Energy Efficiency and Conservation; Status and Prospects

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Abstract

This paper examines the structure of energy supply and the efficiency with which energy is used in India, the regulatory arrangements and the prospects for reducing energy intensity. The measurement of energy efficiency is application, technology and often location specific, which restricts its use as a benchmark for comparison. At the aggregate level, energy intensity is a useful substitute for assessing how efficiently an economy has used energy over time. However, cross-country comparisons of energy intensity may not be meaningful due to differences in economic structures, geo-spatial variances and the level of economic development.

This paper reviews the energy resource use pattern in India and highlights that 60% of the energy is lost at various stages in the energy chain from conversion of primary energy into useful energy services. Of the total energy loss, nearly two thirds is on account of conversion loss of non-commercial energy resources while providing useful energy services. Since these resources are used primarily by the poor, and are highly polluting in traditional ends use applications, improving the efficiency of their utilisation has significant equity considerations. India is dependent on coal for meeting over one third of its primary energy supply and two thirds of its electric power generation. Improving the efficiency of coal extraction and transportation, gasification improving the efficiency of coal fired power generation plants and the direct use of coal by industries impacts energy intensity levels.

The complex regulatory structure for energy, which disperses legal jurisdiction and authority between the Union and State Governments and more recently devolves authority to independent Regulatory Commissions and the multiplicity of Central, and State Government Ministries, Departments and Agencies dealing with energy have prompted government committees since 1979 to advocate a mechanism for effective coordination and the development of an integrated energy policy guidelines. These efforts have proved elusive, beyond the limited role played by the Planning Commission, and jurisdictional overlap and fragmentation continue to be a concern for stakeholders.

On the supply side, low levels of commercialisation in coal have adversely affect the output, productivity and the quality of supplies. The sector remains barred for private and foreign direct investment, which is a drag on its development. Power sector reforms have moved slowly but the overall direction is positive. Independent regulation has contributed to stabilizing this sector and putting it on the path to economic viability. Petroleum and coal would do well to emulate these regulatory arrangements. The continued under development of hydropower resources and the low levels of capacity additions in nuclear power are areas of concern where there are no immediate prospects of an improvement. Underdevelopment of its natural resource base; coal, hydropower and nuclear resources is pushing India towards greater reliance on oil based fuels and natural gas, which are subject to price volatility and possible supply disruptions on account of the growing reliance on their import.

On the demand side, industry has responded well, on aggregate, in improving its energy efficiency subsequent to the two oil shocks of the 1970's and the more recent economic incentives provided by liberalization, competition and facilitation of private sector investment. The

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same cannot be said for the small-scale sector, which is hamstrung by protection, and where technology choices are not available internationally and need to be indigenously developed. Constitution of the Bureau of Energy Efficiency in 2001 is expected to give a boost to the development of enabling, energy efficiency oriented, regulations and standards. The integration of energy efficiency parameters into building regulations, reorientation of the transportation network from a reliance on road to rail, higher levels pf electrification in rail and a shift from private transportation to public transportation requires the introduction of economic incentives like congestion tax, differential tax on vehicles, appropriate road and rail infrastructure development and implementation of a clean fuels policy.

India's energy intensity has declined over the last two decades at a rate of 2% per year measured in TOE per PPP$ 1000, which is better than the world average decline in primary energy intensity at a rate of 1.5% per year. The compulsions of economic development and improvement in living standards require India to consume higher levels of energy well into the future. However, de-linking of economic growth from incremental energy consumption will be facilitated by the "late developer" advantage of adding technologically competitive capital stock. Adoption of the open economy framework with liberalization, economic reform, facilitation of private management and finance and reorientation of public investment to areas of market failure and social development are the hallmarks of future development patterns. In tandem with these principles energy efficiency also will be market driven. However, appropriate interventions through policy, regulations and efficiency standards would still be necessary to address the areas of market failure and to integrate social costs into the private cost-benefit framework.

1. Energy Efficiency; definition, measurement and context

1.1 Improving the efficiency with which energy is used to provide economic services meets the dual objectives of promoting sustainable development and of making the economy competitive. While these objectives have universal application, they are of special relevance for developing economies like India which, though frugal consumers of energy today, are expected to contribute around four fifths of the incremental energy consumption in the World over the next two and a half decades[3].

1.2 Definition of energy efficiency

1.2.1 Energy efficiency is simple in concept. Doing more with less is an attractive environment friendly energy strategy. Using energy rationally is the crux of energy efficiency. Progress towards that objective is termed as improvements in energy efficiency which implies a reduction in the energy used for a given energy service (heating, lighting, etc.) or level of activity. Such reductions in the energy consumption can be due to a number of factors including technological changes, better organisation and management of the energy system, or a conscious change in lifestyles. An example of technological change on the supply side would be the replacement of traditional coal fired power generation systems with Combined Cycle Gas Turbines and low energy intensity CFL lamps on the demand side. An example of better management would be improvement in the Heat Rate of an existing power generation plant while an example of lifestyle induced changes would be the conscious use of sunlight to dry clothes rather than to use a spin dryer. Clearly the way our habitations are built, the manner in which cities are planned, the system for transportation of goods and passengers, the rate of obsolescence for end use equipment, the nominal price of different types of energy, the consciousness of the people with respect to energy conservation; these, and many more, are all significant factors in determining the efficiency with which we use energy.

