at www.bee-india.nic.in

inadequate awareness, lack of access to capital, perceived uncertainty concerning savings, a high private discount rate, limited testing infrastructure with which to ascertain savings and an absence of a reliable measurement and verification regime. Policy interventions are required to address these barriers.

6. To conserve petroleum products, the Petroleum Conservation Research Association (PCRA) was set-up by Ministry of Petroleum and Natural Gas (MOPNG) in 1978. The Bureau of Energy Efficiency (BEE) was established under the Energy Conservation Act, 2001, with effect from 1st March, 2002, under the Ministry of Power (MOP). The mission of BEE is to develop policies and strategies on self-regulation and initiate market interventions aimed at reducing the energy intensity of the Indian economy. While BEE has made a beginning (*see BOX 6.1*), a lot more needs to be done. BEE does not have a fulltime head and, as of September 2005, had only 4 professionals on staff.

7. Since nearly one third of total energy is used for domestic cooking, efficiency of the cooking process should be given a high priority, particularly since this process is currently marked by poor level of efficiency.

8. To promote energy efficiency and conservation we need to create an appropriate set of incentives through pricing and other policy measures. Barriers to the adoption of efficient technologies have to be removed and encouragement to develop and deploy more efficient technologies has to be provided. Public policy can set the pace for such development by offering attractive rewards and imposing biting penalties.

9. An enabling institutional framework is essential to achieve the objectives listed above. Details of such an institutional framework are listed below:

- The BEE should be made an autonomous statutory body under the Energy Conservation Act and be independent of all the energy ministries. It should be funded by the Central Government. A cess on fuels and electricity (adjusted for the cess on fuels used for generating electricity) can be justified as a user charge. BEE staffing should be substantially strengthened.
- Existing national energy efficiency organisations like the Petroleum Conservation Research Association (PCRA) should be merged with the BEE. This will ensure that the BEE is responsible for energy efficiency for all sectors and all end-uses.
- Based on the recommendations of the merged autonomous body the government could directly provide funding support to financial institutions for promoting energy efficiency programmes.
- Energy efficiency and conservation programmes and standards should be established and enforced. The BEE should develop such standards for all energy intensive industries and appliances as well as develop modalities for a system of incentives/penalties for compliance/non-compliance. These standards should be at levels equal to or near current international norms.
- Mechanisms for independent monitoring and verification of achieved energy savings and the cost effectiveness of programmes must be established. Evaluation reports should be quantitative and made publicly available. An annual report of the investments and savings made through specific energy efficiency and DSM programmes should be prepared by the BEE and reported to the Parliament. The feedback from the monitoring exercises should help in modifying programme designs.
- Truthful labelling must be enforced with major financial repercussions if equipment fails to deliver stated efficiencies. In extreme cases, one can resort to black listing errant suppliers at consumer information web sites and on government procurement rosters.

- Verification and labelling requires testing laboratories. A programme for setting up such laboratories in public, private and the NGO sectors is needed.
- National Building Codes should be revised to facilitate and encourage energy efficient buildings.
- Large scope exists to make buildings energy efficient. Construction materials are energy intensive and the use of appropriate materials and design can save a significant amount of energy not only in construction but also during use by building occupants. Innovative and energy efficient building technologies should be widely publicised through an annual prize. Reducing energy needs for heating and cooling by orientation, insulation and using temperature differences in earth or water at some depth could also be significant.
- Improvement in energy efficiency and DSM require actions by a large number of persons and institutions. To mobilise them, the first task is to create awareness of the scope of possibilities and the extent of gains one can make through such measures.
- Promote and facilitate energy service companies (ESCOs) that can identify energy saving options and provide technical support needed for execution to industries and commercial establishments.

10. Some policy initiatives can yield quick returns with small effort just like plucking low hanging fruits. These could include —

- Regulatory commissions can allow utilities to factor EE/DSM expenditure into the tariff.
- Each energy supply company/utility should set-up an EE/DSM cell. The BEE can facilitate this process by providing guidelines and necessary training inputs. A large number of pilot programmes that target the barriers involved and have low transaction costs need to be designed, tested with different institutional arrangements, with different incentives, and with varied implementation strategies. Innovative programme designs can then be rewarded.
- **Implementing Time-of-Day (TOD) Tariffs:** All utilities should introduce TOD tariffs for large industrial and commercial consumers to flatten the load curve. Utilities should support load research to understand the nature of different sectoral load profiles and the price elasticities of these loads between different time periods to correctly assess the impact of differential tariffs during the day. The utility should have focus group meetings with industrial or large commercial consumers, document a few potential case studies illustrating the potential for shifting loads and provide information and analytical support along with implementation of the TOD tariff.
- **Facilitating Grid Interconnection for Cogenerators:** Enforce mandatory purchase of electricity at fixed prices from cogenerators (at declared avoided costs of the utility) by the grid to encourage cogeneration. The buying/ selling price should be time – differentiated and declared by the state regulatory commissions at the time of each tariff notification.
- **Improving Efficiency of Industrial, Municipal and Agricultural Water Pumping:** Institute measures that encourage adoption of efficient pumping systems and shifting of pumping load to off-peak hours. The public sector should be mandated to do so, and the private sector could be encouraged to do so through time-of-day pricing. This will help reduce peak demand and energy demand.
- **Instituting an Efficient Motors Programme:** This initiative should focus on manufacturers/rewinding shops and target market transformation,

by providing incentives to supply energy efficient motors.

- **Instituting an Efficient Boiler Programme:** This initiative should focus on industry and provide incentives for replacement of old inefficient boilers.
- **Promoting Solar Hot Water Systems:** This programme should aim at both industrial and household needs of hot water.
- **Promoting Variable Speed Drives:** All large industries should be required to assess suitability of variable speed drives for their major pumping and fan loads.
- **Undertaking Efficient Lighting Initiative:** Utilities should launch pilot efficient lighting initiatives in towns/ cities (similar to the Bangalore Electricity Supply Company (BESCOM) programme in Bangalore). Features should include warranties by manufacturers and deferred payment through utility bill savings. (International examples are available at www.efficientlighting.net)
- **Improving Cooking Efficiency:** Efficiency of cooking stoves should be improved by targeting manufacturers and requiring them to label stoves so that the consumers know the cost of fuel used. Energy efficient utensils and efficient cooking practices should be promoted as they offer a very large scope for reducing fuel consumption (see www.bachatcooker.com).
- **Making Energy Audits Compulsory For All Loads Above 1 MW:** Energy audits should be done periodically and be made mandatory for public buildings, large establishments (connected load >1 MW or equivalent energy use >1MVA) and energy intensive industries.
- **Reaping Daylight Savings:** Saving daylight by introducing two time zones in the country can save a lot of energy.

11. Medium to long-term initiatives could include —

- Adoption of a least-cost planning and policy approach that ensures that energy efficiency and DSM have a level playing field with supply options. The regulatory commissions should invite bids for DSM while approving new capacity additions. Thus, if a state requires an additional peak demand of 1,000 MW over the next five years, the utility can ask for bids from Independent Power Producers (IPPs) as well as Energy Service Companies (ESCOs). For example, an efficient lighting programme may offer to save 150 MW at a cost of Rs.5,000/peak kW saved. This would then become part of the least-cost plan before putting in new power plants that may cost Rs.40,000-50,000/peak kW generated. Similar exercises should be adopted for the oil sector.
- Initiate benchmarking exercises for different industrial sectors, hotels, hospitals, buildings, etc. In each segment, the benchmark would provide the theoretical minimum energy consumption, the best practice and specific steps required to reduce energy consumption. A road map (5-10 years) should be created for energy efficiency improvements in each industry segment. The BEE can catalyse the benchmarking process by bringing together energy auditors, researchers, end-users and providing the required funding.
- The Government (Central/State), Railways, Defence and public sector units constitute a large market segment for energy intensive products. The basis for selecting a vendor is usually only the lowest initial cost. It is recommended that the procurement process be modified based on the minimum annualised life cycle cost (*see BOX 6.2*). A manual should be prepared establishing the methodology for annualised life cycle costing with a

simple spreadsheet package to enable easy implementation.

- Though life cycle costing seems particularly relevant for appliance purchase since appliances are often bought without consideration of operating costs, it should be used for all decision-making and alternatives should be compared in terms of expected present discounted values of life cycle cost.
- **Increasing Efficiency of Coal-Based Power Plants:** Require NTPC and SEBs to acquire technology to enhance the fuel conversion efficiency of the existing population of thermal power stations from an average of 30% to 35%. No new thermal power plant should be allowed without a certified fuel conversion efficiency of at least 38-40%. While competitive tariff based bidding can balance fuel efficiency against capital cost and provide incentives for efficiency improvement; in the absence of such competition the pace of efficiency improvement needs to be forced.
- **Shifting Freight Traffic to Railways:** Improve railway service to win back the long-distance freight traffic carried by trucks today that consume five times as much diesel per net tonne kilometer of freight carried. Construction of dedicated freight corridors and dismantling of the Container Corporation (CONCOR) monopoly are critical measures for this. Already, the railways have permitted private operators. Carrying 3000 billion tonne kilometres (Bt-km) of freight (half of projected freight traffic in 2031) by rail instead of trucks can save approximately 50 Mt of diesel per year. To attract freight traffic, railways must ensure timely and secure delivery. This can be accomplished by operating scheduled container trains and by charging freight on the container, rather than the content, so that the customers can lock and seal it.
- **Promote Waterways:** Water transport is energy efficient. Make investment to provide the needed infrastructure to facilitate water transport.

BOX 6.2
Initial Cost and Life Cycle Cost

In many cases of energy equipment the annual costs of operation predominate as compared to the capital cost. However the operating costs are often not considered at the time of the purchase, as they are part of the total electricity bill and recurring maintenance costs. The purchase decision is based on the initial cost. *Table* shows the initial cost and the annualised life cycle cost (ALCC) for some typical energy appliances based only on the annual electricity cost since it is the main cost component for these products.

Table: ***Comparison of Initial Cost and Life Cycle Cost***

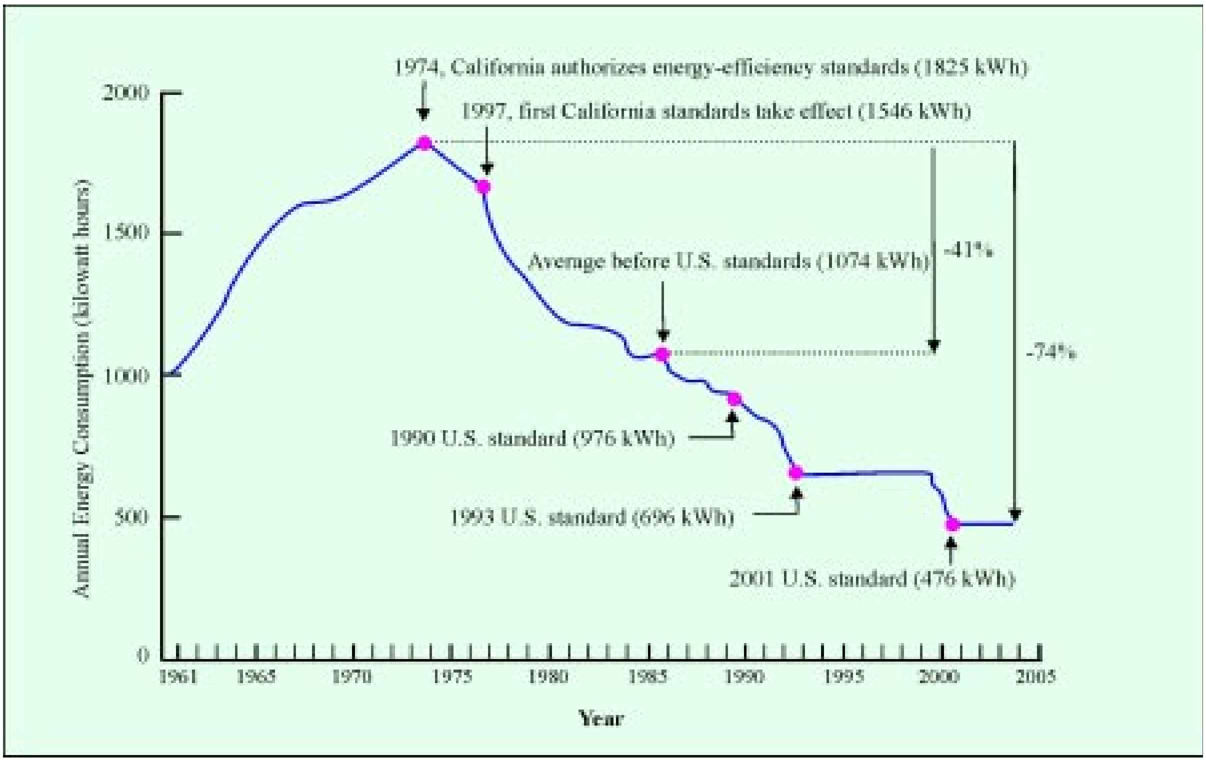
Sl. No.	Equipment	Rating	Initial cost (Rs)	Annual Electricity Cost (Rs)	ALCC (Rs)	Cost of electricity as %of ALCC
1.	Motor	20 hp	45,000	600,000	605,720	99.0
2.	EE Motor	20 hp	60,000	502,600	512,700	98.0
3.	Incandescent Lamp	100 W	10	1168	1198	97.5
4.	CFL	11 W	350	128	240	53.6

- **Promote Urban Mass Transport:** Promote urban mass transport by providing quality services which may be partially financed by imposing congestion, pollution and parking charges on those who use personalised motor transport. Plan for future mass transport corridors in smaller cities and acquire the right-of-way. As the city grows, the permissible built up area may be gradually increased. However the additional right to build should remain with the local government, which it can auction to finance mass transport and other urban infrastructure.
- **Fuel Efficient Vehicles:** Promote hybrid vehicles in India, which are internationally already available commercially. Also promote the already commercial flexi fuel vehicles that can burn varying proportions of ethanol-blended fuels.

12. At an 8 percent growth rate, we will nearly double our capital stock in nine years. Energy using equipment and appliances will also spread rapidly. Thus, the manufacturers of equipment and appliances should be targeted to force the pace of improvement in energy efficiency. The following steps may be taken to improve efficiency of energy consuming equipment:

- Mandate time bound targets of energy efficiency for industrial equipment, boilers, and appliances such as motor vehicles, pump sets, refrigerators, water heaters, boilers, etc.
- Create competition among manufacturers to be the first to achieve the target through a "golden carrot" which is a large monetary reward to

Figure 6.1
Reduction in the Energy Consumption of Refrigerators Sold in the United States of America



Source: Wiel, S. (2001)[9]

[9] Wiel, S. (2001): Introduction, *Energy Efficiency Labels and Standards: A Guidebook for Appliances, Equipment, and Lighting*, S. Wiel and J.E. McMahon, eds. (Washington, D.C., Collaborative Labelling and Appliance Standards Programme (CLASP).

the first one to commercialise products which provide, say a minimum saving of 20% over the best existing design within a given time frame. The Super Energy Efficient Refrigerator Project in the US is a successful example of such a policy initiative(*see Figure 6.1*).

- Mandate clear and informative labelling in well-designed standardised forms for equipments and appliances. Combine this with consumer awareness programmes that illustrate the savings and possible associated gains.
- Strengthen appropriate labelling by creating regional facilities for testing and certification. Such a labelling/ standards initiative should be supported by analytical studies to establish equipment consumption benchmarks (minimum achievable energy consumption targets).

13. Industries may need technical support to identify and execute energy saving options. Energy service companies (ESCOs) can provide such support. We need to promote and facilitate ESCOs. Some possibilities include—

- Financing Support – The support for ESCOs could be in the form of payment security mechanisms (this may be required for projects in municipalities, government buildings), partial credit guarantees, or venture capital. Financial institutions may be encouraged to provide these.
- Encouraging different business models – For ESCOs to be successful in India a variety of alternative business models need to be attempted to determine the appropriate ones in the Indian context. The BEE could facilitate 15-20 demonstration ESCO projects in different sectors. These should be well-documented, independently monitored and made available to the public. This will encourage more entrepreneurs to invest in ESCOs.
- ESCOs as producers of "Negawatts" may be given the same tax breaks that are available for renewable energy programmes or other energy investments.
- Providing an institutional framework for independent monitoring & evaluation of projects delivered by ESCOs. This would involve independent testing laboratories and setting benchmark standards.

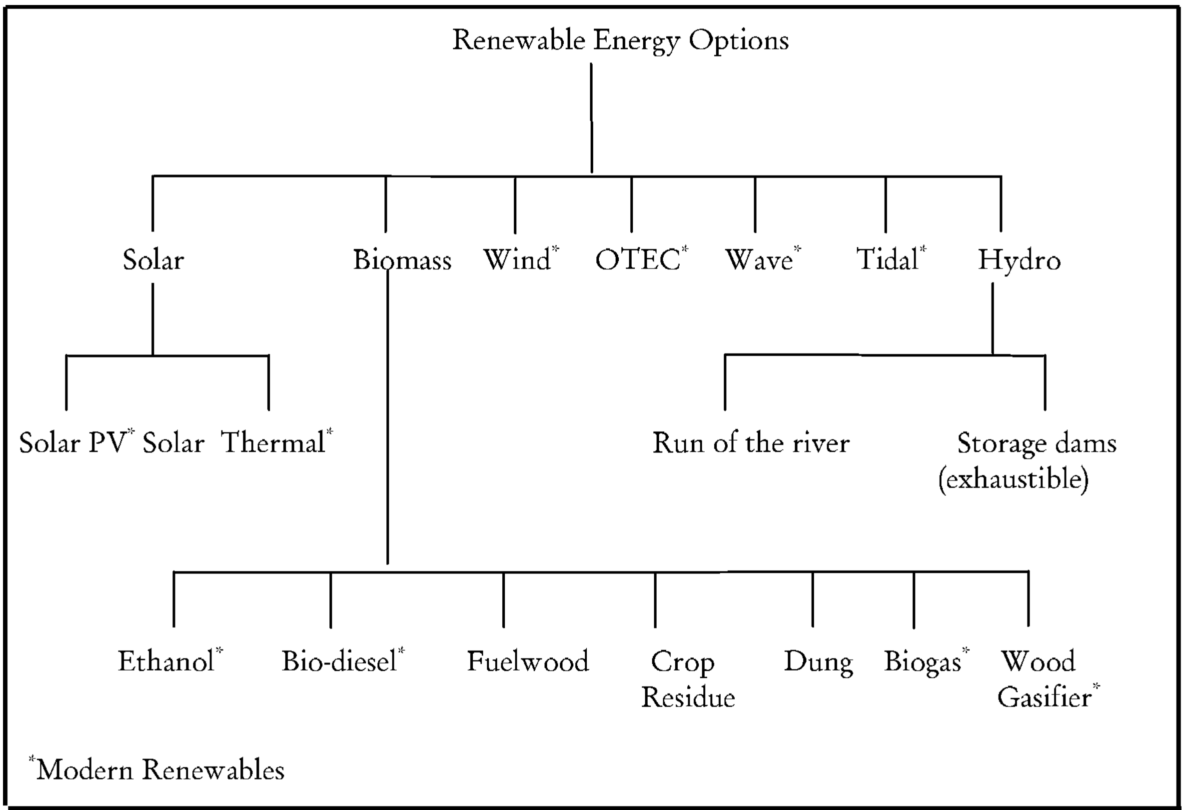
Policy for Renewable and Non-Conventional Energy Sources

An examination of India's primary energy balance shows that renewables account for about 32% of primary energy consumption in 2003-04. Of this, the major contributor is traditional biomass mainly used in cooking followed by electricity generation from large hydro plants. The actual share of modern renewables (*see Figure 7.1*) in India's energy mix is significantly lower (about 2% of the total).

2. Adverse local environmental impacts (SO_x, NO_x, SPM) and global environmental impacts (green house gas emissions mainly due to carbon dioxide) associated with fossil fuel use have resulted in an increased emphasis on renewables. *Figure 7.1* shows a listing of some of the commonly used renewable options. Renewables can be used for space heating, cooling, water pumping, cooking and for almost any end-use that is presently met by fossil fuels.

3. As the country is short of energy resources the need to develop all energy sources including renewable options is paramount. Our

Figure 7.1
Renewable Energy Options



efforts in the past have not been as successful as we would have liked. Many renewables have high initial costs (*see Table 7.1*). Often development efforts have been sub-critical and subsidy driven growth has not provided incentives for technical improvements or cost reduction. There are also externalities of the use of renewables, the benefits of which do not accrue to the user.