1.2.2 Improving the energy efficiency of a system is synonymous with reducing the energy losses, which occur at every point of conversion or transportation/transmission along the energy chain; from primary energy (coal, gas, crude oil, hydro, nuclear or biomass and other renewable forms) to secondary energy (refined petroleum products for generating electricity), from

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[3] Annual Energy Outlook 2004, DOE/EIA-0383 (2004) Washington DC, January 2004

secondary energy to final energy (electricity produced from petroleum products) and finally to energy services (lighting, cooling/heating and motive power).

1.2.3 The reduction of energy loss during conversion or transmission/transmission is largely technology dependent though better maintenance and management of the equipment used at every stage also contributes to improvements in energy efficiency. These are essentially supply side interventions which aim at improving the efficiency with which energy is supplied. Over the last four decades, technology has intervened to enable the gradual replacement of fossil fuel based energy resources with renewable sources of energy, which have contributed directly towards the implementation of sustainable development objectives

1.2.4 As significant are demand side factors, which reduce the demand for energy by rationalising the mix of energy services or the time when these are consumed. The time differentiated pricing of electricity, for example can induce a shift in demand away from the peak hours, thereby averaging out the flow of energy through the system and reducing energy loss in transmission and generation. The use of appropriate architectural designs and building materials can reduce the demand for lighting and heating. Appropriate city planning can reduce the distance and time of travel and thereby the demand for energy. Multi-modal transportation can rationalise the demand for energy in transportation. A stricter version of demand side management is “energy conservation”, which places a positive value on saving energy by cutting back if necessary on the use of energy services.

1.3 Measuring energy efficiency

1.3.1 The measurement of energy efficiency has to be technology and sector specific with spatial features, climate and culture all playing a significant role. The computation of energy efficiency is therefore of limited value in measuring changes over time oracross technologies and sectors making measurement in aggregate terms, across sectors and applications, somewhat meaningless. Energy Intensity (EI) of the economy, defined as the amount of primary energy supply used per unit of GDP, is a practical though somewhat inexact substitute aggregate measure. Consequently, while for a single productive process or application, energy efficiency is the inverse of energy intensity, this does not hold at higher levels of aggregation. Energy Intensity is, at best, an imperfect measure of energy efficiency. At the economy level, a change in the EI can be caused by a number of factors including population growth, changes in energy efficiency or structural shifts from energy intensive sectors to less energy intensive sectors.

1.3.2 Accordingly, a combination of Energy Intensity indicators at the economy level and energy efficiency indicators at the micro level, particularly in energy intensive processes, presents the only practical alternative for measurement of energy efficiency across different time periods within an economy. Inter economy comparisons however remain of uncertain value given the differences in climate, geography, resource endowment, economic structure and income level.

1.4 Energy efficiency; the context.

1.4.1 Improving the efficiency of energy extraction, conversion, transportation/transmission and the efficiency of end use applications of energy are financially cheaper and socially preferable options for meeting the energy demand. The financial constraint operates at two levels. Firstly, enhanced capacity building requirements put pressure on the availability of investment capital. The power conservation potential identified in the 10th Five Year Plan, if realised, can reduce the incremental investment in energy by around 20%. Where much of the incremental capacity building is to happen in the public sector this translates into extreme fiscal pressure with economy wide repercussions for stability. Secondly, spending more than required on incremental capacity drastically reduces the competitiveness of the concerned industry or service. The high cost of electric power in India for industry makes energy intensive industries like the minerals sector, uncompetitive in the global marketplace. Promoting energy efficiency is both an opportunity and a challenge for developing economies.

1.4.2 The process of economic development boosts the demand for energy both as inputs into the growth process and due to rising personal incomes as consumer durables proliferate and residential lighting, cooling and heating demand increases corresponding to improved lifestyles. Listed below are some factors and trends, which are a consequence of development and which, will tend to both promote and to constrain energy efficiency.

1.4.3 Factors supporting energy efficiency

- The benefit of severe under supply and low energy intensity levels is that efficiency levels can improve, over time, merely because of the addition of more efficient capital stock to meet the incremental demand associated with economic growth. The Fertiliser Industry is an example where change in technology and feedstock have reduced the EI both through modernisation of the existing capacity and addition of more efficient incremental capacity. The fertiliser plants constructed in the 1970s had design energy consumption in the range of 11-12 Gcal/t, which has improved significantly today with design energy consumption of only 7.4 Gcal/t[4].
- Simultaneously, since economic growth itself would be a function of economic reform, liberalization and enhanced competition, industrial consumers are forced to adopt energy efficient production processes to remain competitive both in the domestic and international market place. For example, the Indian cement industry has seen significant growth and improvement in energy efficiency in the post liberalisation period. The partial price decontrol in 1982 and full decontrol in 1989 provided the industry the right incentive to cut costs to remain competitive. As compared to a growth rate of 6.3% per annum during the period of administrative control (1973-1983) the growth rate increased to 13.7% per annum in the following period of partial and eventually total decontrol (1983-91)[5]. The average thermal and electrical energy consumptions too improved during these two periods, from 900 kcal/kg of clinker to 750 kcal/kg of clinker and from 125 kWh/t of cement to 110 kWh/t of cement respectively.

- Greater integration of the economy with the Global markets will merge production capacities for the domestic and export markets with a unified production base, thereby exploiting economies of scale and enhancing the energy efficiency standards of end-use-equipment manufactured in India in consonance with the stricter energy efficiency standards in the developed economies. The automobile sector, which was liberalised and opened to foreign competition in 1991 is a good example. Along with enhanced customer choice and a multiplicity of manufacturers energy efficiency has increased by 10 to 50% across the spectrum of two wheelers, cars and Light Commercial Vehicles[6].
- Global concern with climate change will result in the financing of efficiency improvements in India by developed economies on the principle of least cost mitigation. Six priority areas have been identified. Out of the total 44 CDM projects approved till date by Government of India, nearly 16 projects relate to energy efficiency. Six CDM projects have been endorsed under the CERUPT (Certified Emissions Reduction Unit Procurement Tender) of the Netherlands Government, in the area of Renewable Energy. In addition one project under Activities Implemented Jointly (AIJ) is under implementation and four others have been approved. Even conservative estimates of the flow of funds for emission reduction projects under CDM indicate the availability of around $ 2 billion for such projects globally.

1.4.4 Trends impacting energy efficiency negatively

- Public finance led power development while rapidly expanding the network and the number of consumers has resulted in severe tariff distortions, especially in favour of agriculture and peak time residential users which cripple the financial capacity of utilities

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[4] TERI report on technology assessment for the Fertiliser industry, 2004.

[5] India's cement industry: productivity, energy efficiency and carbon emissions. LBNL July 1999

[6] B.P. Pundhir (1994), R.K. Bose (1998); Auto India (August 1999); World LP Gas Association

to invest in upgrading and modernizing capital equipment. Low tariffs also dilute the incentive for using energy efficiently. " Energy consumers….do not face prices which encourage them to use energy efficiently, select the most economic fuel or use the technology that would best meet their needs"[7]. Such subsidization also retards efforts to promote decentralized renewable energy generation by making it uncompetitive with conventional grid based energy supply[8]. The absence of time of use pricing subsidises inefficient consumers at the cost of more efficient consumers[9].

- Stabilisation of the public finance system often requires enhancing tax rates and the tax base. Often consumer durables are classified as "luxury" goods inviting high taxes. Simultaneously high interest rates inhibit capital investment. Low levels of capital investment and delayed obsolescence of consumer durables slow down the pace of equipment turnover thereby retarding the efficiency enhancing impact of economic growth. The positive impact of low interest rates, easy availability of capital and rationalisation of taxes can best be illustrated by the consumer durables sector in India which has seen an explosion of demand in the 1990's. The stock of electrical consumer durables in India increased substantially over the period 1984-85 to 1989-90 with growth per annum ranging from a low rate of 10% in the case of Geysers to a high of 50% per annum in the case of VCR/VCP. Even high-end consumer durables like refrigerators and washing machines registered growth rates in stock of 18% and 30% respectively[10]. The boom was led by rising incomes and lower taxes. It was continued in the 1990s through the availability of consumer finance at reasonable rates.
- Soft budget constraints in public utilities provide no incentives for improving energy efficiency and make new investment more attractive than up-gradation and modernisation of existing equipment[11].
- Rate of Return (ROR) regulation can result in pass through of poor energy efficiency levels to consumers unless cost norms are regularly revised by Regulators and incentives built into the rate structure to mimic the positive impact of competition on consumer prices. ROR guarantees that the utility recovers its costs but does not give it any incentive to keep its costs down[12]. The system of RPI minus X was evolved as a response to the shortcomings of the ROR system but can only be implemented selectively and does not work well where there are significant capacity shortfalls.
- Inadequate regulatory oversight on development of minimum energy efficiency standards for end use equipment and design and construction of buildings provide no incentives for incurring the upfront cost of energy efficient equipment and construction design, which however may be the more viable alternative on a life cycle basis. In the US, for example, all new building constructions have to be approved for meeting the requirements of Federal codes on energy efficiency. In India, there are no such regulations at present. Designing and building energy efficient buildings imposes higher initial costs of between 30% to 100% as compared to conventional buildings. However, the additional initial cost can be neutralised through savings from lower consumption of energy within 5 years[13].

1.5 Energy intensity of the Indian economy.

1.5.1 The Indian economy has become less energy intensive if GDP is taken at constant 1993-94 prices in Rs terms. The Energy Intensity (commercial and non commercial energy) has declined from a level of 0.0496 TOE per Rs 1000 of GDP in 1970-71 to 0.0345 TOE per Rs 1000 of GDP in 2001-02. This represents a reduction in EI of 1.2% per year during this period. Measured in terms of $PPP EI declined from 0.28 TOE/$1000 in 1980 to 0.19 TOE/$1000 in 2002

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[7] Energy Efficiency and Conservation in the Developing World", World Bank Policy Paper, The World Bank, 1993

[8] "Economics of Wind Power" TERI field study 1998

[9] "Electricity Prices in a Competitive Environment" <eia.doe.gov> October 2002

[10] India Market Demographics Report 1999, I. Natarajan, NCAER.

[11] Ruet Joel, "Privatising Power Cuts? Ownership and Reform of SEBs in India" 2005 Academic Foundation, New Delhi

[12] "Resetting Price Controls for privatised Utilities" Richard Green & Martin Rodriguez Padrina, EDI Development Studies, The World Bank 1996

[13] TERI estimates

a reduction of nearly 2% per annum which is in excess of the World Average reduction in EI during the period 1980 to 2002. The world average primary energy intensity continuously declined at the rate of 1.5% per year between 1980 and 2002 with an acceleration to 1.9% per year since 1995[14]. The fastest decline during this period was in North America where the EI declined by 2% per year. The least decline in primary energy intensity was in Latin America with a reduction of only 0.1% per year. Western Europe at 1.1% per year, SE Asia at 0.7% per year and Japan at 0.5% per year were midway between the two extremes.