Table 7.1
Capital Costs and the Typical Cost of Generated Electricity from the Renewable Options

Sl. No.	Source	Capital Cost (Crores of Rs/MW)	Estimated Cost of Generation Per Unit (Rs./kWh)	Total Installed Capacity (MW) (upto 31.12.2005)
1.	Small* Hydro-Power	5.00-6.00	2.50-3.50	1748
2.	Wind Power	4.00-5.00	3.00-4.00	4434
3.	Biomass Power	4.00	3.00-4.00	377
4.	Bagasse Cogeneration	3.00-3.50	2.00-3.00	491
5.	Biomass Gasifier	2.50-3.00	3.00-4.00	71
6.	Solar Photovoltaic	25-30	15.00-20.00	3
7.	Energy from Waste	5.00-10.00	4.00-7.50	46

*<25 MW

4. Renewable energy may need special policies to encourage them. This should be done for a well-defined period or up to a well-defined limit, and be done in a way that encourages outcomes and not just outlays. Suggestions include:

- Capital subsidies which only encourage investment without ensuing outcome should be phased out by the end of the 10th Plan.
- Power Regulators must seek alternative incentive structures that encourage utilities to integrate wind, small hydro, cogeneration etc., into their systems. All incentives must be linked to energy generated as opposed to capacity created.
- Respective power Regulators should mandate feed-in laws for renewable energy where appropriate as provided under the Electricity Act and as mandated in many countries (*see Table 7.2)*. The regulated feed-in tariffs should have time-of-day features that improve economics of renewable power.
- With the capital subsidy available for improving rural access having become uniform for both remote and grid-connected villages/habitations, Ministry of Power (MOP) and Ministry of Non Conventional Energy Sources (MNES) need to better coordinate the outcomes of RGGVY, MNES's rural electrification programme, and the newly developed pilot projects under Village Energy Security Programme. Similar coordination is also called for between the rural electrification programs, telecom and road connectivity initiatives and certain social sector programs. Bundling of services is likely to achieve greater success and is more likely to yield sustainable structures that are replicable through separate franchises.

5. Price subsidy for renewables may be justified on several grounds. A renewable energy source may be environmentally friendly. It may be locally available making it possible to supply energy earlier than possible through a

Table 7.2
International Feed-in Tariffs

Tariff in Rs./kWh**

	Conventional		Wind				Photovoltaics		Biomass		
	Domestic	Commercial		(Windy sites)[b]	(Non windy)		(Cap. < 5 MW)		0-0.5 MW	0.5-5 MW	5-20 MW
Germany*	6.0 (2001)	2.3 (2002)	1st 5 years[a]	5.2	5.2		27.6		5.85	5.27	4.99
			Next 15 years	3.4	4.6		Guaranteed for 20 years [c]				
			(Cap. < 12 MW)	(Windy sites)	(Non windy)	(Inter-mediate)					
France	5.21 (2002)	1.83 (2002)	1st 5 years	4.6	4.6	4.6	8.6	17.2			
			Next 15 years	1.7	4.6	3.4	(Mainland)	(Overseas)			
				(Cap. < 50MW)[d]			(Cap. < 5kW)	(Cap > 5kW)			
Spain+	5.29 (2001)	2.00 (2001)	Fixed	3.6			22.7	12.4	3.5		
				OR					OR		
			Premium of	1.5			20.63	10.32	1.4		
Austria[e]	6.48 (2002)	2.54 (1995)		4.5			26.9 to 34.4		4.4 to 9.2		

* 2002 data
\+ 2003 data

[a] Since 2002 tariff reduced by 1.5% per year
[b] Sites that achieve more than 150% of reference output
[c] For new installation price reduced by 5%. The obligation to pay ends when total installed capacity reaches 1000 MW
[d] Premiums and tariff set by Government
[e] Uniform fixed price for 13 years (2003)

** Based on exchange rate of Rs.57.31 Per Euro (December-2003)

Source: T. Stenzel, T. Foxon, R. Gross (2003): *Review of renewable energy development in Europe and the US*, Report for the DTI Renewables Innovation Review, ICCEPT, Imperial College, London, October 2003.

centralised system. It may also provide employment and livelihood to the poor.

6. The environmental subsidy for renewables could be financed by a cess on non-renewables and fuels causing environmental damage.

7. All price subsidies should be linked to outcomes. Thus, for example, giving a capital subsidy on a wind power plant provides encouragement to set-up a power plant but does not provide any additional incentive to generate power. Instead a price premium on feed-in tariff for wind power into an existing power grid ensures outcome for the outlay. For grid connected renewables, Regulatory Commissions (RC's) should provide feed-in laws to permit renewables to supply electricity to the grid. RC's should ensure that the renewables are given a tariff at least equal to the avoided cost of generation.

8. A premium on feed-in tariff may not benefit a stand alone plant in a remote area. For such a plant, a capital subsidy may be required. Such a capital subsidy, however, can be linked to the amount of power actually generated if it is given in the form of Tradable Tax Rebate Certificates (TTRCs). The rebate claim would then become payable when electricity is generated and would be linked to the amount of electricity generated. This will also encourage earlier exploitation of better wind sites. The need to keep the TTRCs tradable arises from the possibility that small generators may not have adequate taxable income to benefit fully from tax rebates.

9. In areas where there is no electricity grid, there should be minimum clearances/ permissions required for setting up a Distributed Generation (DG) system. Supply companies/entrepreneurs should be free to set-up micro-grids and recover revenues from customers. This is already provided for in the Electricity Act. Each state should clearly define guidelines to facilitate this process.

10. A critical issue in distributed generation for rural electrification is the cost recovery and the implementation mechanism. Different policy experiments for implementation of DG in different regions should be attempted. The village panchayat aided by the state energy agency and technical experts should decide the appropriate technology option (biogas, biomass gasification, wind-diesel, micro-hydel, bio-oil-engine) for their village. For isolated systems it is beneficial to link the DG system to an industrial load (cold storage, oil mill etc.) to improve its load factor and hence its economic viability. The capital subsidy should be based on the annual generation, and should preferably be in the form of an annualised subsidy to be provided based on actual generation. These projects can be set-up by panchayats, independent power producers or renewable energy service companies. A mechanism of bidding can be used to obtain the annualised subsidy level sought for sustainability. For example, if it is decided to electrify a village using a dedicated producer gas engine and biomass gasifier, bids may be obtained for the support required annually for the concession period per kWh of actual generation. The project would then be given to the lowest bidder. Such a programme would require actual tracking of annual generation. This is feasible using existing technologies of remote monitoring and would add only incrementally to the system cost.

11. An annual renewable energy report should be published providing details of actual performance of different renewable technologies at the state and national levels. This would include actual energy supplied from different renewable options, availability, actual costs, operating and maintenance problems etc. The monitoring should also encompass other parameters like user profiles (in order to ensure that government support is indeed going to poor households), as well as livelihood outcomes such as increased income, improved food security and gender impacts. In fact, this also applies to rural electrification, where the monitoring parameter should not just be the villages and/or hamlets electrified. Monitoring must be based on actual households electrified, hours of electricity received by these households and the various impacts described above. In

addition to monitoring the performance of devices, the assessment should critically review the programme objectives and the strategy adopted in order to suggest course corrections as required. Information on any system that is receiving government support should be made publicly available. It is essential to ensure that independent assessment of performance is done for all renewable projects receiving government funding. This will help in tracking programmes, avoiding repeating mistakes and providing mid-course corrections.

12. The Department of Science and Technology (DST) has set up Technology Business Incubators for entrepreneurs for renewable energy, energy efficiency and rural energy. However, entrepreneurs also need finance. Financial institutions should be encouraged to set-up Venture Capital Funds for energy entrepreneurs. DST should monitor actual success on the ground and reshape its programme based on actual results/feedback.

13. The following specific policies to promote various renewables are recommended:

- **Mini Hydro:** A detailed survey should be carried out to identify potential sites. Identified sites should then be auctioned. For plants which are not connected to an existing grid, bids for the lowest tariff with a pre-specified premium in the form of TTRCs should be invited. For village level plants, the entrepreneurs should be encouraged to supply power to meet other requirements such as agro processing and milling and if such productive loads are not available, the entrepreneurs should develop sustainable integrated schemes that aim at developing the community as a whole. If the plant can feed into a grid, the grid should be required to accept power at the regulated feed-in tariff with time-of-day features, and the plant site should be auctioned off for minimum premium in the form of TTRCs linked to electricity generation. The responsibility for investments needed to connect to the grid should be fixed in advance before the bidding.
- **Wind Power:** For wind power, site selection is freer than hydro-power and wind plants can be set-up on private land. Thus there may be a need to auction only sites on public property. The same two types of auctions may be followed as described above for hydro-power plants. Where cultivation is not affected, a wind turbine installation should be permitted on agricultural land without requiring its conversion to non-agricultural land.
- **Bio-Diesel:** The production of bio-diesel needs to be encouraged in a way that primarily involves outcome related fiscal incentives for its economic production. Certain vegetables oils can be directly mixed with diesel, especially for stationary applications, in certain proportions without any significant processing. Transesterification of industrial oils (with high levels of free fatty acids (FFA) or vegetable oils can yield bio-diesel which can substitute fossil fuel-based diesel in both stationary and motive applications. Non-edible oils such as those obtained from Jatropha and Karanj are gaining attention for production of bio-diesel in India. Currently, significant uncertainty prevails over the exact yields from Jatropha or Karanj cultivation with estimates ranging from a low of 0.4 tonne of diesel per hectare to 1.0 tonne of diesel per hectare.

  Bio-diesel can be encouraged in alternative ways. One way is to encourage oil companies to take the lead in developing large-scale plantations directly through contract farming by individual farmers, self-help groups (SHGs), rural cooperatives, panchayats etc. In this case the problem of pricing of seed and bio-diesel are internalised. Another way is to let organised industries, self-help groups or cooperatives on the line of Amul, pursue Jatropha, Karanj and other suitable plantations. They may sell the oil extracted or set up transesterification units individually or collectively to sell bio-diesel either to oil companies for blending or directly to consumers in jerry cans.

Up to 100% tax rebate can be provided for investments made in plantations and bio-diesel processing through TTRCs linked to actual bio-diesel/seed production. In addition, TTRCs could include a premium for use of renewables, employment generation and an environmentally preferable fuel. In cases where the TTRCs are acquired by the oil companies, organised industry and/or large cooperatives, a competitive environment with multiple players would ensure that the benefits are shared with the ultimate grower. Further, this green fuel can be made free of taxes and levies currently imposed on diesel based on fossil fuels with the bulk of the benefit being passed on to the end-consumer as is done in countries such as Germany, Spain, Italy and USA. A part of the benefit could also be used to build a fund that would provide price support to the Jatropha/Karanj farmer in the event that world price of fossil fuel-based diesel goes below a certain pre-set price. The investment incentive can be adjusted as economic viability is established and the country achieves a level of output that meets the targeted replacement in both stationary and motive applications. Employment generated in cultivating bio-plantations may be made eligible for coverage under the National Rural Employment Guarantee Scheme.

A parallel initiative based on bio-diesel production from the residual industrial oil produced as a by-product while refining edible oils may also be encouraged. Significant quantities of such residual oils are available in world markets but current imports into India attract different levels of custom duty based on end-use. A duty of 65% is imposed on use of such residual industrial oils for conversion to bio-diesel. If this duty is reduced to 5% as in the case of crude oil, it would be possible to produce diesel based on such imports of industrial oil at about Rs.25/litre. This may be sold directly to consumers by producers or to oil firms without levying any of the current taxes and levies imposed on fossil based diesel. Again, the oil companies may be required to pass on bulk of the benefit to the consumers.

Thus the following policies are recommended for bio-diesel:

- Support Jatropha, Karanj and other similar species, with incentives as suggested above.
- Since the end objective is to promote bio-diesel and significant research is still needed to establish viable germ plasms and genotypes for bio-fuel plantations, it is recommended that the parallel route based on industrial oils be pursued immediately through a reduction in import duty to 5% for high FFA vegetable oils for conversion to bio-diesel.
- Transesterification facilities set up by importers of industrial oils may also be given TTRCs.
- Encourage direct and local sale of bio-diesel where feasible. This can begin with the metro towns.
- As a green fuel make bio-diesel free of excise and levies charged on fossil fuel-based diesel.
- Bio-diesel and/or blends of bio-diesel should be sold with full disclosure and priced differently from pure fossil fuel based diesel.

❑ **Ethanol:** Ethanol is a more complex issue. At the outset it is stated that any investment in R&D and commercialisation of cellulosic ethanol may be given a full tax credit for an initial period of 5 years based on delivery of defined outcomes. Ethanol blending helps diversify energy mix and so improves energy security. If the ethanol is produced domestically the impact on energy security is even better.

There is no surplus ethanol available in the country for blending in petrol for motive energy. India has been importing ethanol since 2002 and became the largest importer from Brazil in 2005 with imports of 411 million litres. This was over 9% of the world ethanol trade in 2005. The imported alcohol was primarily used by the chemical industry as it could not access domestic alcohol.

As a comparison, a 5% blend of ethanol in petrol in India would require 610 million litres of ethanol – some 14-15% of world trade in ethanol. Clearly, the foregoing numbers show that domestic availability of ethanol in India (which depends on cane production & yields) and India's policy on blending alcohol with petrol can significantly affect domestic and world prices of ethanol. Needless to add that the fate of the chemical industry in India hangs critically in balance between policies that decide end-use of domestically produced ethanol on one hand and the lowering of barriers to international competition in chemicals on the other hand.

An ethanol blending programme was announced in 2003. The programme could not succeed because of non-availability of ethanol. However, domestic prices of ethanol have doubled since 2003 to reach import parity prices. Ethanol in India is produced as a by-product of the sugar industry from molasses. About half the domestic production is used for potable purposes while the balance is used by industry which supplements shortfalls through imports. The value addition in industry is on average 2-3 times higher than the value addition as an additive to petrol.

India is the only large country where potable liquor is produced from molasses – most other countries produce potable liquor from grain. For the Indian liquor industry domestic molasses remains the cheapest option since ethanol import for potable purposes attracts a custom duty of 150%. Since the liquor industry provides huge tax revenues to both central and state governments, they have traditionally managed to maintain their hold on domestic molasses based ethanol to meet their need. The remaining domestically available ethanol is simply inadequate to meet the needs of both the domestic chemical industry and blending with petrol. Thus one or both, the chemical and the petroleum industry have to import ethanol, on which custom duty of only 10% is levied, to meet their needs.

Sugarcane yields in Brazil are some 23% higher on average and sugar yields from sugarcane is about 34% higher. The cost of producing sugarcane based ethanol in Brazil is 40-50% that of India. Brazil produces 42% of world's ethanol. USA, the second largest producer of ethanol, with 37% share of world production, produces ethanol from corn which is heavily subsidised. The per capita land availability in Brazil is more than 15 times and in USA more than 10 times that in India. Only 1% of the cultivable land in Brazil is currently under sugarcane production and water availability is not a problem. Thus Brazil's ethanol industry has significant growth potential. In India water is a big constraint and sugarcane plantations have remained at 3.8 to 4.2 million hectares over the last 15 years. Given persistent shortages in grain, lack of water and pace of urbanisation, India's acreage under sugarcane is not likely to increase.

It is pointed out that the calorific value of ethanol is only 56% of petrol. However, blending improves burning efficiency and thus ethanol is priced some 30-35% below gasoline prices in

Brazil which is the biggest user of ethanol for motive purposes.

Given the above facts, availability of molasses based alcohol from the sugar industry is unlikely to grow significantly. Even if new sugarcane acreage comes up in water rich areas of Bihar and U.P., it should ideally replace current acreage in water scarce areas such as Maharashtra. Productivity gains are potentially possible and the same, if achieved, would by themselves not even be able to keep up with the likely growth in demand if the blending programme takes off in earnest. Even grain based alcohol would become viable only if we first address our food security concerns and agricultural growth rises to at least 4% level. Thus the options available to India to increase availability of ethanol in the short to medium term are:

(a) aggressively support alternate routes to ethanol such as cellulosic ethanol and low water intensity crops such as sweet sorghum;

(b) raise sugarcane yields and divert increased cane output for ethanol production;

(c) promote grain-based alcohol to the extent possible especially from spoilt grains;

(d) remove barriers to import of ethanol for all end-uses; and

(e) like equity oil seek ethanol acreage in Brazil – the world's cheapest producer of ethanol.

Thus the following policies are recommended:

- Set import tariff on alcohol independent of use and at a level no greater than that for petroleum products.
- Require that oil companies may blend upto 5% of ethanol with petrol but do not mandate oil companies to do so.
- Price ethanol at its economic value vis-à-vis petrol but not, in any event, above its import parity price.
- Companies in India such as Praj Industries and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) have developed commercial varieties of sweet sorghum. To encourage alternate routes to ethanol, such production may be procured at the full trade parity price of petrol for 5-7 years instead of being purchased at its true economic value based on calorific content duly adjusted for improved efficiency.
- As a green fuel, however, government may wish to waive all or part of the excise and levies charged on petrol to the extent that it contains ethanol. However, bulk of the benefit must be passed on to the consumer.
- Petrol pumps must declare if they are selling blended petrol and price it differently.
- Incentivise cellulosic ethanol with investment credits as detailed above.

❑ **Fuelwood Plantation:** Cooperatives should be encouraged and facilitated to grow tree plantations in villages. Cooperatives which are open to all members of the community should be given government land on a long-term lease. Women should be encouraged to set-up and manage such plantations so that the time they now spend in gathering fuel can be spent productively in a way that empowers them. They should also be provided finance. If organised and managed properly, such plantations are economically viable and successful as shown by the experience of National Tree Growers Cooperatives Foundation [Parikh et al (1997)[10]]. Field based NGOs could also be involved in this activity. To encourage large-scale plantations, based on contract farming,

[10] Parikh Jyoti K. and Reddy B. Sudhakara, Editors (1997): *Sustainable Regeneration of Degraded Lands through people's participation*", Tata McGraw Hill Publishing Co. Ltd., New Delhi.

the corporate sector could be incentivised to build wood based power plants with assured access to benefits announced under the liberal captive policy enunciated in the Electricity Act, 2003.

- **Electricity from Wood Gasification:** This process can provide electricity based on gasification of wood and can be very useful especially in remote villages. The same set of policies indicated for micro hydel and wind power plants should be followed here.
- **Community Biogas Plants:** Biogas plants have been promoted for families with 5 or more cattle head to obtain 2 to 3 cubic metre of gas per day. The estimated potential is 14 million plants. This leaves out the dung of all those who have fewer animals and also wastes the surplus gas that may be produced in warmer months. The real potential of biogas is thus in community level plants. To encourage private or community entrepreneurs to set these up, they need to be provided land and finance. Also to have the willing participation of all the cattle owners in the community requires an appropriate operating strategy. Parikh and Parikh (1977)[11] have shown the possibility of such a strategy. The essential policy required is the provision of land and finance.
- **Family Size Biogas Plants:** If fuel efficient cooking utensils and methods, with which 60% to 70% energy can be saved, are used than even a biogas plant with one or two cattle heads can provide the bulk of required energy for a family's cooking. This would avoid the institutional complexity of operating community level biogas plants. Compact and monolithic biogas plants suitable for one, two or three animals are now available. Trials with small biogas plants and energy efficient cooking should be carried out to examine their acceptability.
- **Solar Thermal Water Heaters (SWH):** These are economical. The main barrier to their adoption is the expense of retrofitting plumbing in households and industries. Building laws should be amended to ensure that all new buildings and factories have solar water heaters. Existing households, commercial establishments and factories should be encouraged to install solar water heaters through a DSM programme run by electricity utilities. Alternatively incentives may be given in the form of income tax rebates, property tax rebates, rebates in transfer fees and rebates in electricity charges. The government, including the defence and public sector, account for a significant amount of new construction and installation. They can set the example by conforming to revised building laws.
- **Solar Thermal Power Plants:** The economic viability of solar thermal plants has not yet been fully established. To encourage entrepreneurs to invest in such plants, a higher premium of feed-in tariff may be given. The higher premium can be justified given the higher risk and may be available to only the first 5000 MW of solar thermal plants.
- **Solar Photovoltaics:** Even though present costs of photovoltaics are very high, since the ultimate potential is very large, incentive to commercialise and lower the cost may be provided through a higher feed-in tariff, again for the first 5000 MW of installed capacity.

14. We do not recommend any particular set of renewables as the preferred mix. The attractiveness of a particular option depends on local circumstances and each option has its

[11] Parikh J.K. and Parikh K.S. (1977): *Mobilisation and Impacts of Biogas Technologies*, Energy, Vol. 2, pp. 441-445.

own niche and unique advantage. The policy instruments we have recommended permit all options to compete on a level playing field.

15. Some institutional arrangements to promote renewable energy are needed. These are:

- Restructure existing Commission for Additional Sources of Energy (CASE) providing it independent status and authority de-linking it from the Ministry of Non-Conventional Energy Sources and making it responsible for overall development of Renewable Energy Programmes in the country.
- Convert existing Indian Renewable Energy Development Agency Ltd (IREDA) into a national apex refinancing institution on the lines of NABARD/National Housing Bank (NHB) for the Renewable Energy Sector by bringing equity from banks, insurance companies and financial institutions in the country.