1.5.2 In India, the reduction in EI since 1970-71 is partly accounted for by improvements in energy efficiency associated with an increase in the share of commercial energy in total energy consumption from 41.02% to 68.23% over the same period. On average commercial energy sources are at least twice as efficient as non commercial sources in the delivery of energy services. The reduction in EI occurred despite the significant increase, both in the per capita and aggregate consumption of energy in the domestic sector and transportation. Moreover, a structural shift in the economy with the share of services (being less energy intensive) growing from around 32% to nearly 50% over the same period also helped in reducing energy intensity.

1.5.3 By 2011/12 with a projected growth in energy demand of 5.2% per annum to 724 million and a projected growth in GDP of 7% per annum the EI (TOE per Rs 1000 of GDP) would improve to 0.029 implying a reduction of 1.72% per annum over the period 2001-02 to 2011-12, which is very competitive with the projected average decline Worldwide.

1.4 Chapter summary

1.4.1 During the period 1970-71 to 2001-02 there was a significant increase in the aggregate consumption of primary energy (commercial and non commercial) from 147 mtoe to 438 mtoe as is to be expected in consonance with developmental priorities. However the per capita consumption of energy increased only from 243 toe/million in 1970-71 to 450 toe/million in 2001-02, which is about 20% of the World average. More significantly the average Energy Intensity of the economy declined significantly from 0.050 TOE per Rs 1000 of GDP in 1970-71 to 0.035 in 2001-02, a decline of over 1.2% per annum and 2% per annum in PPP $ terms, which is far sharper than the World Average decline of 1.5% per year during 1980-2002. India diluted the link between economic growth and incremental energy consumption due to proactive programmes for energy conservation and the efficiency gains from technological development resulting from the planed substitution of traditional sources of non-commercial energy by commercial energy. Such technological advances will continue to be a source for future energy savings particularly as the ratio of electricity to total final energy supply is still only around 15%. Economic reform, liberalisation and competition will similarly promote energy efficiency by rationalising energy prices and putting pressure on producers to manage costs in a competitive market led framework. Coal is expected to remain the dominant source of primary energy while Natural gas is expected to be the fastest growing energy source. Since the bulk of Natural gas and oil is imported, greater reliance on these imported fuels has strategic implications and can be the driver for greater regional integration and mutual interdependence.

2. India's energy resource use pattern

2.1 India is supply constrained in natural gas as a source of primary energy supply and in electricity as a source of final energy supply. In addition efficient extraction arrangements for coal, transportation facilities for petroleum products, transmission constraints and a fragile distribution network for electric power generate bottlenecks in the supply of final energy. The demand for commercial energy is expected to increase from a level of around 300 million tonnes of oil equivalent (mtoe) in 2001-02 to about 600 mtoe by 2020 and to about 700 mtoe by 2025[15], driven principally by the incremental demand for residential, commercial, agriculture and transportation

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[14] Energy efficiency/CO2 trends in the world. Oct 2003. World Energy Council

[15] Energy Information Administration/International Energy Outlook 2004

use as a consequence of increasing levels of per capita income, while the demand for non-commercial energy is expected to increase only marginally from the existing level of 140 to 170 mtoe, on account of supply constraints and the "utility" of consumers, who prefer commercial energy supply, as they become richer. The emergence of Ethanol[16] extracted from molasses and bio-diesel (Jatropha plant) as an alternative fuel will create a new category of energy supply, which would be renewable and agriculture based but not traditionally "non-commercial" as agricultural residue and biomass are considered today. Similarly successful gasification of larger volumes of biomass, as opposed to its direct use as fuel, can further dilute the artificial classification between "commercial" and "non-commercial" sources prevalent today.

2.2 Primary energy consumption over the period 2002 to 2020 on a business-as-usual basis is expected to increase at the rate of 6.4% per annum. This is much faster than the average consumption of primary energy in the World, which is expected to increase only at a rate of 1.3 % per annum over the period 2000 to 2020 from 10 billion TOE to 13 billion TOE[17].

2.3 Primary Energy Resources:

2.3.1 Non-commercial energy sources (fuel, wood, agricultural waste, dung) account for around 1/3rd of the total primary energy supply in India in 2001-02. Non commercial energy sources have a low energy conversion efficiency ranging between 8 to 13%. They are also extremely polluting when used in traditional end use applications. Consumer Survey data indicates that non-commercial energy sources are "inferior goods" and are used predominantly by the urban poor and in rural areas[18]. Improvements in the efficiency of energy conversion and utilization of these resources therefore can not only contribute effectively to a reduction in the energy intensity but has significant equity considerations.

2.3.2 Around one-half of the total commercial primary energy requirement is met from coal and lignite with crude accounting for around 37% and natural gas for around 9%. Despite abundant hydro resources, due to less than adequate utilization of the potential, hydro contributes only 21% of the total primary energy supply while nuclear power contributes around 0.5% only. Table 2.1 details the structure of primary energy supply:

Table 2.1: Structure of primary energy supply (million TOE)

	1970-71	% share	2001-02	% share	2019-20	% share
Coal & Lignite	37	25	140.41	32	336.5	36
Oil	7.01	5	32.03	7	243.4	26
Natural gas	0.6	0.5	26.72	6	114.6	12
Hydro power	2.17	1.5	6.37	1.5	14.3	1.5
Nuclear power	0.63	0	5.15	1	7.16	1
Wind power	0	0.5	0.14	0	0.30	0
Net imports	12.66	9	87.85	20	Na	0
Sub total commercial energy supply	60.33	41	298.67	68	716	77
Primary non commercial supply	86.72	59	139	32	214.8	23
Total primary energy supply	147.05	100	437.69	100	931.8	100
World primary energy supply	4897		10000		13529	
% India to world	3.0		4.4		6.9	

Source: TEDDY & IEA

2.3.3 The structure of primary energy supply is expected to change significantly by 2020. The share of non-commercial energy will reduce further from 32% in 2001-02 to 23%. The share of oil and natural gas is expected to increase from 13% in 2001-02 to 38%. The share of coal will increase marginally from 32% to 36%. Despite increase in the installed capacity of hydro-power, nuclear power and wind energy, their share in total energy consumption will stagnate.