Household Energy Security: Electricity and Clean Fuels for All

One of toughest challenges before us is the provision of electricity and clean fuels to all; and in particular to rural populations considering their poor paying capacity, the limited availability of local resources for clean cooking energy, and the size of the country and its population. Yet considering that women and the girl child carry most of the burden of the drudgery of gathering fuel wood, agricultural wastes and animal dung and also bear the brunt of indoor air pollution, the urgency to meet the challenge should be high if we are to achieve universal primary education for girls, promote gender equality and empower women. The considerable effort spent on gathering biomass and the cow-dung and then preparing them for use is not priced into the cost of such energy. Additionally, these fuels create smoke and indoor air pollution, are inconvenient to use and have an adverse impact on the health of people, particularly women and children. Easy availability of certain amount of clean energy required to maintain life should be considered a basic necessity. Energy security at the individual level implies ensuring the availability of such energy. This requires the following:

- Electricity in all households – While under its National Common Minimum Programme the Government of India is committed to electrification of all households in 5 years, its flagship programme, Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY), launched to achieve this is designed to provide access to all households and actually electrify only BPL households by 2009-10. A programme that ensures that all households have electricity needs to be developed.
- We must also set a goal to provide clean cooking energy such as LPG, NG, biogas or kerosene to all within 10 years. It may be noted that the requirement of cooking energy does not increase indefinitely with income. Thus the total amount of LPG required to provide cooking energy to 1.5 billion persons is about 55 Mtoe.
- Meanwhile we could provide fuel wood plantations within one kilometre of all habitations. Those who do not have access or cannot afford even subsidised clean fuels will need to gather wood. Neighbourhood plantations within one kilometre of each habitation can ease this burden and reduce time taken to gather and transport wood.
- To develop sustainable energy supply, women's groups can form oil seed plantations or tree-growing co-operatives to manage and produce bio-fuel & fuel wood with the same effort that they put into searching and gathering fuel wood today. Finance through self-help groups should be provided to transform women, who are today's energy gatherers into tomorrow's micro-entrepreneurs for energy management.

2. Energy security for the poor should go beyond providing energy for subsistence. One must recognise the need to provide energy to the poor to increase their livelihood opportunities, production capacities and incomes so that eventually they can afford clean and convenient energy sources. For the poor in rural areas we need an integrated rural

energy programme to ensure energy security. What needs to be done is discussed below.

8.1 ELECTRICITY

3. The Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) aims to electrify the 1,25,000 unelectrified villages, connect all the estimated 2.34 crore unelectrified households below the poverty line (BPL) and augment the backbone network in all the currently electrified 4.62 lakh villages by 2010. While the BPL households are connected free of cost, the rest of the programme receives a 90% capital subsidy. The 5.46 crore unelectrified households above the poverty line are expected to get an electricity connection on their own without any subsidy. However, going by current experience the hope that the above poverty line households will seek connections on their own may not be realised. The fact is that up to 40% of the households remain without electricity even in States that have been fully electrified.

4. Expansion of connectivity under RGGVY will require a corresponding expansion of supply capability. Given the present widespread and endemic shortage of power in many states, special action is needed to facilitate and encourage decentralised distributed generation (DG) systems so that communities can take their destiny in their own hands instead of waiting for utility companies to supply electricity reliably. The DG plants in villages where grid extension is not proposed are covered under RGGVY's subsidy programme. In grid connected areas also DG plants can benefit from the incentives provided by MNES.

5. For RGGVY to deliver electrification of all households, the following needs to be addressed:

- Scope of RGGVY must be redefined to include electrification of all households.
- Power plants based on wood gasification have been shown to be feasible as well as economical. Enough woody biomass is available in many parts of the country for a village to generate adequate electricity to meet its needs. It is possible that a village goes in for the DG option feeding a local grid in the first instance. Subsequently, the village could get connected to the grid in the normal course of grid expansion. At that stage, the DG facility can possibly provide grid support by feeding-in power at the lagging end of the grid. A case can be made for subsidising DG even in villages proposed to be electrified through grid extension.
- To make RGGVY sustainable, a business plan that makes it financially viable needs to be elaborated. A clear pricing and subsidy policy and the means of targeting the subsidy need to be announced soon. Local bodies, panchayati raj institutions, NGOs or even local entrepreneurs can take the franchise to run the local network. Women's self-help groups can be empowered to do so as well. An essential requirement for sustainability is the need to promote paying productive loads in each village.

6. A policy that gives 30 units of electricity per month to each household as a matter of entitlement is recommended. As already pointed out, such lifeline consumption is not likely to require more than 75-80 billion units in absolute terms. As already stated, not more than 60 billion kWh of this lifeline consumption needs to be subsidised to varying degrees even in 2031-32. Any consumption beyond the lifeline consumption should be at full rates. Putting such a lifeline energy support regime in place would require metering and targeting the subsidies to the needy. The decentralisation of the billing and collection foreseen under RGGVY and the distribution transformer based accountability foreseen under the revised APDRP are likely to prove helpful in targeting such lifeline support. However, the most desirable solution remains the provision of direct cash subsidies to the needy through smart cards. In deciding the level of subsidy, it must be recognised that even the

poorest household does spend something on energy for lighting and hence must pay a minimum amount for obtaining the lifeline electricity support. As per the NSS 55th Round Survey in 1999-2000, among the households in rural areas that had electricity, those that belonged to the poorest 5% of all rural households spent more than Rs.300 per year for electricity. Thus a charge of Rs.1.0 per kWh for the first 30 units per month should be within the capacity and willingness of even the poorest 5% of households.

8.2 COOKING ENERGY

7. Providing clean cooking energy to all is also a big challenge. The 2001 census found that 625 million do not have any access to modern (cooking) fuels. It is also true that about 70% of the energy used for cooking in Indian households comes from non-commercial fuels. This may be a result of underlying gender bias wherein the bulk of the cooking energy is 'managed' using non-commercial fuels collected mostly by women and the girl child, with little investment, management or technology inputs and little political or administrative backing. They need attention and help.

8. The available clean cooking fuels are LPG, biogas, kerosene and electricity. Electricity is, in our context, a relatively expensive form of cooking energy and should be provided only in very specific circumstances where other options do not work or are more expensive due to remoteness and or agro-climatic conditions. While these fuels cause less pollution in the kitchen, only biogas is carbon neutral. Other clean fuels are producer gas and coal based Dimethyl Ether (DME) which may be cheaper than LPG. These, however, require extensive development in production and marketing.

9. If most of the animal dung available in rural India is fed into biogas plants (either community size with each producing >20 m^3 of gas per day or family plants suitable for one, two, three or more cattle heads), supplemented with suitable other biomass and with improved micro-organisms, some 30 to 40 percent of rural cooking energy need can be met by biogas. With energy efficient cooking systems, energy need can be substantially reduced and biogas can meet much of cooking energy needs. Community biogas plants managed as commercial enterprises need to be encouraged with finance and provision of land.

10. LPG is the most convenient cooking fuel. If we desire that all households use it, then, besides setting up a distribution network, the poor will have to be provided financial assistance. However, as indicated earlier, lifeline level of LPG consumption that needs to be subsidised is estimated as only about 13 Mtoe even in 2031-32. Again, the most effective way of targeting differing levels of subsidy to support lifeline consumption of cooking energy is by providing it directly to the end-consumer in cash through smart cards.

11. At present kerosene is subsidised. Distribution of subsidised kerosene has not been without problems. The current delivery system of kerosene subsidy by keeping the price of kerosene to the consumer low and compensating the oil companies for the difference in the consumer price and the import parity price has led to shockingly high rate of corruption in the petroleum distribution agencies. A lot of kerosene to be distributed under PDS system is diverted for the adulteration of high priced diesel even at the depot level. Based on NSS data we estimate that only 56 percent of kerosene released by States reaches people as PDS kerosene. Since the different between price of diesel and PDS kerosene was Rs.21 per litre in 2005-06, a leakage of 44 percent implies that Rs.10,400 crore were made by unscrupulous distributors. Removing the subsidy may improve the availability of kerosene in rural areas for at least those who can afford it. They will use more of kerosene freeing biomass based fuels for the poor. Once houses are electrified under RGGVY, or by providing them with solar lighting systems, the need to subsidise kerosene for lighting will also no longer be there. If kerosene is to be subsidised as a cleaner fuel, the only way of preventing this pernicious adulteration and the widely prevalent corruption is to make the price of kerosene

and diesel very close and give the subsidy to the consumer directly by way of coupons or smart cards.

8.3 SUBSIDY THROUGH DEBIT CARDS/SMART CARDS

12. The best way for providing subsidy for electricity and cleaner fuels, kerosene or LPG, is to give an entitlement to the targeted households equivalent to 30 units of power and 6 kg. of cooking gas or equivalent amount of kerosene to cover one or both needs. A system of debit cards or smart cards may be introduced whereby the targeted households get a credit of different amounts of cash for the purchase of these entitlements. The available credit on the debit/smart card can only be used for purchase of these entitlements. With modern ICT, card readers operated on battery and feeding data using mobile technology can work in rural areas of the country too.

13. The problem of bogus cards has plagued our public distribution system. How do we ensure that bogus debit cards would not be issued? One way to do this is to put the names of all cardholders on the village board and internet. Another option would be to provide cards with physiological identification.

14. Even if a household decides to sell the entitlement and not use power, LPG and kerosene, it would still be welfare improving. The poor who prefer to sell their entitlement and still gather biomass based fuels would be better off as there would be much less competition for it. The effort and time involved mainly of women and girls in gathering fuel would go down. To reduce the adverse impact of indoor air pollution on their health, women should be informed about possible defensive measures, such as ventilating the kitchen by removing a brick or two under the roof, using improved smokeless chulahs, keeping the children away from the stove and minimising the exposure to smoke, etc.

15. Within this broad strategy the suggested policy actions to provide electricity and cleaner fuels to all are summarised below:

- Provide a monthly entitlement of 30 units of electricity and 6 kg. of LPG or equivalent amount of kerosene for one or both lifeline energy needs through a system of Smart/Debit Cards with varying levels of direct cash support to targeted households as detailed above.
- To facilitate distributed generation under RGGVY to enhance the speed by which we can electrify all households. Revise the scope of RGGVY to cover actual electrification of all households. Most importantly develop a viable revenue model for RGGVY.
- Eventually when the grid supply reaches the villages electrified using DG, the local generation could feed power price into the grid, at regulated feed-in tariffs, to support the lagging ends of the grid.
- For setting up of off-grid generation facilities in rural areas, encourage the organised sector to adopt rural community/communities in their areas of operation. Even tax rebates may be considered linked to actual outcomes.
- A large-scale socio-economic experiment should be financed to operate community sized biogas plants either by a community cooperative or by a commercial entrepreneur. This should assess various management models in a scientific manner and examine whether the inclusion of the poor and disadvantaged can be guaranteed. Successful management models should be replicated on a large-scale.
- Community land should be allocated to women's self-help groups and they should be provided with finance and technical help to develop fuel wood plantations in convenient locations.

Energy R&D

Research and Development (R&D) in the energy sector is critical to augment our resources, to meet our long-term needs, to promote efficiency, to attain energy independence and to enhance our energy security.

2. A look at the projections of International Energy Agency (IEA), the Energy Information Administration (EIA), British Petroleum (BP) and Shell reveals the continuing growth in global fossil fuel consumption till 2030. India may find it harder and harder to import required energy as our requirements are growing faster than the growth in the world's total fossil fuel supplies. The solution for India lies in: (a) reducing requirements by using fuel/energy more efficiently; (b) seeking substitutes to fossil fuels; (c) shifting to fuel efficient modes of transport; (d) augmenting its domestic energy resources; and (e) adopting leading commercial or near commercial low carbon and high-energy-efficiency technologies that extract and use coal, our most abundant primary energy resource, in a more sustainable manner. Energy R&D has a critical role to play in all these areas. The policy initiatives that stand out for India are detailed in this chapter.

3. Energy R&D has not got the resources that it needs. We need to substantially augment the resources for energy R&D and to allocate these strategically. To take an innovative idea to a commercial application involves many steps. Basic research leading to a fundamental breakthrough may open up possibilities of applications. R&D is needed to develop any new concept and to prove its feasibility. This needs to be followed up by a working model at laboratory scale. Scaling up to a pilot project follows if the economic potential is attractive keeping in mind cost reductions that could be achieved through better engineering and mass production. Demonstration projects, further economic assessment and more R&D then go into making the project acceptable and attractive to customers before commercialisation and diffusion can take place.

4. At each stage appropriate support needs to be provided for R&D. The nature of the support and the attendant institutional arrangements will differ. India has used three approaches; technology development missions that require coordinated research and development of all stages of the innovation chain to reach a targeted goal such as in the departments of atomic energy and space research; technology roll out missions to develop and roll out commercial or near commercial technology such as the missions to provide rural telephony; and broad based R&D support to research institutions, universities and others through project funding. Technology Missions are the most appropriate mechanism, particularly when it requires coordinated action in a number of different areas, which may involve different government ministries, departments or levels and the private sector. A technology mission whether for development or roll out not only brings a single point focus to dispersed initiatives in the relevant field but also provides support to research projects in universities and research institutions with the aim of delivering the mission objectives. Technology missions must cover areas that are of critical importance to India's long-term energy needs. While coordinated effort is desirable for all R&D in all links of the innovation chain, it becomes critical to place such a coordinating role under a commercially oriented entity, with well-identified targets, when one needs to roll out already commercial or near commercial technologies in a time-bound manner. Funding for specific projects to be taken up in universities and R&D institutions as a part of

such programme should be routed through the coordinating agency for time-bound outcomes. In either approach, it is emphasised that R&D requires sustained support over long periods of time.

5. Based on these considerations, we recommend the following:

- A National Energy Fund (NEF) should be set-up to finance energy R&D. Our expenditure on R&D excepting for atomic energy, which as of today provides less than 3 percent of our total electrical energy supply, is miniscule compared to what industry and governments spend in developed countries. In the developed world, industry generally spends more than 2 percent of its turnover on R&D. In India, the total expenditure on R&D in 2004-05 was Rs.610 crores[12] for Atomic Energy and Rs.70 crores for Ministry of Power, Coal and Non-Conventional Energy Sources. Even at one-tenth of the rate at which industry in developed countries spends on R&D, i.e. 0.2% of the turnover of all energy firms whose turnover exceeds Rs.100 crores a year, we end up with Rs.1000 to Rs.1200 crores per year which will increase over time. We should be spending much more than this on R&D. Much of R&D can be considered a public good. There is, thus, a strong case for funding by the government either directly or through fiscal incentives. The latter accounts for the bulk of government support in the developed countries. Fiscal incentives, however, have not resulted in significant expenditure on R&D by Indian industry. An annual allocation should be made by the government for energy R&D. To begin with, for the first year Rs.1,000 crores, excluding atomic energy, may be provided to this fund. Individuals, academic research institutions, consulting firms, private and public sector enterprise, could all compete for grants from this fund for identified and directed research.
- The fund should be governed by an Independent Board with representation of Department of Science & Technology (DST), Planning Commission and Energy Ministries. However, a majority should be outside experts. It would support all stages of R&D from basic research to diffusion with appropriate policies, resources and institutions.

  Each identified technology goal should be broken down into its constituent basic research and applied research. Both types of research should be allowed to access funding from the NEF but all activities must be coordinated to deliver defined goals/ targets/milestones in a time-bound manner.

  The fund should promote the formation of consortia between industry, research institutions, and academia in each of the identified energy technology areas. A virtual network of energy research institutions, like laboratories of Council of Scientific & Industrial Research (CSIR), Department of Science & Technology (DST), Department of Biotechnology (DBT) etc. and private sector, should be created to assist in pooling resources and exploiting synergies through dispersed but well coordinated and directed research for identified technologies.
- Each company in the field of energy should be mandated to spend at least 0.4% of its turnover on R&D. Any contribution made by the company to NEF could qualify for full deduction from the income taxes due from the company.

[12] Only about 15% of this amount viz., Rs.610 crores, was for R&D on nuclear power. The rest of the expenditure is for R&D on non-electricity applications of Radiation Technology and Fundamental Research.

- The NEF should aim at making India a global leader in energy technologies most relevant to India's energy security for sustained growth.

6. We have already identified some projects for R&D earlier. However, we recognise that the world of technology is dynamic and one should be flexible in one's strategy.

- Resources devoted to research in different areas depend on the economic importance of that particular area, the scope of technology and the likelihood of success of R&D in developing these. The latter changes with time as new developments in science & technology take place and uncertainty reduces. R&D priorities have to be based on a strategic vision which is frequently updated. Of critical importance is research and analysis to outline technology road maps. The NEF should commission, encourage and fund such studies on a regular basis in a number of institutions and through individuals.
- The NEF should support energy policy modelling activities in a selected institution on a long-term basis. Different modellers should be periodically brought together in an energy modelling forum to address specific policy issues.

7. In view of the discussion above the Committee felt the need for several National Technology Development Missions crucial to India's long-term energy security. These technology missions must pull together all current efforts and resources being devoted to the technologies relevant to the mission and place their responsibility as separate but linked parts of a single chain of command working towards specific and time-bound deliverables. The missions must engage industry, academia and India's R&D infrastructure of laboratories and research institutions. The missions identified below exclude nuclear energy as research in that field is progressing well under the various institutions controlled by the Department of Atomic Energy and covers fission, fusion, breeding of fissile material, use of Thorium as also a number of non-energy related fields. The following National Technology Missions are recommended:

- **In-situ coal gasification:** Given its vast reserves of relatively poor quality coal which might prove uneconomical for extraction beyond 300 meter depth using convention technologies, India needs to take the lead in developing this technology in order to enhance the life of its most important and dominant energy resource. This technology would extract energy from deep seated coal without the high ash that accompanies Indian coal.
- **Integrated Gasification Combined Cycle (IGCC)** is a clean coal technology that India has been pursuing for some 3 decades. These efforts should be brought under a mission to establish efficacy with Indian coal and likely commercial viability.
- **Coal to liquids and/or gasified coal to liquids:** If crude settles at above $45/barrel on a long-term basis, adapting this technology to Indian coal could increase India's energy security. This technology was successfully deployed in South Africa using South African coal. They have tested Indian coal and confirm that the technology works.
- **Carbon capture and sequestrations:** India's energy mix will remain dominated by coal at least to 2031-32 and possibly beyond. In order to grow in a sustainable manner capturing carbon and sequestering it would become critical for India in the years to come. Such technology has already been deployed commercially in conjunction with enhanced oil recovery from adjacent oil fields in three locations worldwide.
- **Bio-energy mission:** This mission could cover three distinct areas related to bio-energy. These include: (i) Bio-diesel from non-edible oils such as

Jatropha and Karanj; (ii) Cellulosic ethanol; and (iii) energy plantations. A bio-fuel mission to plant Jatropha or other appropriate oil plants on 4,00,000 hectares of wasteland within three years has been undertaken to assess yields under alternative agro-climatic and soil conditions, diverse cultivation practices and different levels of inputs such as water and nutrients. The mission will identify germ plasm of promise and develop high yielding varieties. Even if the experiment shows little scope for economic exploitation of bio-diesel, the expenditure could be justified just as a failed oil exploration effort, by the large local employment generated. A similar mission needs to be mounted for energy plantations wherein the biomass generated could be gasified or combusted directly in wood fired boilers for power generation. Funds available under NREGA (National Rural Employment Guarantee Act) could be used for meeting the cost of planting under both these schemes. Production of cellulosic ethanol is getting considerable attention and India should also mount a separate mission for R&D in this emerging energy source.

- **Storage technologies:** Storage technologies are important for using intermittent sources of power and for the automotive sector. Super conducting storage devices and super battery technology should be focused on, given that cost and higher capacity to weight ratios are still big challenges.
- **Solar:** Solar technology is often seen as relevant for niche applications. Given that solar energy is one of our major energy sources and the only renewable energy source with sufficient potential to meet almost all our energy needs, we should give a high priority to development of solar technology for large-scale deployment. A technology mission should be mounted to break barriers to wider use of solar thermal and for bringing down the cost of solar photovoltaic by a factor of five as soon as possible.
- **Advanced materials:** Several technologies depend on developing advanced materials. A mission to support this could actually cut across several technologies and could also draw from current work done in a variety of fields such as nuclear, space, transport, etc. for applications in the field of energy.
- **Hydrogen:** Development of Hydrogen as an energy carrier is being pursued in many countries. Hydrogen can be used to generate electricity in a fuel cell or it can be burnt directly in internal combustion engines. Hydrogen, however, has to be produced by expanding another primary or secondary form of energy. This can be gas, coal, oil, solar energy, biomass, hydro or nuclear energy. It is also possible to produce it through microbial action. A mission covering all aspects of hydrogen production, storage, transport, deployment and use, can be justified on three considerations:
  - (i) Since many countries are working on hydrogen, the R&D on applications will find international market.
  - (ii) Some of the R&D for fuel cell based vehicles is common for electric vehicles which may become attractive with advancement of battery technology; and
  - (iii) If economic production of hydrogen through electrolysis of water using solar energy, and/or nuclear energy or from microbial action materialises, and storage, transportation and distribution of hydrogen becomes economically viable, hydrogen could become a clean and endless energy option.
- **Gas hydrates:** A technology mission for assessment and exploitation of gas-hydrates is justified given India's abundant gas hydrate reserves in deep waters.