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[16] From 1st January 2003 it is mandatory to use a 5% blend of Ethanol in petrol in nine sugar producing States and four Union Territories of India. This is expected to be extended to a 10% blend Nationally in phases.

[17] UNDP, WEC, DOE/EIA, EPRI estimates

[18] NSSO 2001

2.4 Secondary/Final Energy Sources:

2.4.1 Secondary energy is an intermediate stage between primary energy supply and final energy supply. Petroleum products are a form of secondary energy. They are produced by refining the primary energy form of crude oil. In turn Petroleum products are used to generate electricity, which is the final energy form. Petroleum products are also used as final energy in industrial process heat applications, transportation and for domestic heating and cooking appliances.

2.4.2 Coal and natural gas are two sources of primary energy supply, which have a dual role since they are a form of final energy being used both directly by industry for process heat and commercial and domestic consumers for cooking purposes and also as a form of primary energy for the generation of electricity.

2.4.3 Electric power accounts for only 15% of the total final energy supply in India in 2001-02. Coal and lignite, primarily for industrial purposes, account for around 35% with petroleum products accounting for 44% and natural gas only for around 6% of the final commercial energy supply. If non-commercial energy resources are included in final supply, they would account for around 41% of the total final energy supply. Increase in the share of electricity is closely associated with economic growth. Electricity is an efficient source of final energy. The share of electricity in total energy consumption was 10% (fairly close to the current share in India) in 1940 in the United States. It grew to 25% by 1970 and is currently around 38%. Table 2.2 below identifies the pattern of secondary/final energy supply.

Table 2.2: Secondary/Final energy supply (mtoe)

Fuel	2000-01	% as total commercial	% as total
Power	30.1	14.9%	8.8%
Coal & Lignite	70.31	34.9%	20.6%
Natural gas	12.49	6.2%	3.7%
Petroleum Products	88.83	44.0%	26.1%
Uub-total commercial	201.73	100.0%	59.2%
Non commercial	139.02		40.8%
Total	340.75		100.0%

2.5 Sectoral decomposition of energy use

2.5.1 Since 1972-73 the share of Agriculture, Residential use and other (non-energy) use in the total consumption of commercial energy has increased. The share of commercial energy consumption in Agriculture increased from just 0.2% in 1972-73 to 9% in 2000-01. The share of the residential sector in total commercial energy consumption similarly increased from 8.5% to 11%. The share of industry and transport decreased from 56% to 48% and from 26% to 17% respectively. While the nominal consumption in both industry and transport increased; with consumption in Industry doubling and with an increase of around 50% in Transport since 1984-85, their reducing share in total commercial energy consumption illustrates the success of initiatives to improve energy efficiency and conserve energy in these sectors. Conversely, poor incentives for energy conservation in agriculture and the growth in population and incomes boosted consumption by around nine times in Agriculture and around two and a half times in Residential sector.

2.5.2 There was also a shift in energy resources use. The share of electricity in the total energy consumed in agriculture declined from 86% in 1984-85 to 48% by 2000-01 while the share of petroleum products increased from 14% to 43%. The shift can be explained by the growing incapacity of the power sector to service agricultural demand, frequent power cuts, uncertainty in supply and conversely the growing need of agriculture to have assured supply especially in the case of cash crops and value added crops. It has been established that certainty of supply is the most important factor, far more important than the price at which electricity is supplied, for progressive farmers in the State of Harayana[19]. In the Residential sector there has been a sharp reduction since 1984-85 in the use of coal, possibly with consumers moving up the value chain to the use of Kerosene for cooking. The shift is beneficial for energy efficiency since the efficiency of wood or charcoal is only 25% compared to an efficiency of 50% for cooking on kerosene or gas. The share of petroleum products has also decreased from 77% to 70% though in absolute terms the consumption has more than doubled. The consumption of electricity has increased by five times during this period and its share in total commercial consumption in this sector has also increased from 16% to 29%.

2.5.3 In comparison the profile of resource use in Industry has remained fairly stable. The share of Natural Gas has increased from 1% in 1984-85 to 3% in 2000-01 at the expense of the other Petroleum Products. The share of coal and electricity remained stable at around 73% and 12% respectively. In Transport the share of coal declined significantly from 18% to 1% while the share of electricity increased from 1% to 2%, explained probably by the dieselisation and increased electrification of the Railways, respectively. In 2000-01 petroleum products accounted for a share of 98% in the total commercial energy consumption of the transport sector.

2.5.4 Residential use will be the fastest growing sector in energy consumption. There is also severe undersupply currently in agriculture. It is estimated that against a minimum availability of 2kW/Ha for optimum productivity in 1999-2000 the actual availability was only 1.15 kW/ha. However, irrational prices constrain the availability of electricity for agriculture and provide poor incentives for energy conservation. Improvements in energy efficiency of up to 30% are estimated to be possible if the appropriate price incentives are introduced along with facilitating technology change and the metering of supply[20]. On the supply side, Natural Gas and electricity will be fastest growing sources of energy supply. This is in keeping with the international trend of moving up the energy value chain from solids (coal) to liquids (petroleum fuels) to gas (Natural gas, biomass gasification) and finally electricity in step with economic development.