8. The Committee has identified the following areas wherein technologies are either fully commercialised elsewhere or are near commercialisation. Even technologies that have been commercialised elsewhere a certain amount of adaptation may be called for. In all these areas, technology roll out missions are proposed. An industry, or a group of industries or a commercially oriented agency should be asked to take the role of lead coordinator and seek early acquisition, adaptation and commercialisation. R&D funding for in-house research and directed outsourced research should be provided based on competing offers.

- A number of energy efficiency technologies including DSM technologies. Technology Information, Forecasting & Assessment Council (TIFAC) can be asked to identify specific technologies ready for adaptation and/or commercialisation in India.
- Recovery of coal bed methane and mine mouth methane. Blocks have been allocated already. ONGC and others holding blocks should be asked to indicate firm dates for tapping this energy and identifying any specific hurdles or technology needs.
- Fluidised bed boilers and advanced circulating bed fluidised boilers should be promoted for use with low quality Indian coals and/or washery rejects. BHEL, L&T and others should be asked to take the lead in developing this application and its wider use.
- Washing of Indian coal, requires that a well-established technology be adapted for Indian coals of different quality so that yields and viability can be improved. BHEL and NTPC should lead this effort with the support of the research institutions of the coal industry.
- Reduction of SO_x/NO_x and particulate emissions to match global standards. NTPC, private sector and SEBs could compete for taking the lead on this.
- Current practices/technologies for exploration and extraction of coal for adaptation in Indian conditions. Coal India and Neyveli Lignite to be given the lead in this area.
- Increased/enhanced oil and gas recovery and recovery of hydrocarbons from abandoned and isolated fields. ONGC should be given a time-bound programme to acquire and deploy such technologies.
- Fuel-efficient vehicles. The automotive industry should be asked to achieve higher fuel efficiency standards in steps so as to reach efficiencies that are at least twice current levels. Companies reaching defined milestones first to be given large cash awards along with fiscal incentives based on outcomes.
- Hybrid vehicles and battery operated vehicles. Automotive industry to lead the efforts in commercialising these technologies. Large cash awards and fiscal incentives given based on outcomes.
- Off-shore wind potential to be tapped. Wind mill manufacturers to take lead in delivering a time-bound programme. GOI to provide fiscal incentives.
- Alternate routes to alcohol such as sweet sorghum should be promoted. Industries such as Praj and industrial alcohol users to compete for R&D funding and fiscal/cash rewards against defined outcomes.
- Promoting community bio-gas plants. The real potential of biogas is in community level plants. To have the willing participation of all the cattle owners in the community requires an appropriate operating strategy. Individual and community entrepreneurs should be encouraged to experiment with alternate strategies by providing land and finance. Industries should also be roped in to execute the programme through adoption of villages. Tax rebates to be provided on a graduated scale based on actual outcomes in the field.

9. The above list is neither a comprehensive list nor a mandatory one. It is an indicative list of technology areas relevant to India's needs. The primary idea is to conduct and fund research that is directed and outcome oriented. All funding made available and fiscal incentives provided should be linked to achievement of defined outcomes. Finally, a variety of institutions and individuals can be tapped but in a coordinated fashion to deliver defined outcomes.

10. In addition to the two types of technology missions, the NEF should also provide R&D support for application, innovation of new ideas, fundamental research etc., to researchers from different institution, universities, organisations and even individuals.

11. Such a R&D programme will require large number of trained researchers. However, a vigorous programme of research and teaching in academic institutions will itself attract students and, over time, relevant expertise will develop. A number of academic institutions should be developed as centres of excellence in energy research. Generous funding for fellowships for energy R&D may be provided to students pursuing post-graduate degrees.

12. Energy R&D, particularly that devoted to reduce green house gas emissions, has characteristics of global public good. India should link up with other countries and cooperate with international R&D initiatives. India's manpower strength in R&D can then be leveraged to get better results sooner and at lower cost. Joint research with shared IPRs could boost India's R&D efforts significantly. Also, with our growing and diversified energy market, R&D efforts can find quicker returns on successful commercialisation in India. Such a strategy would give India its appropriate place in global energy R&D.

Power Sector Policy

When India became independent in 1947, the country had a power generating capacity of 1362 MW. Generation and distribution of electricity was carried out primarily by private utility companies. A few of these are still in existence. Power was available only in a few urban centers; rural areas and villages did not have electricity supply.

2. The Electricity (Supply) Act, 1948, was enacted to facilitate faster power sector development and State Electricity Boards (SEBs) were set up in all the states to achieve the desired objective. All new generation, transmission and distribution came under the purview of SEBs. The creation of SEBs led to faster development of power sector in the country. However, financial constraints of the State Governments precluded the SEBs from adding the desired capacity to meet the growing demand. During the Fifth Plan period (1974-79) it was felt that Central Government should supplement state governments' efforts to expand the power system in order to ensure that the country achieves the desired economic growth. The National Thermal Power Corporation (NTPC) and National Hydroelectric Power Corporation Ltd. (NHPC) were set up in 1975 and North Eastern Electric Power Corporation Ltd. (NEEPCO) in 1976 to achieve this objective. Under the Department of Atomic Energy (DAE) the country's first Nuclear Power Plant was set up in 1969. Later in 1987 Nuclear Power Corporation of India Ltd (NPCIL) was set up by the DAE to develop nuclear power plants in the country. These Central Power Sector PSUs were responsible for their own transmission schemes till the National Power Transmission Corporation (POWERGRID) was created in 1989 with the responsibility of constructing, operating and maintaining the inter-state and inter-regional transmission system of the country.

3. Although the Central Public Sector units delivered their objectives to a satisfactory level, it soon became evident that the public sector dominance of this crucial sector was increasingly being seen as a weakness. Power sector reforms were initiated in 1991 to encourage competition and seek private participation in each sub element of the sector, namely generation, transmission and distribution. Fast Track private sector projects with Government guarantees followed by the Mega Power Policy were announced to attract large-scale private investment into the sector. These efforts did not bear fruit but the Government persisted and proceeded to usher in an independent and transparent regulatory regime. After the enactment of Regulatory Commissions Act, 1998, Central Electricity Regulatory Commission (CERC) was set up at the central level and twenty four states have either constituted or notified the constitution of State Electricity Regulatory Commissions (SERCs) since then. The SEBs of A.P., Orissa, Haryana, Karnataka, U.P., M.P., Uttaranchal, Delhi, Gujarat, Maharashtra, Rajasthan and Assam have been unbundled and corporatised.

4. Despite these reform initiatives, most of the SEBs continued to make financial losses because of an unsustainable level of aggregate technical and commercial losses. Unpaid dues of the Central Public Sector Units mounted and, by 2001, had crossed the Rs. 40,000 crore mark. These dues were seen as a major impediments to the reform process and were securitised under a tripartite agreement covering Central Sector Power Utilities, Coal India and Railways. The tripartite agreement guaranteed payments to these Central PSUs and used incentives to encourage commercial discipline and initiation of reform process in the States.

5. It has become increasingly evident that distribution reform holds the key to long-term

sustainability of the sector. Distribution has been privatised in Orissa and Delhi but results have been mixed, at best. The presence of the private sector, even today, remains limited to about 12% of generation and covers distribution in only a few cities. To encourage distribution reforms, the Accelerated Power Development and Reforms Programme (APDRP) was launched. APDRP supports distribution reforms in the states through investment support and incentives for lowering AT&C losses. APDRP set out to bring down AT&C losses to 15% by 2007 from an estimated level of 45% in 2002 and restore the financial health of SEBs. However, the performance of APDRP has fallen well short of the promise. Investment in the distribution sector remains low and the overall AT&C loss level continues to remain high.

6. As a result, power shortages remain a persistent problem. The inability to expand generating capacity, strengthen transmission networks and improve distribution systems reflect the financial sickness of SEBs. They do not have the resources to invest themselves nor have the credibility to attract private investors. The large AT&C losses are partly an outcome of neglect of investment in transmission & distribution (T&D) over the years. Substantial investments are needed in T&D. Simultaneously, changes have to be made to better manage the distribution of electricity. The problems of pilferage, misclassification of consumers, under/over billing and non-collection of bills would also need to be addressed. At the national level AT&C losses still exceeded 40 percent in the year 2004-05 (CEA 2005). The ratio of energy billed to energy available was a low 68 percent in 2004-05.

7. Among those that are billed for electricity are large number of farmers and domestic consumers who are subsidised. Cross subsidies from industrial and commercial consumers that were meant to fund the subsidies given to farmers and domestic consumers are, today, also funding the losses and the inefficiencies of the distribution companies. Less than 48 percent of the billed energy is sold to industrial and commercial consumers (including sales to public water works and railway traction). However, this 48 percent of billed energy yields over 70 percent of the actual revenue collected by the state utilities. The cross subsidies cannot be raised any further as they have reached a level where industries find it cheaper to set-up their own generating plants.

RESTRUCTURING OF APDRP

8. The problems with APDRP are: lack of baseline data to assign accountability and assess outcomes, poor preparation of projects as revealed by some independent assessment and a lack of incentives for the staff to reduce AT&C losses. APDRP needs to be restructured as follows:

- Introduce automatic meter reading (AMR) of all distribution transformers to track how much loss occurred in each area served by a transformer and establish accountability. Back this with a Geographical Information System (GIS) that maps the distribution system to facilitate power audits, pinpoint the offenders and improve customer service. Introduce an incentive scheme for staff whereby they share the additional revenue collected in their distribution circle.
- Data generated with AMR and GIS mapping can help split up AT&C losses into technical, billing, collection & theft and help in designing specific corrective actions and assigning responsibility and accountability. This data should be disseminated to the public to create support for corrective action.
- Bifurcate agricultural pumping load from the non-pumping load in all rural feeders. Use available technological options to limit and measure the amount of agricultural pumping energy provided
- For all loads above say 50 kWh, introduce intelligent meters that permit real time and remote recording of data and allow remote control over the power supplied by each meter. This would help effective management of

connected load and the reported pilferage by large consumers.

- Introduce time-of-day pricing with shift to electronic meters.
- All central assistance to state governments for the power sector must be linked exclusively to loss reduction and improved viability.
- The improvements listed above and the base line data generated as a result would bring greater transparency in the process of privatisation (if pursued) and provide a better estimate of the transition funding needs under outcome driven privatisation models that seek to restore the viability of distribution.

POWER SECTOR REFORM

9. Ideally, agricultural consumers should be metered and the subsidy should be given to the distribution utility by the State Government based on actual energy delivered. However, given the political reality where many Chief Minister's promise free power to farmers, separation of feeders is suggested as a second best solution. It will enable the distribution utility to ration agricultural consumers and to meet their requirement at off peak hours thus lowering the economic burden of free power to farmers and providing more accurate estimates of real agricultural consumption.

10. Privatising distribution is seen by some as an alternative solution to reducing AT&C losses. Based on experience worldwide, privatising utilities is definitely part of the solution. India's experience with privatising the Delhi and Orissa distribution has, however, raised as many questions as it has answered. Where privatisation is politically feasible, it should be done in a transparent manner based on authentic base-line data and through a genuine round of competitive bidding. There should be no shifting of the publicly announced terms of privatisation post bidding. The restructured APDRP can, in the very least, help create an authentic base line.

11. As the provisions of the Electricity Act, 2003 take root, the pace of reforms is likely to accelerate and private sector participation should become easier. The Act provides the basic framework for encouraging competition in the sector and creates open access to encourage private sector investments in each element of the electricity value chain. Moreover, it permits setting up of captive and group captive power plants without the clearance of the distribution utility and provides for wheeling power from the captive plants to captive consumers without any cross-subsidy surcharge. However, significant private sector participation and competition still elude the sector. While movement of the reform process is in the right direction, actual achievements have been minimal.

12. Worldwide, the efforts in introducing competition and in deregulating the power sector have yielded mixed signals. Emphasis on competition has, in several countries, highlighted the limitations of open market orientation, unbundling and open access. The resulting stress on capacity creation especially in transmission, loss of price stability, uneven sharing of benefits between large and small consumers, high institutional and transaction costs etc. have together created support for integrated utilities with monopolies in licensed geographical areas. The question being asked today by some is if well-functioning regulation that creates capacity through competition is not a better answer than totally free competition that permits full access to consumers. It has been seen worldwide that spot markets, power pools, retail choices, etc. require an elaborate and often expensive institutional and regulatory framework without which the benefits are difficult to achieve. Similarly worldwide experience shows that privatisation in the electricity sector can certainly help but may not be necessary or sufficient to effect transformation.

13. It might be argued that in the electricity sector competition should be encouraged, where appropriate, rather than taking it as a default principle. The lumpy investments needed to create capacity, the relatively large incremental step when new capacity is added, the gestation

lag in creating additional capacity and environmental and logistical issues create hurdles to perfect competition in the power sector with available technology choices. This could change in the future. Specifically with respect to India, management reforms (particularly in the distribution sub-sector) are as important as a liberal captive and open access regime driven by a desire to create competition in the power sector. While it might be utopian to assume that perfect regulation could substitute competition, it is unambiguously clear that regulation will indeed expand once competition sets in. It is equally unrealistic to assume that perfect competition can be introduced in the power sector in a short time. The key for India might be effective stakeholder involvement for successful regulation. This may go as far as appointing an office of "Consumer Advocate" at the state level. Again, while privatisation is one possible option for distribution, it cannot be a pre-requisite or a necessary consequence of APDRP restructuring. The door for reform under public ownership must be left open.

14. The above should not be read as a vote against entry of private sector into the power sector or negating the benefits of competition. As stated above, competition is very much possible in each element of the electricity value chain under a well-functioning regulatory regime. In the context of India, the strength of the dominant public sector can be effectively leveraged to introduce competition that extracts efficiency gains in generation, transmission and distribution.

15. Capacity expansion is currently done mainly by the Central PSUs who have been insulated from payment problems by the Tripartite Agreement (TPA) involving SEBs, State Government and Reserve Bank of India. The TPA protects payments to Central Power Sector PSUs, Railways and Coal India through recourse to the account of the state governments with the Reserve Bank of India. Although the TPA came into existence in 2001 in the context of past dues of state governments to Central Power Sector PSUs, Railway and Coal India; it has been applied also to all new capacity created by Central Power Sector PSUs, Railway and Coal India since then. The states have been maintaining payment discipline vis-à-vis Central Power Sector PSUs, but the long-term viability of the arrangement is questionable, particularly as the share of Central Power Sector PSUs in power generation keeps on increasing. There is, thus, an inescapable need to reform the power sector.

REDUCTION IN COST OF POWER

16. There is at present no level playing field between Central Power Sector PSUs and others. The tariff of the Central Power Sector PSUs is determined on the basis of costs and norms with a guaranteed 14/16% post tax return on equity. This tariff determination regime gives little incentive to be efficient. The private sector generators do not get the comfort of the payment security mechanism available to Central Power Sector PSUs under the TPA and the State power utilities do not get the assured post tax returns.

- In cases where tariff continues to be determined on the basis of costs and norms, regulators may either adopt a return on equity approach or return on capital approach, whichever is considered better in the interest of consumers. In deciding the level of return provided, the regulator should *inter-alia* take into account the return available on long-term government bonds and reasonable risk premiums associated with equity investments.
- Distribution should be bid out on the basis of a distribution margin or paid for by a regulated distribution charge determined on a cost plus basis including a profit mark up similar to that described above.
- All generation and transmission projects (with the exception of one time capacity expansion of up to 50% of installed capacity of a generating plant) should be competitively built on the basis of tariff-based bidding. Public Sector Undertakings shall also be encouraged to participate in such bids even though the tariff policy allows them a 5 year window wherein projects undertaken

by the public sector need not be bid competitively.

- The liberal captive and group captive regime foreseen under Electricity Act, 2003, should be realised on the ground. India's liberal captive regime will not only derive economic benefits from availability of distributed generation but set competitive wheeling charges to supply power to group captive consumers. This will pave the way for open access to distribution networks.
- The Ministry of Power (MOP) should facilitate large-scale capacity addition (20,000 MW or more) to meet identified demands of beneficiary states through international competitive bidding. Bulk orders of this size, to be delivered over a given time frame, can, if executed properly, be used to: (a) lower capital costs; (b) introduce plants that deliver internationally comparable conversion efficiencies; (c) promote coastal locations with dedicated facilities for handling domestic coal transported by sea or imported coal; (d) realise internationally comparable emission standards; and (e) under certain circumstances, create new domestic manufacturing and engineering capacity to build power plants. Since the projected capacity additions over the next 25 years are more than 6,00,000 MW, there is no danger of pre-empting future competition or limiting technology options by such bulk purchases.
- Any subsidy given to poor households or farmers should be funded by the State Government through its budget.

REGULATOR

- Existing projects and future investments that are not competitively bid must comply with CERC's tariff guidelines. States that do not comply should be made ineligible for Central Sector support for their power sector.
- Operationalise the flexible and enabling captive regime foreseen under the Electricity Act and provide consumer choice through open access. This requires the development of normative wheeling and distribution costs at different voltages by respective Regulators, the introduction of time-of-day pricing at the bulk and retail levels, and the identification of cross subsidies embedded in the cost of supply in each distribution circle. Time-of-day tariff may make gas-fired peaking stations economical.
- Electricity prices are currently set by State Electricity Regulatory Commissions on cost plus basis. Regulators should set tariffs for a number of years and differentiate them by time of day.
- Respective Regulators should adapt best international practices that reward utilities for seeking: (i) distributed generation with waste heat recovery where feasible; (ii) demand side management; and (iii) energy conservation and energy efficiency technology adoption through Negawatt incentives.
- Regulators must establish feed-in-tariffs for power from renewable energy sources. The feed-in-tariffs should also provide time-of-day benefits to renewable energy supplies.

17. Other policy initiatives needed are:

Transmission and Distribution

- Separate content from carriage in both transmission and distribution. Regulated caps for: (i) wheeling charges at different transmission voltages; and (ii) distribution margins for consumers at different voltage levels must be introduced. Competition should be introduced in building transmission capacity on the basis of wheeling tariffs and in distribution on the basis of distribution margins.
- Inter-state transmission networks

should be managed by a regulated monopoly. Transmission lines critical for inter-state flows of power and for system stability should also be managed by the central body, even if it is entirely within one state.

- Independent and/or fully transparent load dispatch is required at regional and state levels to ensure a level playing field among competing common carriers. An independent planning body for transmission networks is necessary to ensure proper development of such networks.

Rural Electrification and Distributed Generation

- Require the State Governments to notify rural areas as required by the Electricity Act, 2003. Such notification could assist the emergence of independent rural suppliers of electricity thereby enhancing access for both household and productive uses. Many remote villages may be provided electricity and energy security through locally available renewable resources.
- To facilitate distributed generation and encourage generation by renewables, make grid connections for feeding in surplus power to the grid, at the grid's avoided cost, mandatory. In order that this does not jeopardise grid stability, variable frequency transformers for asynchronous network connections may be used along with appropriate grid management.
- To set up off-grid or distributed generation facilities in rural areas, encourage the organised sector to adopt rural communities in their areas of operation. They can build local capacities to operate such plants and eventually transfer the plants to local groups.
- Ensure sustainable revenue models for rural electrification programmes. Without such revenue models programmes such as RGGVY are unlikely to be sustainable.

Adding Domestic Manufacturing and Engineering Capacity

- The available manufacturing and engineering capacity in the country is grossly inadequate to support the ambitious capacity addition programme in thermal, hydro, nuclear, renewable and T&D sectors. There is an urgent need to create these capacities, preferably in the private sector.

18. In order to avoid power shortages and take timely action annual electricity requirements should be projected and year-wise targets for generation capacity be set for seven years. Each project, public or private, should be monitored along with a number of milestones. This will help entrepreneurs to take timely decisions to invest.

Coal Sector Policy

The origin of coal mining in India dates back to 1774. Demand for coal started rising mainly for use by the railways after 1885 and coal production reached a level of over six million tonne per annum by the beginning of twentieth century. Coal mining was predominantly done by the private sector and pricing was market driven. A surge in demand was witnessed during the First World War, which multiplied many-fold during the Second World War. Government control over prices, production and distribution was imposed upon the coal industry during this period by the Colliery Control Order, 1944 modified under the Essential Commodities Act, 1946 and it remained in force even after independence. By 1950, coal output had risen to about 32 Mt and Railways continued to be the single largest consumer (31%) followed by Iron & Steel and brass foundries (14%), brick kilns (9%), power utilities (7%), cotton mills (7%), others (32%) including colliery consumption (11%).

2. The Coal Board was set up in 1951 for the conservation of coal resources and safety of mines under Coal Mines (Conservation & Safety) Act, 1952. The Mines & Minerals (Regulation & Development) Act, 1948, was consolidated in 1957 to deal with procedures for granting and operating mineral concessions and prescribing royalties to State Governments. Also, the Mines Act, 1923, enforcing safety in mines and welfare of miners was replaced by a more comprehensive act in 1952.

3. After independence, the Government passed an Industrial Policy Resolution in April, 1956 thereby including coal in the list of industries earmarked for development in the public sector and the National Coal Development Corporation (NCDC) was created in 1956 to carry on coal mining in the public sector. The Coal Bearing Areas (Acquisition & Development) Act was enacted in 1957 to help NCDC acquire coal bearing land in various states.