2.6 The energy loss matrix

2.6.1 Significant volumes of energy are lost while converting primary energy into secondary/final sources of supply and also while converting final energy into useful energy services like heating, lighting and motive power. Focusing on the areas of conversion loss helps us find ways of minimizing the volumes of energy this dissipated. It is useful therefore, to assess the volumes of energy lost in various processes. The supply side energy losses are listed in Table 2.3. The loss estimates have been calculated using a number of assumptions and are meant to provide only back-of-the-envelope estimates[21].

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[19] World Bank study on Rural Energy 2001

[20] DSM in agriculture sector of Uttar Pradesh-investment strategies and pilot design. 1996. TERI report number 1995EM52

[21] (a) Direct use of coal: Domestic/commercial use efficiency of 14%, industry combined efficiency of 32%, railways efficiency of 15%, and captive use efficiency of 2.5%. Overall weighted average efficiency across all uses: 30.7% (b) Direct use of Lignite: Industry efficiency of 13.7%, (c) Direct use of Natural Gas: Tea plantation efficiency of 35.3%, Domestic efficiency of 60%, Industry efficiency of 47.5%. Overall efficiency of 48% (d) Direct use of oil/oil products: Transport efficiency of 26%, Domestic/commercial efficiency of 34.8%), Industry efficiency of 35.4%, Agriculture efficiency of 22.5%, Misc applications efficiency of 35%). Overall efficiency of 29.8% (e) Electricity: Domestic efficiency of 62.6%, Commercial efficiency of 49.2%, Water works efficiency of 14.7%, Industry efficiency of 36.9%, Public lighting efficiency of 20%, Agriculture efficiency of 14.9%, Railways efficiency of 30%, Misc. efficiency of 34.7%. Overall efficiency of 35.1% (f) Non-commercial fuels direct use efficiency of 16.3%

Table 2.3: Energy loss at various stages of energy conversion (2001-02), mtoe

	Primary to secondary	Primary/secondary to final	Conversion to energy services	Total losses	Losses in power %	Total losses in %
Coal		56.98		56.98	40.4%	14.8%
Petro. Products		2.03		2.03	1.4%	0.5%
Natural gas		6.51		6.51	4.6%	1.7%
Hydro		0.05		0.05	0.0%	0.0%
Nuclear		0.16		0.16	0.1%	0.0%
Power generation	0	65.73	0	65.73	46.6%	17.0%
Power supply		7.72	67.46	75.18	53.4%	19.5%
Total power	0	73.45	67.46	140.91	100.0%	36.5%
Coal direct use			49.25	49.25		12.7%
Petro. Prod. Direct use	11.79		62.49	74.28		19.2%
Nat. Gas direct use			6.25	6.25		1.6%
Total commercial, mtoe	11.79	73.45	185.45	270.69		70.1%
Total (%)	4.35%	27.13%	68.51%	100%		
Non-commercial fuel	0	0.75	114.67	115.42		29.9%
Total, mtoe	11.79	74.2	300.12	386.11		100.0%
Total (%)	3.05%	19.22%	77.73%	100.00%		

Notes: The column "Primary to Secondary provides refining loss for Petroleum Products while the power T&D loss is given in the column Primary/secondary to Final. Energy lost in transport of coal, oil and petroleum products is not included.

2.6.2 Out of a primary energy supply of 438 million TOE over 88% or 386 million TOE is lost at various stages in the energy chain. Of this energy loss, 86 million TOE or 22% is lost on the supply side. The largest share in supply side energy loss is of electricity, in which around 66 million TOE are lost during conversion from various forms of primary or secondary energy (coal, PP or N. Gas) to electricity and another 8 million TOE during its supply to the consumer. It is significant that the loss in transmission and distribution of power is much smaller than the aggregate loss in generation though public attention is more easily focused on the latter. Despite a loss of around 22% of the primary energy in conversion to electricity and its transmission and distribution to the end consumer, electricity is the most efficient energy source for energy services like lighting and motive power due to the high energy efficiency of the end use applications, which convert electricity into useful energy services.

2.7 Demand Side Energy Loss

2.7.1 Energy is lost while converting a particular energy form into useful energy services through the use of an intermediate appliance. In this manner when coal, gas, kerosene or electricity is converted into heat through the use of stoves, significant volumes of energy are lost in this process of conversion. Similarly electricity is converted into light energy by bulbs and tubes and into motive power by the use of motors. Petroleum products similarly get converted into motive power through internal combustion engines. The volume of loss depends on the efficiency of the conversion device, which in turn is a function of the age of the capital stock since conversion efficiencies have been consistently improving through innovations in materials and technology.

2.7.2 Table 2.3 illustrates that around 300 million TOE or nearly 78% of the total energy lost is in end use applications while converting the primary, secondary or final energy resources into useful energy services. Of this, about 115 million TOE or 38% is on account of non-commercial energy. Energy loss in end-use applications, using energy forms other than electricity, have a share of 21% while only 19% is on account of energy loss in electrical end-use applications. This highlights the need to focus on the quality, design and efficiency standards of end-use equipment. Computing the demand side energy loss rigorously requires exhaustive data on the type and numbers of end use applications and the pattern of use across sectors and regions. Data on this scale is unavailable though its collection and collation on a regular basis is a prime input for monitoring changes in energy efficiency. The estimates of end use energy loss in Table 2.3 have been derived using a number of assumptions about the ratio of final energy consumption by different end users and average energy efficiencies of end use equipment. These are usable assumptions for a thumb rule analysis but would need to be further substantiated if a rigorous analysis is done[22].