4. Coal mining by the private sector led to a situation wherein there were a number of small pits, which functioned with little regard to conservation, safety of workers and use of scientific methods of development. This led to hazardous working conditions and loss of coal. Recognising these, the coal industry was nationalised in two phases - coking coal in May 1972, and non-coking coal in May 1973. A holding company, Coal India Limited (CIL), was formed in November 1975, with several coal producing subsidiary companies based on geographical location of coalfields and one company dedicated to mine planning and design. Mines belonging to NCDC were merged with different subsidiary companies. Tata Iron & Steel Company in private sector and Indian Iron & Steel Company and the Damodar Valley Corporation under the public sector continued to operate their captive mines. Singareni Collieries Company Ltd. is the oldest public sector coal company under the administrative control of Government of Andhra Pradesh with an equity share of 51%. The balance 49% belongs to the Government of India.

5. Lignite development was pursued through a public sector enterprise, the Neyveli Lignite Corporation Ltd. (NLC) established in 1956. Besides NLC, lignite is also being mined by the State PSUs of Gujarat and Rajasthan.

6. Geological Survey of India (GSI) is vested with the responsibility of regional exploration for coal. Mineral Exploration Corporation Ltd. (MECL), Central Mine Planning & Design Institution Ltd. (CMPDIL) & Geological Survey of India (GSI) have been identified for undertaking promotional explorations to supplement regional explorations with a view to expedite

exploratory efforts for coal and lignite. Detailed exploration is being carried out primarily by MECL & CMPDIL on behalf of the coal companies. Some of the mining and geological corporations of the State Governments are also taking up coal exploration on their own.

7. Coal consumption in the country has been rising steadily and in 2005-06 India consumed some 432 Mt of coal. This included import of 17 Mt of metallurgical coal and 20 Mt of thermal coal. Given limited reserves of high grade metallurgical coal and the high cost of underground mining, India currently imports about 66% of its requirement of metallurgical coal. Thermal coal imports are not significant. However, the quality of domestic thermal coal has deteriorated over the years due to the increased reliance on the more cost-effective opencast mining. The improvement in overall labour productivity has been marginal primarily because the mechanisation of underground mines has not been successful to a large extent. The Industry also continues to face problems in regard to land acquisition and rehabilitation.

8. Following the economic reforms instituted in 1991, the private sector has been allowed to mine coal for captive consumption under the Captive Mining Policy of 1993. The captive mining policy allowed allocation of blocks to designated end-users for mining coal for their own use. The current list of authorised end-uses includes power, steel and cement producers. FDI was permitted in coal mining, and joint ventures were also permitted. A large number of coal blocks stand allocated to private entrepreneurs for developing captive mines but only few of these mines have started production. The captive mining policy has significant hurdles and has not been a success, so far, either in raising domestic production or in increasing the number of domestic producers. State Government Corporations and CPSUs are permitted under the Coal Mines (Nationalisation) Act to take up coal mining at par with CIL. Some state governments like Jharkhand and J&K operate small mines.

9. In line with the economic reforms aimed at raising the level of competition in various core sectors, the government proposed to allow private participation in commercial coal mining. A Bill was introduced in the Parliament in April, 2000, to amend the provisions of Coal Mines (Nationalisation) Act, 1973, for facilitating private participation in commercial coal mining. The Bill proposes to open up the coal sector to private investment, but it does not have the requisite political support for passage. While waiting for the April 2000 Bill to be enacted by the Parliament, the Government is trying to remove the barriers to captive mining under the current law.

10. Keeping in view the railway infrastructure, distribution of coal among various user industries and movement plans are controlled through a mechanism of linkages. A long-term and short-term linkage committee allocates coal to various core industries such as power, steel, cement etc. The linkage committee, an inter-ministerial group, evaluates the requirement of coal by consumers at the planning stage and links it to what seems like a rational source from a long-term perspective after examining factors like quantity and quality required, time frame, location of the consuming plants, transport logistics and the development plan for the coal mine. Unfortunately, the linkages remain frozen, and as mines and users develop, they no longer remain rational.

11. Coal prices were decontrolled totally from the 1st of January, 2000 after scrapping Colliery Control Order 1946; and coal producing companies (CIL and SCCL) fixed prices on their own and revised the same periodically based on an escalation formula under a cost plus approach. As a result, coal prices have been revised several times in the recent past. Decontrolling price in a monopolistic situation is adversely affecting the interest of consumers. In the absence of a coal market with competing suppliers, there is a need to develop a transparent mechanism for pricing domestic coal.

12. Currently there is no competition in the coal sector and the public sector monopoly continues. No regulatory framework is available and in such a situation grievance redressal for

consumers, particularly in regard to price/ quality disputes, is difficult. To raise the commercial performance of the industry to meet international standards and to sustain the projected growth of energy sector, it is important to address these issues.

13. Coal accounts for over 50% of India's commercial energy consumption and some 78% of domestic coal production is dedicated to power generation. Since prices were de-controlled, the sector has become profitable primarily as a result of price increases and the rising share of the more remunerative open cast production. The sector has also recorded improvements in productivity but despite these improvements, the coal sector scores poorly against international comparators because of excessive manpower, poor project formulation, inefficient procurement, poor accounting and financial management systems, low productivity etc. Despite these inefficiencies domestic coal is internationally competitive at mine-mouth. In fact, coal at the mine-mouth is the only primary or secondary form of energy in which India is internationally competitive. Another positive for the coal sector is its good safety record when compared with international experience.

14. A concern often voiced for India's coal sector is the inefficient exploitation of the in-place coal reserves and the lack of control on mining practices that could potentially be sterilising significant parts of existing reserves. Driven by short-run maximisation of economic benefits if coal is mined in an open cast mine only to the depth of 150 metres, and the overburden is used to fill up the void, coal lying in the lower horizon and reserves below 150 metres depth in the same horizon, then get practically sterilised as it would be even more uneconomic for subsequent exploitation using conventional mining technologies. At current levels of production growth, the known extractable reserves will be exhausted in less than 45 years. A large part of India's coal reserves may not be extractable with current mining technologies. India must, thus, lead the way for extracting this energy through in-situ coal gasification in the interest of her energy security.

15. Primary energy from the coal resources can be augmented if mining plans exploit coal efficiently and if coal bed methane as well as mine-mouth methane is captured and used. The needed technology is globally available but has to be adapted to Indian conditions. Similarly in-situ coal gasification can use coal that is difficult to recover with conventional mining. Technology for in-situ gasification needs to be developed.

16. Most of India's coal resources - proved, indicated and inferred - are said to be within 300 meter depth. There is a concern that this is an outcome of insufficient exploration of deposits below 300 meters and a sense that exploiting coal below that depth with conventional mining is, in any event, uneconomical for low quality coal. Detailed coal exploration is almost exclusively done by CMPDIL, which is a subsidiary of CIL. Concern has been raised about CMPDIL's independence under this structure. Moreover, CMPDIL's drilling capacity is limited and this has resulted in a limited detailed exploration programme for proving reserves. CMPDIL should be made an autonomous institute. Its capacity should be strengthened and exploration for coal should be opened up to others just as exploration for petroleum has been opened up.

17. Enlarging the coal resource base is important to meet coal requirements. Under the various scenarios coal requirement is projected from a low of 1580 Mt to high of 2555 Mt for 2031-32 and about 1128 to 1870 Mt for 2026-27. Coal India Ltd. has targeted a maximum production of 839 Mt by 2025 in its 'Vision 2025' document. Clearly, if India is to avoid large-scale imports of coal, not only does India need to increase the pace of growth in coal production but also raise coal production targets significantly. What this requires is to: (a) increase the number of players in coal mining; (b) since Coal India currently has blocks with 70% of the proven reserves, de-block those blocks that Coal India does not propose to bring into production by 2016-17 and assign them to captive users with a condition that these blocks be brought into production by 2011-12; and (c) raise the

exploration effort significantly to prove additional reserves.

18. Building domestic capacity for mining equipment and significantly raising domestic engineering capacity is necessary to achieve the projected level of production.

19. India is the third largest coal producer in the world but remains a marginal player in international coal markets. Even domestically, there is an absence of a coal market with bulk of the sale taking place under a system of coal linkages based on available rail capacity. Pit-head prices of coal are set by Coal India, the monopoly producer. Railways, another Government monopoly, cross subsidises passenger traffic with coal freight thereby making delivered price of coal 2-4 times the pit-head price of coal in states such as Punjab, Haryana, Rajasthan, Gujarat, Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu, Western U.P. & Delhi.

20. The constrained supply of thermal coal and the projected requirement of thermal coal suggest the need to import coal. By the end of the 11th Plan India's import needs could rise to 50-60 million tonnes of high quality thermal coal. Import of coal will also put a competitive pressure on the domestic coal industry to be efficient. No significant import of thermal coal is evident in the near future despite the fact that long-term import contracts would make imported coal competitive against domestic coal at coastal locations in the above states. The reason for this is the absence of coastal power plants, inadequate port capacity and the need to trans-ship imported coal on domestic rail/road linkages to consumption points. While power generated at pithead and delivered through HVDC transmission lines can be cheaper than power generated from imported coal at coastal location, there is a limit to the amount of generation that can be done at pithead due to environmental considerations. Coastal power plants based on imported coal thus have an economic space (*see BOX 11.1*). Thus India must:

- Encourage coastal power plants based on imported coal.
- Develop the needed infrastructure for coal imports.

21. Unlike in the rest of the world, coal in India is sold without any "preparation" or "dressing". Simple deshaling, improved mining procedures and sizing of coal could bring down the average ash content of Indian coal to around 35% from the current level of over 40%. Full washing could reduce the ash content further, thereby saving transport costs and resulting in more efficient power plant design and operation. Only a small fraction of thermal coal is actually "washed" in India. One of the hurdles to washing is the prevailing unique practice of pricing coal on grades based on wide bands of Useful Heat Value (UHV) instead of the fully variable system based on the more precise Gross Calorific Value (GCV) as done in the rest of the world.

22. In the light of the foregoing, the sector is in serious need for market based reforms. The following policy initiatives are suggested:

Policies not requiring legislative amendments:

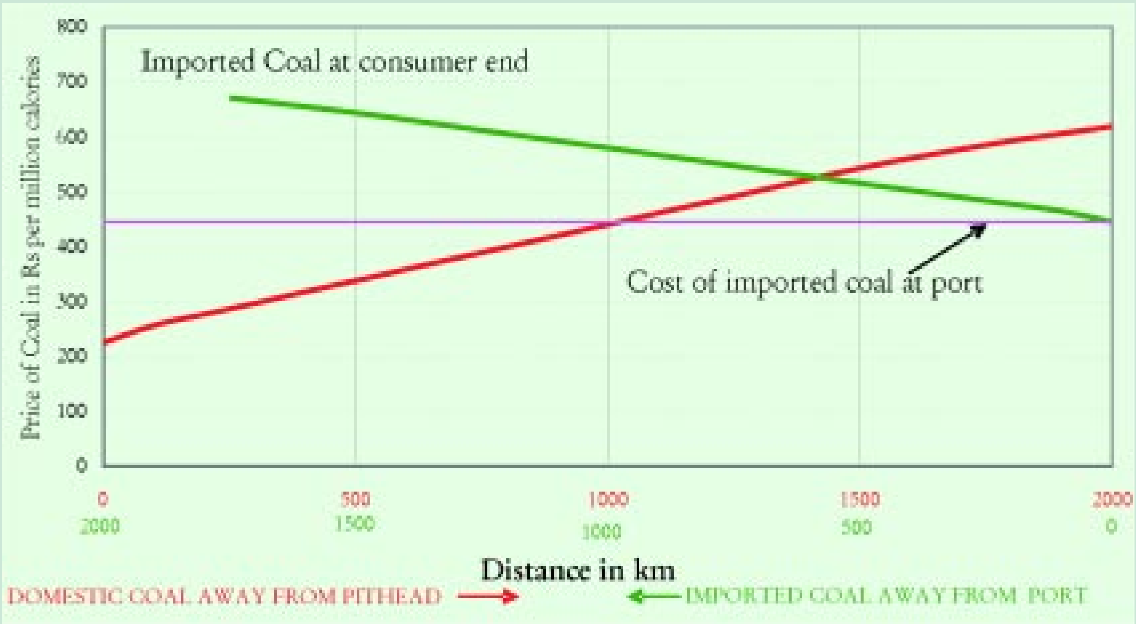
Increasing Number of Coal Producers

- Pending the passage of the Coal Mines (Nationalisation) Amendment Bill, 2000, the number of players in coal mining should be increased through avenues available under the existing legislation that permits mining by state governments, public sector companies and for captive use by recognised end-users (power, steel and cement). Captive block holders must be permitted to sell incidental coal surpluses during the development and operation of a block to CIL. Group-captive mines should be allowed for small end-users, and a target must be set for the Ministry of Coal to achieve at least 100 Mt of captive production by 2012.
- Coal blocks held by Coal India Limited (CIL) that cannot be brought into production by 2016-17, either directly or through joint ventures, should be

BOX 11.1

Delivered Cost of Domestic and Imported Thermal Coal

Most of the domestic coal supplies to power sector fall under Grade E and F having average delivered calorific value of 3500 kcal/kg against at least 6000 kcal/kg of imported coal. Domestic and imported coal in terms of cost per million kilo calories of delivered heat value at the consumer end were compared. It may be seen that the delivered cost of the power grade Indian coal exceeds the cost of imported coal at port when transported to consumers beyond 1000 km. Further, imported coal is the cheaper option even with inland transportation of some 500 km if domestic coal has to travel beyond 1400 km to reach the consumer.



Assumptions:

Domestic coal from mine to consumer and imported coal from port to consumer are being transported by rail. Landed CIF price of imported coal having GCV of 6000 kcal/kg is taken as US$60. Exchange rate assumed is Rs 44.50 per US$. Domestic coal price includes weighted average notified price of coal for the respective grades, royalty, stowing excise duty, transportation charges from mine to railway siding, central sales tax and rail freight. Landed price of imported coal at port includes all applicable taxes and duties. However cost of handling imported coal at the Indian port and transporting it to the railway siding for inland transportation is not included. If this is done, the economical distance to which imported coal can be transported inland will reduce further.

made available to other eligible candidates for development with the condition that they be brought into production by 2011-12. Allottees of captive blocks in general should be required to work the block within a specified time limit failing which allotment should be cancelled and/or a pre-agreed penalty imposed.

- The gestation periods for the end-use project may be different than that of the coal mine. To ensure that both the mine and the end-use project are developed in a cost-effective manner the innovative use of short-term linkages can be made. This must be linked with strictly enforced guarantees that back performance related to both the end-use project and the captive mine.

- Transfer pricing of coal from captive mines needs to be established both for the sake of assessing coal royalties as well as tariffs in a regulated sector such as power wherein coal cost is a pass through. Even if power tariff is determined on the basis of competitive bidding, transfer price would be needed to assess state levies/royalties.

Pricing of Coal

- Ideally coal price should be determined in a competitive market. This, however, is not possible as long as the number of suppliers are limited and as long as for the largest coal consuming sector, i.e. power, coal cost is passed through and fully compensated in determining electricity tariff. However, since other users of coal are numerous and consume substantial quantities of coal, a strategy for competitive price discovery is possible. We recommend as follows:
  - High quality coking and non-coking coals which are exportable may be sold at export parity prices as determined by import price at the nearest port minus 15%. This practise is currently being adopted satisfactorily for supply of good quality coking coal to the steel industry.
  - 20% of the total coal produced should be sold through e-auctions. For e-auctions to be successful, CIL should, directly or otherwise, ensure availability of coal and offer it for sale to meet the total demand. Quantities to be sold through e-auction from different mines must be determined annually with a monthly mine-wise schedule to be independently monitored and enforced by a coal regulator.
  - Remaining coal should be sold under long-term Fuel Supply and Transport Agreements (FSTAs). Regulated utilities should be allowed upto 100% of their certified requirements through FSTAs. Other bulk consumers may be allowed partial FSTAs based on coal availability. Any shortfalls in requirement not covered by FSTAs should be met through e-auction supplies or imports.
  - Pithead price of coal under FSTAs should be revised annually by a coal regulator on a basis that *inter-alia* take into account prices obtained through e-auction, FOB price of imported coal (both adjusted for quality) and domestic production cost, inclusive of return based on efficiency standards.
- Replace the practice of grading coal under wide bands of the empirically determined UHV by the international practice of grading coal based on GCV. This is expected to encourage efficient use of coal and promote use of washed coal.
- Coal prices should be made fully variable based on Gross Calorific Value (GCV) and other quality parameters.

Reducing Coal Cost

- Rail freight rates for coal transport should be rationalised. Cross subsidy surcharges imposed on freight traffic to benefit passenger fares must be reduced. Alternate means for moving coal through coastal shipping, river/ canal movement and coal slurry through pipeline must be promoted where feasible.
- Infrastructure status should be extended to the coal industry. Duties on capital goods imported for coalmines must be lowered to put them at par with duties on imports for other energy sub-sectors.
- There is a need to improve governance for dealing with malpractices and corruption in the coal industry. It is common knowledge that there is a

significant black market for coal obtained through pilferage and illegal mining of abandoned mines worked by local inhabitants. Apart from the loss of royalty to the state there is, more importantly, loss of precious lives resulting from unsafe mining practices.

- Coal companies should be required as per international practice to "prepare" and "dress" coal prior to sale.

Facilitating production

- Strategies for matching the growth of infrastructure needed for movement of coal to load centres should be aligned with the growth of coal industry.
- Wherever the techno-economic parameters of the geological resource demands development of underground mine, related technology must be encouraged by giving incentives to operators because underground mining helps preserve the land form and extract deep seated resource.
- National Rehabilitation and Resettlement Policy for people affected by coal/lignite mining projects should be mooted. Such policy should be acceptable to all state governments.
- Grounding coal projects is often delayed due to environmental regulations and delays in getting approval for the project's Environmental Management Plan (EMP). Simplification of procedures, preparation of comprehensive EMPs and demonstration of environmental responsibility on the ground can help reduce such delays. A reserve of compensatory afforestation built in advance should be accepted against specific project-wise commitments to reduce such delays.
- Notify in-situ coal gasification and coal liquefaction as end-uses under the current captive consumption policy. This will encourage private enterprise to invest in development of these new technologies.

Regulation

- Institute an independent regulatory body to regulate upstream allotment and exploitation of available coal blocks to yield coal, coal bed methane, mine mouth methane, coal to liquid and for in-situ coal gasification. The proposed Regulatory Body would, as an interim measure, approve coal price revisions, ensure supply of coal to the power sector under commercially driven long-term FSTAs, facilitate the development of formulae/indices for resetting coal prices under long-term fuel supply agreements, monitor the functioning of the proposed e-auctions, ensure that the price discovery through e-auctions is free of distortions, regulate trading margins, develop a mechanism for adequate quantities of coal imports under long-term contracts to bridge the gap between supply and demand thereby assuring that the e-auctions and consequent price discovery does not take place in a supply constrained market and, finally, create the environment for a competitive coal market to operate. Once the market matures, all large consumers (including power) will become part of a competitive coal market with purchases through both long-term FSTAs and e-auctions. It is stressed that once a competitive market develops the role of Regulator in determining the prices would become one of merely ensuring a free and transparent market for coal. A key responsibility of the Regulator would be to make India, with the third largest reserves of coal in the world, a long-term player in the highly liquid international market for coal that realises long-term trades under well-tested indices such as the Japan coal import index.
- The proposed Regulator must facilitate replacement of current coal linkages for power plants with FSTAs. As a step towards abolishing coal linkages completely, these linkages could be made tradable in the first instance. This

is expected to make coal movements more optimal and responsive to market forces.

- The Regulator must ensure that mines are planned, designed and developed in a scientific manner giving due importance to coal conservation thereby maximising percentage of coal recovery from geological blocks.
- The Regulator must standardise norms of operation, establish benchmarks and ensure that coal companies raise their level of competence to be at par with international standards.

Policies requiring legislative amendments:

- Amend Section 3 of the Coal Mines (Nationalisation) Act, 1973 to facilitate (a) private participation in coal mining for purposes other than those specified and (b) offering of future coal blocks to potential entrepreneurs through competitive bidding.
- Raise the domestic level of trading and marketing of coal by removing it from the list of essential commodities.
- Amend the provisions of Contract Labour (Regulation & Abolition) Act, 1970 to facilitate offloading of certain activities in coal mining for improved economics of operations.

Oil and Gas Sector Policy

The Indian Petroleum industry is one of the oldest in the world. Oil was struck at Makum near Margherita in Assam in 1867. The industry has come a long way since then. At the time of independence in 1947, the country produced about 0.25 Mt of crude oil in Assam and refined 0.23 Mt of crude oil. Digboi was the only refinery and the market infrastructure was confined to urban and well populated areas.

2. The Indian petroleum industry in the post independence period (1947-2005) has passed through three distinct phases

- Early phase (1947 to 1969)
- Development phase (1970 to 1990)
- The economic liberalisation phase (1991-2005)

3. Historically, the Indian petroleum industry was controlled by few Anglo-American companies. They maintained their dominance till the end of 1950s. After independence, the newly independent state wanted to play a significant role in this vital industry. The industry policy resolutions of 1948 and 1956 had clearly stated the government's aspiration and future plans for core industries like petroleum. All future development of the petroleum industry was reserved for public sector undertakings. But foreign assistance was a necessity at least in the early stages. It was recognised that majority ownership and effective control of critical industries like petroleum should always rest in Indian hands and the need for developing an independent and self-reliant petroleum industry was felt. The industrial Policy Resolution of 1956 specifically increased the role of public enterprises, and led to the creation of Oil & Natural Gas Commission (ONGC), for exploration and production, and Indian Oil Corporation (IOC) for refining and marketing. The Government took over the multinational controlled petroleum companies like Burmah Shell, Esso and Caltex between 1974-79. Oil India limited (OIL) which was a Joint Venture Company with equal share of Burmah Oil Company and Government of India became a wholly owned PSU in 1981.

4. The steep increase in oil prices during 1973-74 and hardly any increase in indigenous production of crude oil put a heavy burden on the economy due to an escalating import bill. To meet this challenge, augmentation of indigenous production of hydrocarbons and their accelerated exploitation became the key element of planning and development strategies. Both ONGC and OIL took up the challenge and formulated ambitious exploration programmes. The exploration efforts yielded results in the form of discoveries of oil and gas in a number of fields in the Bombay Off-shore area. Oil was struck in Bombay High in 1974. This led to substantial increase in the production of crude oil thereby reducing the oil import bill considerably. Another prominent discovery was the South Bassein gas field. Exploration was extended to other offshore areas like the Eastern coast and off the Andaman Islands, with varying degrees of success.

5. The liberalisation and globalisation processes started in 1991 have thrown up many opportunities and challenges for the Petroleum & Natural Gas Sector in India. To increase domestic production of crude oil and natural gas, the New Exploration Licensing Policy (NELP) was launched in 1997-98. 110 blocks have been awarded under the five bidding rounds under this policy. The sixth round of bidding (NELP-VI) for 55 blocks has recently been announced. The acquisition of equity oil & gas abroad in a number of countries is also

being pursued by both PSUs and Private Sector companies. In order to meet the shortfall in the demand of natural gas, imports from Iran, Myanmar and Central Asian Countries through transnational pipelines are being pursued. The import of gas in the form of liquefied natural gas (LNG) has already started at the Dahej LNG terminal in 2005. Other avenues for import of LNG are also being explored.

6. The consumption for petroleum products including refinery fuels grew from 2.72 Mt in 1947 to 120.17 Mt in 2004-05. Excluding refinery fuels, the consumption of petroleum products in 2004-05 was 111.59 Mt. India exported 18.21 Mt of products in 2004-05 and product exports have risen to 21.5 Mt in 2005-06. However, domestic consumption in 2005-06 rose only marginally to reach 111.92 Mt. India is now a net exporter of petroleum products. The crude oil production, which had increased from merely 0.25 Mt in 1947-48 to 33.02 Mt by 1990-91, has stagnated since then. The balance requirement has been met through imports. With the setting up of a number of refineries over the years, the country is self-sufficient in its refining capacity which currently stands at 132.47 Mt. A number of refineries are either expanding their capacity or planning new investments with a view to export products. Net of export, domestic production of crude met about 28% of the country's requirement and the balance 72% was imported in 2004-05. With the increasing prices of crude oil in the international market, the oil import bill and oil security are causes of concern. To reduce the gap between demand and supply, in addition to enhanced production of crude oil & natural gas, the oil companies are seeking opportunities to tap coal bed methane, blend motor spirit with ethanol and promote bio-diesel as a diesel substitute and/or for blending with diesel. However, these efforts have yet to make any impact.

7. With a view to create competition, new entrants are being allowed to market transportation fuels namely, motor spirit, high speed diesel and aviation turbine fuel since March, 2002. The Government has issued retail licenses to Reliance Industries, Essar Oil, Shell, ONGC, Mangalore Refineries & Petrochemicals Limited and the Numaligarh Refinery.

8. With the recent discoveries in the Krishna-Godavari basin, domestic natural gas is expected to become the second most dominant commercial energy source in India. Efforts are being made to raise import of natural gas in the form of LNG and through transnational gas pipelines. The rising price of natural gas, though, would make it uncompetitive for use in the power sector.

9. Till 1975, the prices of petroleum products were based on import parity prices. Based on the recommendation of the Oil Price Committee of 1976, the Administered Price Mechanism (based on a retention pricing concept) was introduced. This mechanism was dismantled in a phased manner starting October, 1998 to 31st March, 2002. From 1st April, 2002, the prices of petroleum products except domestic LPG and Kerosene for Public Distribution System (PDS) are again being fixed on an import parity basis. However, with the recent steep increase in the prices of crude, the government has put on hold the increase in prices by the oil companies. The issue of pricing of petroleum products is under review.

10. With a view to protect the poorer section of the society; subsidies on kerosene and Liquefied Petroleum Gas (LPG) had been introduced. These subsidies were to be phased out by 31st March 2002, but this was not done. A flat subsidy rate under "PDS Kerosene and Domestic LPG Subsidy Scheme, 2002" was approved. The subsidy was equal to the difference between the cost price and issue price as on March 31st, 2002 and was to be phased out in 3 to 5 years. The oil marketing companies (OMCs) were to adjust the retail selling prices of these products in line with international prices during this period. Again, this has not been done and with the unprecedented sharp increase in the international prices, the under recoveries of OMCs on these accounts have been rising and seriously affecting their profitability. The Government has been making good these losses, in part, by asking upstream companies to offer

discounts on the price of domestic crude and by issuing GOI bonds to the oil marketing companies.

11. The petroleum and gas sector is also devoid of any competition or independent oversight of either its upstream or the downstream activities. Despite the dismantling of the Administered Price Mechanism, the GOI continues to control the pricing of automotive fuels, LPG, a large part of domestic natural gas, and PDS kerosene. Again despite the presence of several domestic, public and private players as also some foreign groups, there is no real competition in the sector except in peripheral products such as lubricants. In fact, the prevailing pricing & taxation policies and the market structure provide significant protection to refineries. The result is that India's refining capacity exceeds the demand by 18% already.

12. Competition is limited in the downstream sector to cornering retail outlets and is often wasteful. Efficiencies in retailing can only be realised if companies are allowed to set their own prices and entry barriers for new entrants are dismantled. These barriers currently include minimum investment requirements and lack of open access to certain marketing infrastructure. The Petroleum & Natural Gas Regulatory Board Act, 2006 has already been notified and should, hopefully, raise the level of competition in the sector on level terms.

13. On the upstream side, the dominance of the public sector continues although in recent rounds of bidding under New Exploration Licensing Policy (NELP) domestic private sector and state sector participation and, to a more limited extent, foreign participation has emerged. India's currently known oil and gas reserves will be exhausted in 23 years and 38 years respectively at current production levels. While exploration has not resulted in any significant new oil find, large gas finds have been reported though uncertainty still prevails with respect to precise gas availability. The current upstream regulation provided by DGH is neither independent nor comprehensive in a technical sense with respect to optimal development of the hydrocarbon resources.

14. Given its lack of success in finding oil and gas in the Indian sedimentary basin, ONGC has been successfully acquiring equity oil and gas overseas. While these are largely commercial opportunities, they do help energy security concerns to the extent that they increase access to a more diversified supply base under certain eventualities. Indian Oil Corporation has also successfully tapped retailing and refining opportunities overseas. Other players have also looked at various opportunities overseas but with little success. The risks of the overseas operations are largely being carried on the balance sheets of the parent Indian companies.

15. The following policy initiatives are suggested for the oil and gas sector:

Pricing of Petroleum Products

- Full price competition at the refinery gate and at the retail level for all petroleum products should be pursued. Differential pricing in different markets may be permitted to reflect the cost of supply. State governments may choose to subsidise prices in remote areas in a transparent manner through their budgets. Similarly, the Central Government could subsidise certain strategic consumption or lifeline energy consumption transparently through its budget.
- In case of products wherein demand far exceeds available supply, exceptions may be made to the above policy of full competition. Such products may need to be allocated for specific end-uses and priced differently based on economically valid arguments. As an example, the case of pricing and allocating gas has been detailed under *Chapter V*.
- Till such competition is introduced we may use a pricing mechanism that mimics it. The pricing mechanism of petroleum products on import parity basis needs to be replaced by a trade parity basis i.e. products for which the

country is a net exporter/importer over a specified time period should have export/import parity prices. A product for which the country is self-sufficient should have a price in between the two depending on the price elasticity of demand for the product in the domestic market. Trade parity pricing should ideally be a short-term measure; the most preferred option being price competition at the refinery gate and at the retail level.

- The domestic economy may have to be protected against short-term volatility in the International market caused by speculators and manipulators. An option to achieve this could be to allow price adjustments based on lagging 1-3 month average prices, thereby forcing oil companies to use short-term hedging. Another alternative would be to use long-term supply contracts linked to a variety of more stable energy price indices. In a period of continuously rising prices the government can adjust the *ad-valorem* taxes and levies in a revenue neutral manner to cushion the price rise for the consumer. Of course any persistent price change that cannot be absorbed by change in taxes and duties, should be passed on to the consumers.

Petroleum & Natural Gas Regulation

- There is a need to have an independent regulatory body to regulate upstream allotment and exploitation of available oil and gas reserves and provide downstream regulation that primarily ensures competition on level terms in refining, transportation, distribution and retailing of oil and gas. The Regulator must review the current regime that limits competition from both foreign and domestic private players in the downstream sectors. A key responsibility of the Regulator would be to enforce universal service obligations by marketing companies active in a region as well as universal and subsidised access to PDS kerosene and LPG by the intended beneficiaries. The notification of the Petroleum & Natural Gas Regulatory Board Act, 2006, is thus welcome.
- On the upstream side, Directorate General Hydrocarbons (DGH), an arm of the Ministry, oversees allocation and exploitation of oil & gas reserves and enforces profit sharing with exploration & production companies. The current arrangement needs to be strengthened and made independent.

Subsidy

- The high price difference between kerosene and diesel (Rs.21 per litre in 2005-06) leads to large-scale diversion of kerosene from the public distribution system to adulteration of diesel. Similarly, differential pricing of LPG for domestic and commercial use leads to leakages increasing the burden of subsidies. The mechanism for subsidised supply of kerosene and LPG needs to be revised so as to make it transparent and directed only to the targeted beneficiaries. For this purpose, the possibility of introducing a coupons and/or smart/debit cards directly to the intended beneficiaries should be explored. This would eliminate dual prices for kerosene and LPG in the market. Further, the subsidies on these products should be charged directly to the budget and not loaded on to the oil companies.
- Ministry of Petroleum & Natural Gas (MOP&NG) could bid out available subsidies for LPG and kerosene to obtain the lowest price at which a given amount of these products could be supplied to a defined number of targeted beneficiaries or on the basis of the minimum subsidy at which these could be supplied in specified quantities and at specified price to the targeted number of beneficiaries.

Reserve Enhancement and Competition

- The assessment of the sedimentary basins and development of unconventional hydrocarbons such as shale gas, biogenic gas and tight gas reservoir/basins needs to be accelerated, and outsourcing of the evaluation of potential should be undertaken wherever needed.
- Provide level terms for foreign operators willing to bring technology and investment to recover oil/gas from currently abandoned and/or marginal fields with the right of first refusal to acquire any/all of the production on competitive terms.
- All non-dedicated transportation and distribution assets in the oil and gas sector including facilities at ports and airports should provide services and/or access to competing suppliers under common carrier principles.
- Follow international best practices governing the declaration of hydrocarbon finds and claims relating to in-place reserves discovered, acquisition of required technologies and pooling of development risks so as to maximally exploit a reserve in a timely fashion. This is critical to India's energy security concerns.
- The Mumbai High Crude is lighter and sweeter than general crude average and can fetch a higher price. Its price may be discovered through an open auction wherein Government can mop up incremental revenue.
- In line with crude oil and coal, Natural Gas and LNG may also be included in the category of declared goods so that a central sales tax of 4% is levied on them and exemption from any state sales tax is extended.
- Instead of a piecemeal approach to reform in the petroleum and natural gas sector, there is a need to implement a comprehensive reform package including pricing, regulation, industry structure, subsidies, etc.
- Raise the level of diplomacy to access hydrocarbon reserves overseas and realise gas pipelines to India.
- Importing LNG through long-term contracts provides a flexible alternative to pipelines. Since the global gas market has developed and LNG trade has increased, the price of natural gas is likely to match the opportunity cost of selling it as LNG.

Strategic Reserves

- Maintain a reserve of strategic-cum-buffer stock equivalent to 90 days of oil imports and/or buy options for emergency supplies from neighbouring large storages such as those available in Singapore. Operating the strategic reserves in cooperation with other countries who maintain such reserves could also increase their effectiveness.

Natural Gas Allocation and Pricing

- Natural gas price can be determined through competition among different producers where multiple sources and a competitive supply-demand balance exist. As long as there is shortage of natural gas in the country and the two major users of gas, namely fertiliser and power, work in a regulated cost plus environment, a competitive market determined price would be highly distorted. Such distortions would get further amplified by the prevailing regime of fertiliser subsidies & power sector subsidies and cross subsides. In such a situation price of domestic natural gas and its allocation should be independently regulated on a cost plus basis including reasonable returns.
- Another option could be to price gas on a net-back basis. Should a scenario wherein gas becomes 10-12% of India's energy mix materialise by 2031-32, some 60% of the gas supply will be used for power generation. This would mean that beyond the level of gas consumption in the fertiliser,

petrochemical, automotive and domestic sectors, gas must compete with coal as the key alternative for power generation. This implies that the cost of generating peak or base electricity using gas cannot exceed the cost of peak or base electricity from coal, the cheapest alternative. A competitive coal market is thus important for setting a proper price of natural gas on a net-back basis. An alternative for a gas producer is to export gas, in which case the domestic gas price could be the net realisation of the domestic natural gas producer after investing and getting a return on the investment needed to make the natural gas tradable across borders through either a trans-border pipeline or through liquefaction and shipping facilities. This suggests that in the short-term, natural gas prices should be determined on a cost plus basis by an independent regulator.

Gas Pipeline Network

- The Petroleum and Natural Gas Regulatory Board Act, 2006, provides that the Regulator shall moderate access to gas pipelines as common or contract carriers. The Regulator shall also ensure fair trade and competition amongst entities, specify the pipeline access code, ascertain transportation rates for common or contract carriers and determine access to city or local natural gas distribution networks so as to ensure competition amongst entities as per the pipeline access code. These provisions would pave the way for accelerated development of the gas pipeline network in the country.

Using Gas Abroad

- In case India can use diplomacy to access cheap natural gas under long-term (25-30 years) arrangements, it should consider setting up captive fertiliser and/or gas liquefaction facilities in such countries. This would essentially augment energy availability for India.

Energy-Environment Linkages

In order to achieve sustainability in the energy chain, it is important to identify, measure, value, and integrate the environmental impacts of activities in the energy sector. Environmental concerns are associated with all forms of energy including fossil fuels, nuclear energy, and renewables, throughout the energy chain from exploration/mining, transportation, and generation to end-use. However, the precise nature, intensity, and spatial extent of environmental impacts varies across different energy forms. These effects can occur at the household, local, regional, national or global levels. India, with its size, diversity and current pace of growth, needs to use and to develop all forms of energy sources optimally, in particular to be able to meet its poverty alleviation goals.

13.1 ENERGY SUPPLY SIDE: ENVIRONMENT CONCERNS

2. Energy production and use often involves environmental externalities. These externalities, as well as any social externalities such as for example, the social value of employment created in a bio-diesel programme, need to be economically valued and appropriately reflected in the prices of various fuels and energy sources.

- Studies should be carried out to determine the economic value of externalities in the production and use of different sources of energy.

13.1.1 Exploration, Production and Transformation of Fossil Fuels

3. The environmental impacts of various energy options are of growing concern owing to increasing and widespread use of energy. Coal mining, exploration and production of oil and gas (both on and off shore) have a wide range of adverse environmental impacts. Some of these impacts may be reversible, but many are irreversible. Some of the adverse environmental impacts of open cast mining may be contained, but on the other hand, the loss of biodiversity due to loss of, or severe disturbance to, habitats may be irreversible. Advanced technologies and better management practices may, however, reduce environmental impacts. For example, by using the latest exploration and drilling technologies, the

Table 13.1
Environmental Impacts Associated with Energy Transformation Based on Fossil Fuels

Stage of fuel cycle	Natural gas	Oil	Coal
All stages/all fuels	CO_2, CH_4, N_2O, NO_x, CO, Reactive organic gases, Hydrocarbons, partial trace metals, and thermal pollution		
Exploration/Mining	Drilling accidents, sludge	Drilling accidents, sludge, SO_2	Mining injuries, land degradation, SO_2, NO_x
Processing/Refining	Refinery accidents, waste disposal	Refinery accidents, waste disposal SO_2	SO_2, SPM
Transport/distribution	Pipeline accidents, Liquefied natural gas explosion	Pipeline accidents, oil spills, SO_2	SPM, SO_2, NO_x, CO, CO_2
Conversion/electricity generation		Ash disposal, SO_2	Fly ash SO_2, CO_2, NO_x, Sludge

adverse impact of petroleum exploration on natural ecosystems can be minimised. Transportation of coal and petroleum products by rail, road and sea also causes considerable environmental damage. Pollutants associated with the combustion of fossil fuels SPM, SO_x, NO_x, and CO_2 either in transformation activities (to petroleum products or power and heat combustion) or in end-uses pose a major threat to both ecological and manmade resources, and to human health. Additionally the poor calorific content of Indian coal implies that the disposal of fly ash generated in thermal power plants is a major concern. Some of the environmental impacts associated with energy based on fossil fuels are summarised in the *Table 13.1*.

13.1.2 Environmental Impacts of Nuclear Power

4. While SPM, CO_2, SO_x, and NO_x, emissions and waste disposal are dominant in the context of generating energy from fossil fuels, nuclear power is associated primarily with risks of radioactive release. Environmental impacts identifiable at various stages of the nuclear fuel cycle are: mining (accidents, release of radon gas and radioactive dust from Uranium mines and mills), radioactive seepage from waste and land degradation, processing (accidents), transport (accidents, risk of proliferation), and electricity generation (risk of catastrophic accidents, low and high level radioactive wastes). Additionally, decommissioning of nuclear plants entails the disposal of radioactive wastes. While significant technological development has been made in the area of radioactive waste disposal and decommissioning, they are yet to be proven at large enough scale to satisfactorily resolve economic issues. However, despite these risks, global data suggests that of all the conventional energy options, nuclear energy has posed the least risks in terms of mortality per billion megawatt hours of generation.

13.1.3 Environmental Impacts of Large-Scale Hydropower

5. The major impacts of large hydro projects are rather site specific, and in particular, centre around submergence of land and displacement of traditional communities from their ancestral domains. Such displacement inflicts a high social cost including change in the resource base of traditional culture and a loss of livelihood. In such cases, rehabilitation efforts can address only a part of the social costs experienced. In addition, loss of pristine natural forests and its associated unique biodiversity may occur due to submergence. Methane emissions, a major greenhouse gas, may also be emitted in large quantities if insufficient care is taken to remove vegetative matter susceptible to anaerobic microbial processes from the submerged area. Submergence of large areas may also increase the risk of seismic events, for which dams need

Table 13.2
Supply Side, Local and Regional Environmental Impacts

Impact/Option	SO_2, $NO_x TSP_s$	Solid Waste	Liquid effluent	Thermal impact on receiving waters	Flora, Fauna impacts	Forest loss	Involuntary resettlement
Thermal power (inc. Mining)	Y	Y	Y	Y	Y	Y	Y
Hydro-power	N	N	N	N	Y	Y	Y
Nuclear Power (inc. Mining)	N	Y	Y	Y	Y	Y	Y
Petroleum (inc. Mining)	Y	N	Y	Y	Y	Y	Y
Transmission & pipelines	N	N	N	N	Y	Y	Y

to be designed, for if they lead to failure of the dam structure, it may be catastrophic for downstream populations. Other adverse impacts include the spread of water-borne disease, such as schistosomiasis.

6. *Table 13.2* summarises the supply side environmental impacts of the major forms of conventional energy options:

13.1.4 Environmental Impacts of Renewable Energy

7. Energy from renewable sources is generally viewed as involving lower environmental impacts than that based on fossil fuels, nuclear and large hydropower. The main environmental benefits of renewable energy sources is that they avoid the air pollution emissions from fossil fuels and the catastrophic risks associated with nuclear plants. Small hydro projects may also help conserve water supply. Biomass based systems promote the cultivation of energy crops in wastelands and help arrest land degradation. Nevertheless, renewable energy sources may also cause environmental degradation of a different kind. Unsustainable use of biomass leads to depletion of forests, wind energy may cause noise, result in bird mortalities, and despoil the aesthetics of landscapes. Large arrays of solar photovoltaic panels put considerable demand on land and impair aesthetics. Use of chemicals in the manufacture of solar panels and use of lead acid batteries cause several adverse environmental impacts. While bio-energy is generally considered carbon neutral over the vegetation life cycle, the potential environmental impacts of such projects can include impacts on soil and water resources in addition to an increased competition for land-use. Since net carbon emissions correspond only to net deforestation, sustainable harvested biomass fuels do not add to green house gases.