2.8 The role of technology in energy efficiency

2.8.1 Over one half of the economic growth in developed countries is on account of technological innovation. Similarly the application of technology is crucial for improving energy efficiency. Non commercial energy sources are inefficient energy sources in traditional end use applications. The efficiency of dung as a cooking fuel is as low as 8% while agricultural waste and firewood is around 13%. A simple switch from open hearth to closed hearth applications increases the efficiency to 16% while gasification in a biogas stove increases it to 55%. In comparison the efficiency of a soft coal stove is only 10% and of a pressurised kerosene stove 40%. Liquified petroleum gas as a cooking fuel has an efficiency of 60%.

2.8.2 Technology has significantly improved the conversion efficiency from primary fuel to electricity of around 28% in 1950 to an average of 32% in 2000 and is expected to further increase it to 40% by 2020. The bulk of efficiency enhancement has happened due to an increase in the share of natural gas based combined cycle turbines however clean coal technologies (Integrated gasification combined cycle (IGCC) operating on pressurised fluidised bed combustion (PFBC)) are assessed to have the potential to deliver an energy efficiency of 50%. Natural gas based generation conversion efficiencies are assessed to be able to deliver efficiencies of 60% by 2020 and 80% by 2050 when natural gas and fuel cell combined turbines are envisaged.

2.8.3 Technological development is primarily driven by the requirements of the world economy in which the demands of the developed economy markets predominate. Accordingly, developing countries are generally passive absorber of technology, which is developed, essentially in developed economies for developed markets. In this environment, improvements in the efficiency of conversion can become a matter of changing the fuel mix i.e. by utilizing the fuel, which is compatible with the most efficient conversion technology currently on the market. In the context of India, which is abundant in coal (over 200 years' consumption is available), this can mean a shift towards natural gas based thermal generation of which India has meagre resources. The import of natural gas with a view to seek out higher levels of energy conversion efficiency raises both commercial and political opportunities as well as risks and illustrates the possible conflicts between the competing objectives of energy security and energy efficiency.

2.9 Section 2 summary

2.9.1 The bulk of the potential for enhanced energy efficiency and a reduction in conversion losses of energy lies in improving the energy efficiency of end use equipment. This aspect has received less attention so far than the supply side measures to reduce the energy losses in the conversion of primary energy into secondary and final energy forms. Efficient consumer prices, deregulation, competition in the supply of end use equipment and privatisation of energy suppliers are some of the prime requirements for focusing consumer attention on upgrading the energy efficiency of end use equipment. In addition the role of labelling and minimum standards

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[22] See "Reference Energy Systems for India (1995-96)" IEI & CMIE, in Energy for Sustainable Development, Volume IV No 1, June 2000 for an earlier version (1995-96) of end use energy loss analysis.

for energy efficiency cannot be over emphasised. Administered pricing regimes distort the prices consumers face in electricity, petroleum products and coal. While electricity is now being regulated in a structured manner by Regulatory Commissions, regulation of the petroleum sector is entirely within the Government. Rationalisation of consumer prices is underway in both electricity and petroleum. However the pace of reform is slow and the sequencing is uncertain. There are no visible steps being taken to reform the coal sector, which remains a public monopoly regulated from within Government. Similarly efficient use of our non-commercial energy resources is yet to acquire technological momentum. However, liberalisation of the economy, facilitating easy entry for suppliers, public finance constraints on subsidies and financial support to public utilities and enhanced opportunities for the private sector to enter into the business of becoming energy suppliers are positive developments and are yielding significant returns. The enhanced efficiency levels in automobiles and consumer electrical durables are examples of positive change on the demand side. Meanwhile, the exigencies of regulatory pressure and the need to remain competitive are also driving supply side efficiencies.

3. Institutional arrangements for energy efficiency policies

3.1 The Constitutional provisions and Acts;

3.1.1 The Constitutional basis for regulation of energy is provided by the provisions of Article 246 read with specific entries in Lists I, II and III of Schedule VII which respectively enumerate the subjects in which the Union Government has sole legislative powers (List I), where the State Governments have sole powers (List II) while List III is the Concurrent List, where both the Central Government and State Government can legislate though the former has overriding powers over the latter in case of a conflict between the two on any particular subject.

3.1.2 Under List I where the Union Government has sole legislative powers the following subjects, which have implications for energy efficiency are listed;

- Entry 6: Atomic energy and the mineral resources necessary for its production.
- Entry 22: Railways
- Entry 23: National Highways
- Entry 24: National waterways
- Entry 25: Maritime shipping
- Entry 27: Ports
- Entry 29: Airways, aircraft and air navigation
- Entry 53: Regulation and development of oilfields and mineral oil resources – petroleum and petroleum products – other liquids and substances declared by Parliament by law to be dangerously inflammable.
- Entry 54: Regulation of mines and mineral development (including coal)
- Entry 56: Regulation and development of inter-state rivers and river valleys.

Hence atomic energy, the major mineral including coal, oil and petroleum products and the entire transportation sector, except state highways and roads are all directly under the legislative jurisdiction of the Central Government.

3.1.3 Under List II where the State Government has sole legislative powers the following subjects, which have implications for energy efficiency are listed;

- Entry 17: Water including water supply, irrigation and canals.
- Entry 25: Gas and gas works
- Entry 49: taxes on land and buildings.
- Entry 53: Taxes on the consumption or sale of electricity.
- Entry 56: Taxes on goods and passengers carried by road or inland waterways.
- Entry 57: Taxes on vehicles.