13.2 ENVIRONMENTAL DIMENSIONS OF DEMAND SIDE IMPACTS

8. The end-use of energy may also impose severe environmental costs. Industrial and vehicular emissions have assumed serious proportions in urban areas. Petrol-driven vehicles are the major source of CO emissions, contributing over 85% of total emissions, while diesel-driven vehicles are the major source of NO_x, contributing over 90% of total emissions. Improper use of energy in the agricultural sector has resulted in the depletion of groundwater in several parts of the country. Indoor air pollution due to the domestic consumption of both traditional and commercial fuels is most likely the second largest source of disease, particularly among women and children, in the country.

9. To understand the demand side of energy-environment interactions, one can begin with an impact matrix that classifies each fuel by key end-use, environmental effects, indicators, and level of impact. For example, diesel fuel is (a) commonly consumed in trucks and buses; (b) has negative impacts on respiratory health, acid deposition, lead contamination and related health ailments, (c) has effluents of CO and particulates that can be measured; and (d) generates environmental impacts at the community, local and regional levels. To go beyond this simple level of matrix analysis requires an assessment of the causes of energy related environmental concerns, information on the physical amounts of pollution from each source that users are exposed to, and a quantification of impacts according to indicators for human health, the economy, and/or ecosystems.

13.3 UNDERSTANDING THE DETERMINANTS OF AIR QUALITY

10. Typically, the exhaust gases from burning coal and oil contain particulates (SPM), sulphur oxides (SOx), nitrogen oxides (NOx), and volatile organic compounds (VOCs). The concentrations of these pollutants in exhaust gases is a function of the firing configuration, operating practices, and fuel composition. Gas fired plants produce negligible quantities of total particulates and the level of nitrogen oxides are about 60 percent compared to plants using coal. A number of factors during energy transformation (power generation and use of petroleum products in transportation) affect

air quality. The knowledge of the direction and size of all these factors and their interaction is important for developing an effective mitigation strategy. These factors include:

(1) Composition and characteristics of emission sources including:
- Absolute emission levels
- Height of emissions
- Location of emissions

(2) Meteorological parameters such as rainfall, wind velocity, thermal inversion etc.

13.3.1 Levels and Trend Analysis of Urban air quality in five major Indian cities

11. Historically, the national ambient air quality standards have differed by land-use, with the most stringent standards set for "sensitive" areas, followed by "residential, rural, and other areas"; and the most lenient standards set for "industrial" areas. *Figures 13.1 and 13.2* provide SPM, RSPM, SO_2 and NO_2 concentrations for Delhi, Kolkata, Mumbai, Hyderabad and Chennai from 1993 to 2005.[13]

12. For the most part, in all five cities except Chennai, were not in compliance with the national annual average air quality standards for residential area for particulate matter during the period from 1993–2005, and particulate pollution remains a cause of concern today. The air quality data takes into consideration various energy transformation activities in these cities. However, figures for SPM and RSPM levels also include other activities such as construction, etc. In addition, in several cities, high levels of natural air-borne dust may have contributed to the SPM/RSPM levels exceeding the standards.

13. In contrast to particulate matter, annual average SO_2 concentrations were low during the same period and in compliance with the national annual average standards of 60 microgram per meter cube for residential areas. NO_2 concentrations were also low, except in Delhi and Kolkata. Overall, by comparison with SPM, these two gas pollutants do not seem to be a major problem. However, with our growing energy requirements and consumption levels of fossil fuels, the problem of local and regional air pollution should be an important concern of energy policy.

13.4 LONG-TERM SUSTAINABILITY OF INDIA'S ENERGY USE

13.4.1 Local and Regional Impacts

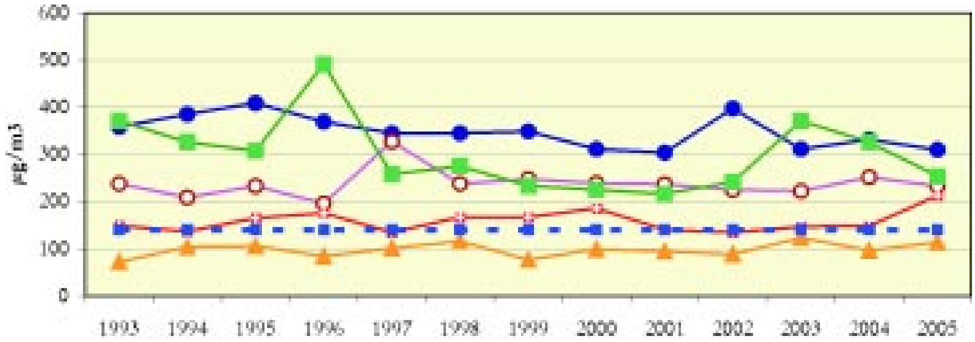
14. The question of long-term sustainability of India's energy sector in relation to environmental impacts at local, regional, and national level is important. In order that future growth is sustainable, it needs to be resource-efficient and environmentally accountable. The challenge is to thus use conventional energy resources in a manner, which cost-effectively maintains environmental quality.

- Environmental taxes and subsidies based on a consistent application of the "polluter pays" principle or "user pays" principle can go a long way in preserving environmental quality. This would be relatively easily implementable for organised establishments.
- In cases where such taxes and subsidies are not easy to administer and transaction costs are high, alternative policies such as setting emission and energy consumption standards on equipments may be followed. Some specific policies are discussed in the chapter on Energy Efficiency.
- Environmental impact assessment of power plants, dams, mines, infrastructure, construction etc., are already required. Environmental conditionalities and ameliorative actions should be specified to maintain the desired level of environmental quality.

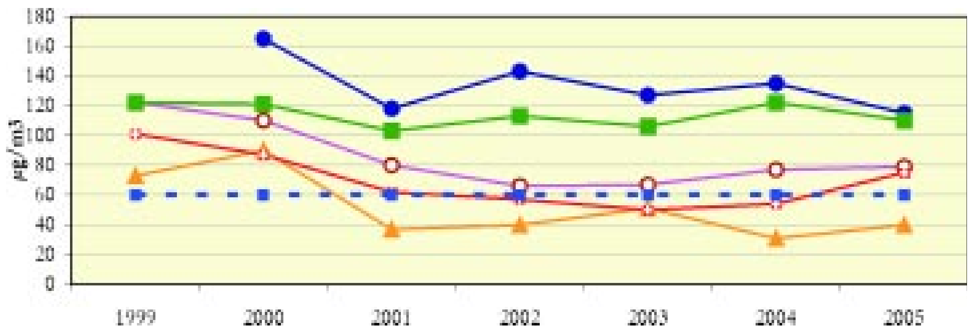
[13] Source: For a Breath of Fresh Air, The World Bank, June 2005, updated with recent data

Figure 13.1

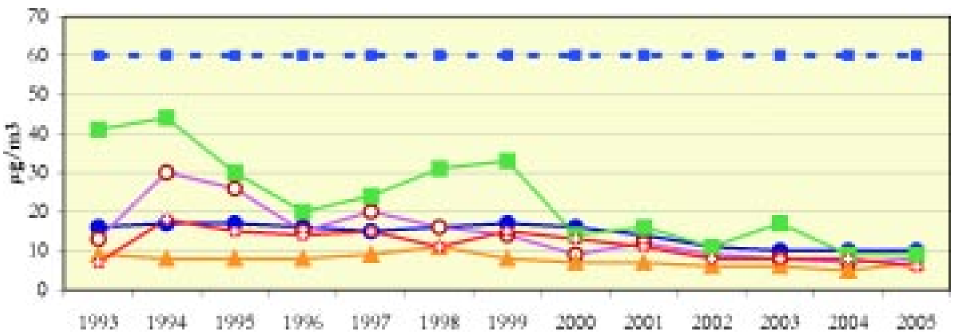
Air Pollution in Residential AreasAnnual Average SPM Concentrations



Annual Average RSPM Concentration



Annual Average SO_2 Concentration



Annual Average NO_2 Concentration

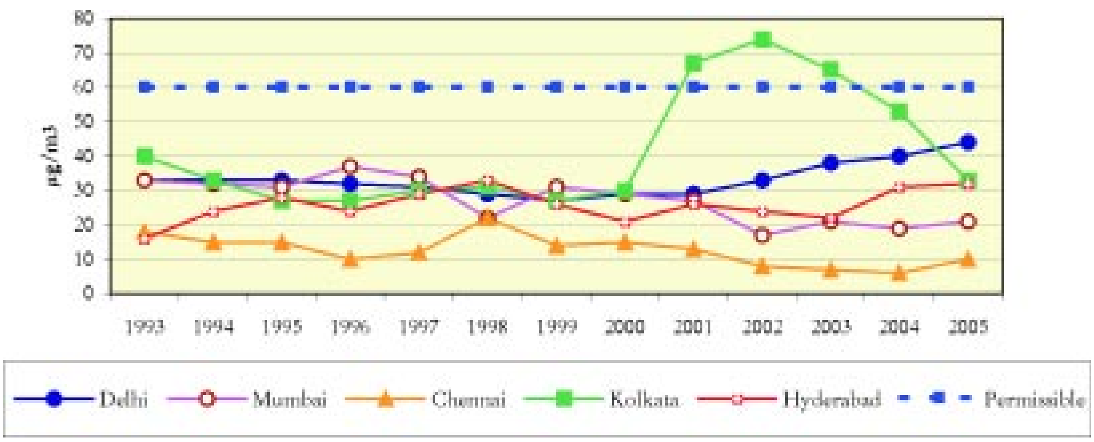
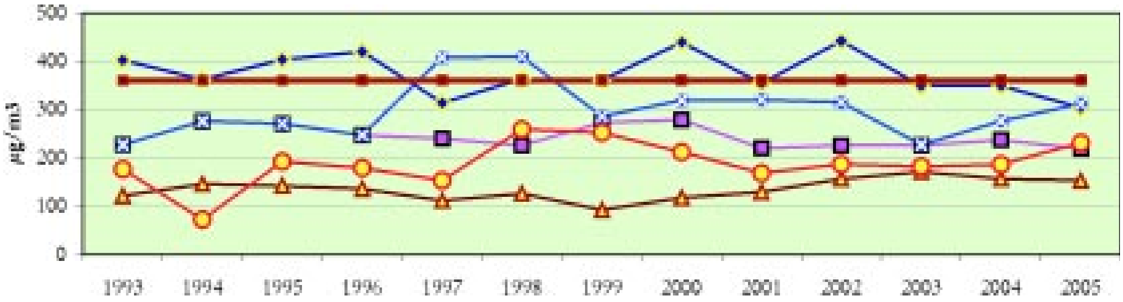
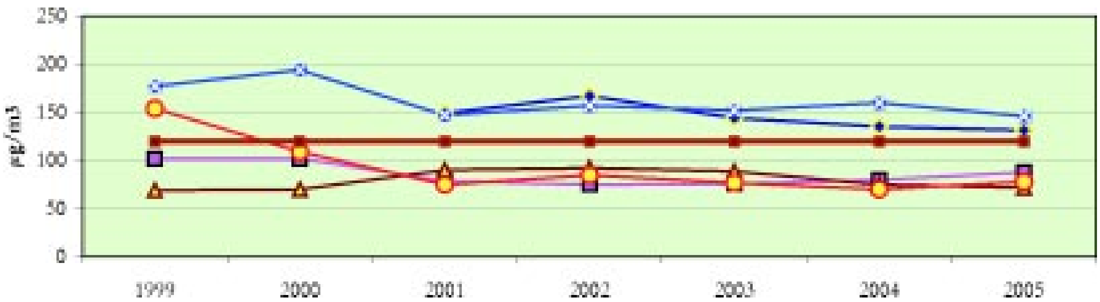


Figure 13.2

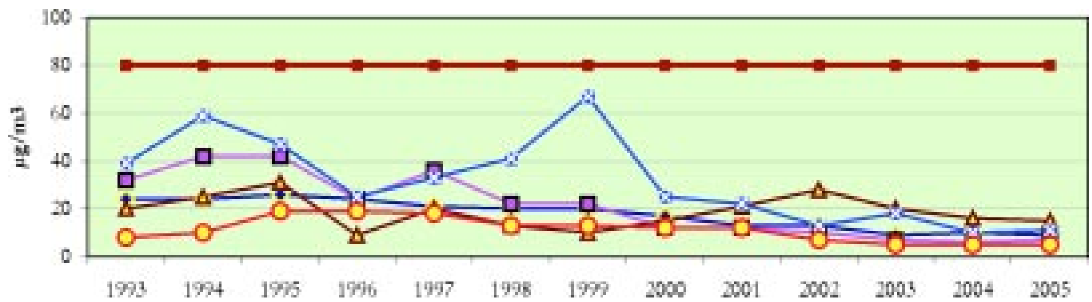
Air Pollution in Industrial AreasAnnual Average SPM Concentrations



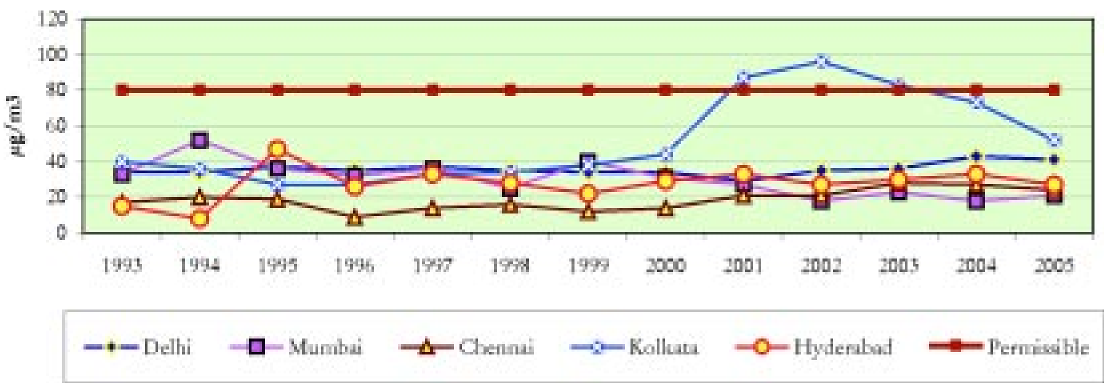
Annual Average RSPM Concentration



Annual Average SO_2 Concentration



Annual Average NO_2 Concentration



13.4.2 India's Approach to Climate Change

15. Climate change, resulting from anthropogenic emissions and increasing concentrations of a suite of gases (called "greenhouse gases" or GHGs) mainly due to fossil fuel use, certain agricultural and industrial activities, and deforestation, has the potential, over the next few generations, to significantly alter global climatic conditions. This would result in large changes in ecosystems, leading to possibly catastrophic disruptions of livelihoods, economic activity, living conditions, and human health. On the other hand, the abatement of GHGs involves significant economic costs.

16. While climate change is a global environmental issue, different countries bear different levels of responsibility for increases in atmospheric GHG concentrations. Further, the adverse impacts of climate change will fall disproportionately on those who have the least responsibility for causing the problem, in particular, developing countries including India.

17. Though India is a signatory to the United Nations Framework Convention on Climate Change (UNFCC), she is not required to contain her GHG emissions. India's policies for sustainable development, by way of promoting energy efficiency and the use of renewable energy, changing the fuel mix to cleaner sources, energy pricing, pollution abatement, afforestation, mass transport in and of themselves result in a relatively GHG benign growth path.

18. India's GHG emissions in 1994 were 1228 million tonne (Mt) CO_2 equivalent, which is below 3% of global GHG emissions.[14] In per-capita terms, it is 23 percent of the global average, and 4 percent of USA, 8 percent of Germany, 9 percent of UK and 10 percent of Japan's per-capita emissions in the same year. In terms of the GHG intensity of the economy in Purchasing Power Parity terms, India emitted a little above 0.4 tonne CO_2 equivalent per 1000 US dollars in 2002, which is significantly lower than those of the USA and the global average. In terms of primary energy use, India's share of renewable energy (with zero net GHG emission) at 36 percent is far higher than industrialised countries can hope to reach in many decades. Since GHG emissions are directly linked to economic activity, India's economic growth will necessarily involve increase in GHG emissions from the current extremely low levels. Any constraints on the emissions of GHG by India, whether direct, by way of emissions targets, or indirect, will reduce growth rates, and impair pollution abatement efforts.

19. Anthropogenic climate change, significant responsibility for which clearly does not lie with India, may, on the other hand,

Table 13.3
India Approved CDM Projects

	No. of Projects	CERs till 2012*	Investment (Rs Cr)
Energy Efficiency	98	70,834,710	2973
Fuel Switching	15	28,307,202	4894
Industrial Process	19	71,665,674	558
MSW	7	3,871,096	256
Renewable	72	32,391,075	6934
Renewable (Biomass)	86	29,641,607	3477
Total	**297**	**236,711,364**	**19092**

*CER (Certified Emission Reduction) = One Tonne of CO_2 eq abatement

[14] Source: India's Initial National Communication to the UN Framework Convention on Climate Change (UNFCCC), 2004.

have severe adverse impacts on India's precipitation patterns, ecosystems, agricultural potential, forests, water resources, coastal and marine resources, besides the increase in range of several disease vectors. Large-scale resources would clearly be required for adaptation measures for climate change impacts, if catastrophic human misery is to be avoided.

20. As the global concern *vis-a-vis* climate change grows and as the threat of climate change is perceived to be real, pressures on India to contain GHG emissions will rise. India should be willing to contain her GHG emissions as long as she is compensated for the additional cost involved. India acceded to the Kyoto Protocol on 26 August 2002. The Government of India established National CDM Authority (NCDMA) in December 2003, with its office in Ministry of Environment and Forests. As of 8th May 2006, a total of 297 projects have been approved by the NCDMA. These projects expect emissions reduction of 236 Million CERs till 2012 at a potential total investment of more than Rs.190 Billion. *Table 13.3* below gives the sector-wise break up of approved projects and the expected total emission reductions.

21. India recognises the possibilities of selling GHG emission reductions. We should choose options that permit doing so at a later date when it is found to be attractive. In any case, for us the imperative is to push energy efficiency, promote modern renewables, develop new technologies that augment our energy supply such as in-situ coal gasification that also provides scope for carbon capture, and emphasise nuclear power. All of these will automatically help reduce the GHG emissions.

Concluding Comment

India faces an enormous challenge if it is to meet her energy requirement over the coming 25 years and support a growth rate of 8 percent. This challenge can be met with a coherent approach, which develops all available energy resources. The main areas of action, for which detailed policy recommendations have been made, are as follows:

- Reducing energy requirements through energy efficiency and conservation.
- Augmenting energy resources and supply.
- Rationalisation of fuel prices to mimic free market prices that promote efficient fuel choice and substitution.
- Promoting coal imports.
- Accelerating power sector reforms.
- Cutting cost of power.
- Encouraging renewables and local solutions.
- Enhancing energy security.
- Promoting and focusing energy R&D.
- Promoting household energy security, gender equity and empowerment through targeted entitlements for the poor.
- Creating an enabling environment and regulatory oversight for competitive efficiency.

The broad policy framework and the development thrusts suggested here need to be made more specific in certain areas. Once the policy framework is accepted, it will be necessary to chalk out roadmaps of development and draft specific policy measures for implementation.

With implementation of the recommendations of the Committee, India can meet her energy requirements in an efficient, cost effective way and be on a path of sustainable energy security.

No.M-11011/1/2004-EPU (P&E)
Government of India
Planning Commission

Yojana Bhavan, Sansad Marg,
New Delhi, 12th August 2004

ORDER

SUBJECT: SETTING UP OF AN EXPERT COMMITTEE TO FORMULATE ENERGY POLICY

In pursuance of the decision taken by Prime Minister and Deputy Chairman, Planning Commission to set up an Expert Committee to prepare an integrated energy policy linked with sustainable development that covers all sources of energy and addresses all aspects including energy security, access and availability, affordability and pricing, efficiency and environment, it has been decided to set up an Expert Committee to formulate Energy Policy.

2. The composition of the Expert Committee is as under:

1. Dr. Kirit S. Parikh, Member, Planning Commission-Chairman
2. Shri Jagmohan Bajaj, ex-Chairman, SERC, UP
3. Prof. Rangan Banerjee, IIT, Bombay
4. Shri Pradeep Chaturvedi, Representative of the Institution of Engineers (India)
5. Sh. Gajendra Haldia, NCAER
6. Mr. Ajit Kapadia, Vice Chairman, Centre for Fuel Studies & Research, Vadodara
7. Dr. Urjit R. Patel, Chief Policy Officer, IDFC
8. Sh. Subimal Sen, Member, West Bengal Planning Board
9. Shri T.L. Shankar, Administrative Staff College, Hyderabad
10. Dr. Leena Srivastava, Executive Director, TERI
11. Secretary, Ministry of Power
12. Secretary, Ministry of Petroleum and Natural Gas
13. Secretary, Ministry of Coal
14. Secretary, Ministry of Non-Conventional Energy Sources
15. Secretary, Department of Atomic Energy
16. Secretary, Ministry of Environment & Forests

17. Secretary, Planning Commission
18. Secretary General, FICCI
19. Secretary General, ASSOCHAM
20. Director General, CII
21. Shri Surya P. Sethi, Adviser (Power & Energy): Convenor

3. The Terms of Reference of the Expert Committee would be to address the following:

i) How to meet demand for energy of all sectors and energy needs of vulnerable sections in all parts of the country at the least-cost considering different fuels and forms of energy such as coal, oil, hydro electricity, nuclear power, electricity and various non-conventional energy sources?

ii) How to ensure that energy input costs in India are internationally competitive?

iii) What policy including pricing policy would lead to efficient use of energy, promote conservation and at the same time provide incentives to producers to produce adequate energy to meet the demand without imposing an unsustainable subsidy burden on the system?

iv) How to ensure energy security against physical as well as financial risks (shocks) with the desired degree of confidence level at minimum cost using alternatives such as physical and financial stocks, options contract, acquisition of equity hydrocarbons abroad, in providing energy security?

v) What is the role and importance of regional and international cooperation in promoting energy security?

vi) What is the relative role of public and private investments in the development of each energy source or what is the scope for public-private partnerships to ensure adequate supply?

vii) What are the institutional, legal and regulatory policies required to ensure competitive energy markets and effective implementation of suggested policies especially in an environment where public-private partnership is being encouraged?

viii) How to ensure that exploration for oil, gas, coal and hydrocarbons takes place at the required level?

ix) What policies are needed to promote development and use of energy technologies?

x) How to accelerate the development of new and renewable sources of energy?

xi) How to ensure environmental sustainability of the energy sector through emission and effluent control, appropriate choice of fuel, promotion of clean coal technology, energy conservation, restoration of mine sites, use of renewable resources, etc.?

xii) How to ensure uninterrupted supply of quality power to both urban and rural consumers on demand?

xiii) How to ensure supply of clean household energy in rural areas to improve the quality of life of women and reduce the burden of indoor air pollution on them?

xiv) How to provide needed subsidies in non-distorting ways?

4. The Expert Group will have the powers to co-opt/associate professionals/domain experts into the Group. The Expert Group will also have the powers to set up Sub Groups/Steering Committees of officials/non officials to finalise its views on specific issues. The Expert Group should, however, encourage active participation of the State Governments in the areas of concern of the Group.

5. The expenditure of the members on TA/DA in connection with the meetings of the Expert Group will be borne by the Ministry/Department/State Government to which the members belong. In case of private members TA/DA will be borne by the Planning Commission as admissible to the Class I officers of the Government of India.

6. The Expert Group will submit its report to the Planning Commission within **six months** from the date of its constitution.

7. The Expert Group will be serviced by the Planning Commission.

Sd/-
(T.R.Meena)
Director(Admn.)

To

All Members of the Expert Group

Copy to:

1. Deputy Chairman, Planning Commission
2. Minister of State (Planning)
3. Members, Planning Commission
4. Cabinet Secretary
5. Secretary to the President of India
6. Pr. Secretary to Prime Minister
7. Joint Secretary to Prime Minister Sh. Jarnail Singh with reference to his U.O. No.210/31/C/25/04-ES.I dated 15.07.2004
8. Pr. Advisers/Advisers, Planning Commission

Gist of Earlier Energy Policy Committees/Groups

The two main committees set-up on energy policy were the Fuel Policy Committee in 1974 and Working Group on Energy Policy in 1979. A brief on the constitutions, terms of reference and the gist of their recommendations is given below:

(I) THE FUEL POLICY COMMITTEE (1974)

The Fuel Policy Committee was appointed by the Ministry of Petroleum and Chemicals, Government of India on 12th October, 1970. The terms of reference of committee were as follows:

(a) Undertake a survey of fuel resources and the regional pattern of their distribution;

(b) Study the present trends in exploitation and use of fuels;

(c) Estimate perspective of demand by sectors (in particular the transport, industry, power generation industry and domestic fuel) and by regions;

(d) Study the efficiency in the use of fuel and recommend:

- (i) the outline of a national fuel policy for the next fifteen years;
- (ii) a pattern of consumption and measures, fiscal and otherwise, which would help the best use of available resources; and
- (iii) the measures and agencies, to promote the optimum efficiency in use of fuel.

Recommendations

(i) General

1. If the energy plans and policies are to be operationally meaningful, there is a need for periodic review of the energy policy. The review may be taken at least once in three years and the planning horizon extended at each time to 15 years.
2. To set-up an Energy Board consisting of the ministers of concerned energy related ministries supported by a suitably structured Secretariat to assist this board. The board may initiate or undertake any analysis relevant for the review or revision of the fuel policy.

(ii) Coal Sector

1. Coal should be considered as the primary source of energy in the country for the next few decades and the energy policy of the country should be designed on this basic premise.
2. The need for developing an efficient and adequate transport system, which would ensure the flow of coal from the points of availability to the demand centers should be noted.
3. The coal industry should accept the responsibility to supply the required grade of coal on a long-term basis, if necessary, by changing the source of coal supply from time to time or by blending different grades of coal to make up the required grades.
4. To increase the productivity of coalmines, studies should be initiated immediately to determine the optimal use and maintenance of machines, and for training coal mines workers in the use and maintenance of the same.
5. R&D work should be continued on techno economic aspects of coal gasification and specific possibilities should be investigated for using poor quality coal for gasification.
6. Railways constitute the most economic way of moving coal for most of the

consuming classes and consumer locations in India. Adequate attention should be paid to rail transport planning in regard to development of additional line capacity, yard capacity and signalling and communication which would facilitate a speedier turn-around time for wagons. The augmentation of the wagons fleet should also be considered.

7. The selection of optimal technology for coal mining should be made on economic grounds using appropriate weightages for machine utilisation under Indian conditions and keeping in mind the availability of an abundant labour force.

(iii) Oil Sector

1. India's oil policy should be based on an understanding of the international oil situation. It should be designed with the specific objectives of
   (a) Reducing the quantity of oil products to be imported;
   (b) Reducing the total foreign exchange expenditure; and
   (c) Improving the security of supplies in crude and oil products required from sources outside the country.

2. Oil exploration in India should be given priority attention. The exploration activities particularly in the offshore areas and selected onshore areas should be speed-up. There is an urgent need to augment the capabilities of ONGC by providing them with more modern equipment.

3. All attempts should be made to take advantage of the complementarities of the resource endowments of India. Meaningful bilateral agreements may be entered into with oil exporting countries including participation in crude production.

4. To provide insurance against short-run breakdowns in the supply of crude to the country, there is a need to build up stock of crude within the country.

5. While planning refining capacity, there should be a careful examination of refinery locations, the product mix required in each refinery, the extent of secondary process to be established and a feedstock choice in the fertiliser industry.

6. Road and rail transport must be coordinated in an optimal manner in order to manage the HSDO demand. Long distance movement of commodities by road should be discouraged while simultaneously increasing the capabilities of rail transport.

7. Fuel oil being a valuable raw material for the production of high cost petroleum products which have good export potential or can serve as import substitute, large quantities of it should be earmarked for the high value products like lubes, bitumen, petroleum coke and wax.

8. The price of HSDO and kerosene should continue to be kept at par with each other to avoid diversion of kerosene for use in transport sector.

9. The production of fertilisers, methanol and other chemicals based on natural gas will have to be given preference over the use of natural gas solely as a fuel.

(iv) Power Sector

1. Efforts should be made to develop a more optimal load structure:
   (a) By setting up of more pumped storage schemes.
   (b) By shifting production of electricity intensive industries from peak to off peak periods.
   (c) By general pricing of the industrial tariff and agricultural tariff to provide incentive for use of more electricity during off peak hours.

2. In the overall interest of the economy and keeping in mind environmental considerations, more power stations should be located at pitheads.

Depending on the local conditions, however, construction of power stations at load centres can be considered on merits as a special case.

3. The schemes for setting up of regional grids and regional load dispatch centres should be vigorously pursued.
4. A proper pricing policy for the power supplies to the agricultural loads so as to encourage the consumers to use the optimal size of pump sets, and to draw supplies during off peak hours.
5. In the overall national interest and given the limited available resources, the setting up of captive power stations should not be encouraged.

(v) Domestic sector

1. To take up programmes of afforestation with quick growing wood species to increase the availability of firewood.
2. To intensify the popularisation of 'gobar gas plants' in view of the social benefits of the nutrient production, pollution abatement etc.
3. The problem of substitution of non-commercial fuels with the commercial fuels in the domestic sector has to be considered with due regard to the overall economic implications of the use of different fuels in this sector. Pricing and distribution policies should be based on a full understanding of the social costs of the use of different fuels.

(vi) Costs and prices

1. The price fixed for any fuel-coal, oil or electricity should be such that the particular fuel industry, as a whole, is enabled to earn a return of al least 10% on the investment made in the industry.
2. There should be a serious examination of the need to continue the import parity formula for pricing of petroleum products and to evaluate other possible methods of fixing prices, which will best serve the national interest.
3. The electricity tariff should be designed so as to discriminate between the use of power during the peak periods and during the off peak periods.

(vii) Technology

1. A National Fuel Efficiency service may be instituted to ensure improvement in energy efficiency in the industries.
2. Research and development in areas relating to combined gas turbine – steam turbine plants should be intensified for increasing the overall efficiency of coal utilisation in thermal power plants.
3. A long-term programme for development of coal to oil should be drawn up.
4. R&D work on coal gasification and pipeline transport of coal gas should be undertaken.
5. R&D on solar energy in India may be concentrated on the development of thin-film technology, developing low cost solar water heaters etc.
6. Development of battery powered vehicles, fuel cell technology, Fast Breeder Reactors etc. should be emphasised.

(II) The Working Group on Energy Policy (1979)

The Working Group on Energy Policy (1979) was constituted by an order of the Planning Commission on 6th December, 1977, with a view to "carry out a comprehensive review of the present situation in the light of recent developments both within the country and outside, to develop a perspective for the next five to fifteen years and to recommend appropriate policy measures for optimal utilisation of available energy resources including non-conventional sources of energy". The terms of reference of the Working Group were set out as follows:

(a) To estimate the perspective energy demand in the different sectors of the economy and regions of the country by 1982-83 and a decade thereafter;

(b) To survey the present and perspective supplies of energy;

(c) To recommend measures for optimum use of available energy resources; and

(d) To outline the national energy policy for the next five years, fifteen years and the longer term conservation policy.

Recommendations

General

1. A reappraisal of our economic development strategies, especially those elements of the strategy which have a direct link to energy consumption like technology choice, location policies, urban growth, and mechanisation in agriculture etc., with reference to the new awareness of the energy supply and demand in future needs to be addressed.

2. Examination of the technological processes and the achievable levels of efficiency for each industry or equipment, and to prescribe the standards of efficiency to be achieved by energy users or equipment manufacturers.

Oil Sector Policies

1. All efforts should be made to reduce the demand of oil to levels even below what is forecast in the Optimum Level Forecast (OLF). It would be prudent to plan a pattern of growth of the economy, which is less dependent on oil. Demand Management should form the most important element of oil policy in the future.
2. The techno-economics of converting gas into liquid fuels for use in the transport sector should be examined.
3. Larger investment should be made in secondary processing like Hydro-crackers, catalytic crackers or delayed coking equipment, which would convert the heavy end products to middle distillates.

Coal Policy

1. Planning and construction of coalmines should proceed on a steady basis without linking specific mines to specific consumers.
2. There is a need to develop a well-defined policy towards mechanisation of coal mines taking into account the need to increase production very quickly and with due consideration for employment and training implications. In doing so the changes in the share of open cast and underground mines and the optimal technology that could be used in such mines would also deserve careful consideration.
3. There is a need to synchronise investment in coal production and coal transportation by railways with due flexibility so that transport would not be a constraint to the use of coal.
4. The idea of washing non-coking coal should be pursued cautiously and resorted to only where its techno-economic benefits are clearly established. The planning of thermal power stations based on middlings should proceed in step with planning of coal washeries. There are also possibilities of using the rejects and middling as raw material for manufacturing domestic fuels similar to soft coke.

Power Sector Policies

1. Power planning in the future should be based on the concept of an optimal mix of thermal/nuclear and hydro stations in which the hydro stations should take the Peak and the thermal stations provide the base load.
2. With the steeply increasing costs of power generation, it might become more remunerative to invest in System improvements that might reduce losses in T& D, than investing in additional capacity and if this is done, it may be possible to reduce losses still further.
3. Detailed State-wise and region-wise power planning studies should be undertaken.

4. It is essential that a long-term transmission plan be prepared for each region, which could be executed in a phased and systematic manner.

Rural Energy Policy

1. A comprehensive survey of all the energy needs in a village community should be carried out.
2. Pilot installations should be set-up as early as possible for Micro-hydel stations to be constructed in rural areas on irrigation canals.
3. A study should be made to install community type biogas plants and the utilisation of gas from such plants for households, pumping and industrial applications should be explored.

Cost and Prices in the Energy Sector

1. The energy prices must at least reflect long-run marginal costs and allow for a reasonable return. A suitable institutional framework for regulating, monitoring and adjusting energy prices in a mutually comparable manner should be set-up.
2. A tariff schedule for electricity that distinguishes between peak and off-peak consumption on a diurnal and seasonal basis may be put in place. The relative prices of different fuels should encourage the required inter-fuel substitutions.

Research and Development in the Energy Sector:

(a) **Oil Sector**

1. R & D efforts aimed at enhancing our exploration capability, maximisation of yield from oil reservoirs and efficient utilisation in all the consuming sectors need to be encouraged. In this context, Secondary and Tertiary recovery technologies should be developed to maximise yield from oil reservoirs.
2. The potential of Hydrogen as a substitute for liquid fuel for the transport sector should be examined.

(b) **Coal sector**

1. R&D activities in the areas of gasification and liquefaction of coal and their economics under Indian conditions must be pursued.
2. R & D efforts in the field of coal combustion (e.g. fluidised bed combustion) & other technologies should be reviewed and intensified so that these technologies are adequately developed for use in both industrial and power sector.
3. Research on coal beneficiation for achieving better coal recovery from washeries, utilisation of rejects, etc., may be intensified.

(c) **Nuclear Energy**

1. R&D work for development of Fast Breeder Test Reactor (FBTR) being constructed at Kalpakkam should be expedited.
2. Development work for fabrication of reactors based U_{233} with Thorium needs to be carried out.

(d) **Power Sector**

R&D efforts are recommended in the following areas:

1. Improvement in the methodology of load estimating and forecasting, power system planning etc.
2. Reliability of Power Systems
3. Optimisation of System Economics
4. Software development for problems in power system operation, load flow, short circuits etc.
5. Research in the problems of Integrated operation of Power Systems
6. Improvement in Power System protection techniques.

(e) **Other Energy Technology Areas**

1. R&D effort should be intensified for development of alternative technologies (Solar energy, Wind energy & biomass) that appropriately harness these sources of energy.
2. Research on biomass should be directed towards identification of fast growing species, methods of increasing the photosynthetic efficiency and development of cost-effective processes utilising bio-degradable materials for producing fuels-gaseous as well as liquids with high priority.
3. R&D to establish the feasibility of integrated systems based on solar, wind, biogas, and mini hydro wherever available, will have to be expeditiously undertaken.

(f) **Sectoral Policies/Prescriptions**

(a) Transport

1. The coordination of rail and road traffic and the extent to which other less intensive modes like inland waterways, coastal shipping etc., can be used should be understood and encouraged.
2. Accelerated pace of electrification of the high-density traffic trunk routes, especially those connecting Bombay, Delhi, Calcutta and Madras deserves serious consideration.

(b) Agriculture

1. Standards of fuel efficiency have to be prescribed for electrical and diesel pumps and the manufacturers persuaded to adopt a time bound approach of increasing the efficiency of pumps to the level suggested in the report. Similarly in the case of diesel tractors also there is a need to prescribe fuel-efficiency standards.
2. Improve the design of the animal drawn water lift and agricultural implements, which would increase the useful energy delivered by animal driven appliances/ implements.

(c) Household sector

1. Setting up of standards of fuel efficiency for manufacture of lighting and cooking appliances and introduction of more efficient chulhas at subsidised rates on a large-scale.
2. Efforts must be made to maximise the use of agricultural waste as fuel directly by burning or by conversion into liquid/gas fuels by microbial conversion. Biogas plants capable of using more of agricultural waste are to be developed.

(d) Industry sector

1. In many of the industries the specific energy consumption is inversely proportional to the level of capacity utilisation. Therefore, the utilisation factor should be improved with special reference to conservation of energy.
2. Co-generation holds prospects of large energy savings in the industrial sector, as it improves the overall thermal efficiency. Such possibilities in existing industries should be identified and pursued. Further, for new industries the energy implications of the technology chosen need to be studied to select the least energy intensive option, particularly with respect to the use of depleteable sources of energy and electricity.

Calorific Values, Units and Conversion Factors

Calorific Value of Various Fuels

Sl. No.	Name of Fuel	Unit	Calorific Value (kilo-calories)
1.	Biogas	M^3	4713
2.	Kerosene	kg	10638
3.	Firewood	kg	4500
4.	Cow-dung Cakes	kg	2100
5.	Coal	kg	4000
6.	Lignite	kg	2865
7.	Charcoal	kg	6930
8.	Soft coke	kg	6292
9.	Oil	kg	10000
10.	LPG	kg	11300
11.	Furnace Oil	kg	9041
12.	Coal gas	m^3	4004
13.	Natural gas	m^3	9000
14.	Electricity	kWh	860

Conversion Factors

Kilo Calorie	3.96832 BTU, 4186.8 Joules
Kilowatt Hour	3412.14 BTU, 3.6×10^6 Joules
Btu	0.252 Kilo Cal, 1.055 Kilo Joules
US Gallon	0.833 Imperial Gallon, 0.134 Cu. Feet 0.00378 Cu.M
Imperial Gallon	1.2009 US Gallon, 0.1605 Cu. Feet 0.0045 Cu.M
Cubic Metres	264.172 US Gallons, 219.969 Imperial Gallons, 35.3147 Cu. Feet
Cubic Feet	7.4805 US Gallons, 6.2288 Imperial Gallons, 0.0283 Cu. M
1 BkWh Hydro or Wind Electricity	0.086 Mtoe*
1 BkWh Nuclear Electricity	0.261 Mtoe
1 Mt of Coal	0.41 Mtoe
1 Mt of Lignite	0.2865 Mtoe
1 Billion Cubic Meter of Gas	0.9 Mtoe
1 Mt of LNG	1.23 Mtoe
1 Mt of Fuel wood	0.45 Mtoe
1 Mt of Dung Cake	0.21 Mtoe

*Mtoe conversion factors are taken as per International Energy Agency (IEA) Practice

Crude Oil	Tonnes (Metric)	Kilolitres	Barrels	US Gallons
Tonnes (Metric)	1	1.165	7.33	307.86
Kilolitres	0.8581	1	6.2898	264.17
Barrels	0.1364	0.159	1	42
US Gallons	0.0032	0.0038	0.0238	1

Natural Gas	B Cu. Meter-NG	B Cu. Feet-NG	Mtoe	Mt-LNG	Trillion BTU	Million Barrels of Oil
B Cu. Meter	1	35.3	0.9	0.73	36	6.29
B Cu. Feet	0.028	1	0.026	0.021	1.03	0.18
Mtoe	1.111	39.2	1	0.805	40.4	7.33
Mt-LNG	1.38	48.7	1.23	1	52.0	8.68
Trillion Btu	0.028	0.98	0.025	0.02	1	0.17
Million Barrels of Oil	0.16	5.61	0.14	0.12	5.8	1

Units

Units	Name	Remarks
BCM	Billion Cubic Meter	= 10^9 m^3
BkWh	Billion Kilowatt Hours	
Bt	Billion Tonne	= 10^9 Tonne
GWe	Giga Watt Electrical	
GW-Yr	Giga Watt Year	= 8.76 x 10^9 kWh
kcal	Kilo Calorie	= 4186.8 J or 396832 Btu
kg	Kilogram	-
kgoe	Kilogram of Oil Equivalent	-
kW	Kilo Watt	= 10^3 Watt
kWh	Kilo Watt Hour	= 3.6x10^3 J, also expressed as Unit
M. ha	Million hectares	
M. ltrs	Million litres	
MMBtu	Million British Thermal Unit	Traditional British unit
MMscmd	Million Standard Cubic Meters per Day	Traditional unit used in gas industry
Mt	Million Tonnes	= 10^6 Tonne
Mtoe	Million Tonnes of Oil Equivalent	-
MVA	Million Volt Amperes	
MW	Mega Watt	= 10^6 Watt or 10^3 kW
MWe	Mega Watt Electrical	
MWt	Mega Watt Thermal	
T	Tonne	Same as Metric Ton = 1000 kg
tkm	Tonne Kilometer	tonne of material moved by km
TWH	Terawatt Hour	