As is evident from the list the scope for regulation of energy efficiency is limited at the State level except through the levy of taxes on electricity, goods and passenger traffic and vehicles in a manner, which provides economic incentives for energy conservation. The provisions of Entry 25

have been the cause of regulatory confusion due to an overlap with Entry 53 of List I, which relates top the regulation of Natural Gas. The State of Gujarat in particular has raised this issue in the context of regulation of coal bed methane claiming jurisdiction under Entry 25.
3.14 Under List III where the Union and State Government have concurrent powers with the former prevailing in the case of a clash on any subject, the following subjects which have implications for energy efficiency are listed;

- Entry 35: Regulation of mechanically propelled vehicles including the principles on which taxes on such vehicles are to be levied.
- Entry 38: Regulation of electricity.

Under the Scheme of the Constitution, the primary role for regulation of energy vests with the Central Government either directly through the subjects reserved for it in List I or via provisions of List III where the Central legislation can supersede State legislation.

3.1.5 The Constitution (Seventy Fourth) Amendment Act, 1992 with effect from 1st June 1992 inserted Articles 243G and 243W, which respectively empower the State Governments to endow Panchayats and Municipalities as institutions of self government by devolving powers and responsibilities to them out of the subjects listed in the Eleventh and Twelfth Schedules respectively. No State Government has so far used this provision to decentralise powers. However the following subjects which will have an implication for energy efficiency are listed in these schedules.

- Subjects under the Eleventh Schedule
    - Entry 3: Minor irrigation, water management and watershed development
    - Entry 6: Social forestry and farm forestry
    - Entry 7: Minor forest produce
    - Entries 8 & 9: Small scale industry, Khadi, village and cottage industry
    - Entry 12: Fuel and fodder
    - Entry 14: Rural electrification including distribution of electricity.
    - Entry 15: Non-conventional energy sources
- Subjects under the Twelfth Schedule
    - Entry 1: Urban planning including town planning
    - Entry 2: Regulation of land use and construction of buildings
    - Entry 4: Roads and bridges
    - Entry 17: Street lighting along with other public amenities.

The list of subjects which can be devolved to Panchayats and Municipalities is extensive. However, unless supportive arrangements are made for devolution of finances the net result may be retrogressive since the finances of Local Bodies are already under strain and avenues for fresh taxation limited.

3.1.6 The statutory provisions for conservation of energy are available in the Energy Conservation Act, 2001 which was notified on 29th September 2001. This Act provides for creation of a Bureau for Energy Efficiency which is discussed in detail in subsequent paragraphs. It also enjoins the Central Government and State Governments with specific responsibilities.

Energy Conservation Act 2001

3.1.7 This legislation, which is of recent origin, seeks to acquire the necessary legal authority to enforce a variety of energy conservation measures. The Act provides for setting up of a central energy conservation authority (called Bureau of Energy Efficiency) to facilitate and enforce efficient use of energy. Laying down energy efficiency standards, making energy audit mandatory, banning manufacture of the equipment not conforming to energy efficiency standards and imposition of penalty for non compliance upon the designated consumers are some of the important functions of the authority.

3.1.8 The Act seeks to establish a comprehensive law that adopts standards and procedures, and prescribes measures for energy conservation. It was pioneered with the intention of reducing energy consumption by adopting energy-efficiency measures in various sectors of the economy. It is also expected that the Act would result in substantial environmental benefits in terms of reduced GHG (greenhouse gas) emissions. The main elements of the Act are:

- Designating energy-intensive consumers
- Prescribing standards for equipment and building
- Setting up an energy conservation fund
- Applying penalties when and where necessary.

Electricity Act 2003

3.1.9 In order to address the problems of the power sector in a holistic manner, Government of India has enacted a new legislation known as Electricity Act 2003. The Act proposes to consolidate the laws relating to generation, transmission and distribution, promote competition and create a regulatory framework for the development of the sector. The main objectives of the Act are as following:

- To consolidate the laws relating to electricity generation, transmission, distribution, trading and use
- To deconstruct the electricity value chain
- To promote competition and efficiency in the power sector by providing choice of service provider to the consumer
- To rationalize tariff and reduce subsidy and cross subsidy

The key features of the Act are as following:

- Abolition of licensing requirement and techno-economic clearance for generation projects other than hydel projects
- Provision of open access in transmission on enactment and at a later date in distribution
- Repealing of the existing laws/Acts (The Indian Electricity Act 1910, The electricity Supply Act 1948, The Electricity Regulatory Commission Act 1998)
- Fillip to power trading
- Competition in distribution

The Act provides the much-needed platform for change/reform in the power sector. There is emphasis on competition among the service providers, which in the long run will benefit the consumers.

3.1.10 The Electricity Act, 2003 also has specific functions with respect to energy efficiency and conservation, which are to be discharged by the Central Electricity Regulatory Commission and the State level Regulatory Commissions.

- Under the provisions of Section 79(1)(h), the CERC is to specify the Grid code having regard to Grid standards and (i) to specify and enforce the standard with respect to quality, continuity and reliability of service by licensee.
- Under the provisions of Section 79(2(ii), the Central Commission is to promote efficiency and economy in the activities of the electricity industry.
- Under the provisions of Section 86, the State Commissions have mirror functions as in the case of Central Commission and in addition under 86(i)(e) are to promote cogeneration and generation of electricity from renewable sources.

3.1.11 The Coal Mines Nationalization Act, 1973 provided for the acquisition and transfer of all private coal mines by the Government with a view to reorganizing and restructuring such coal mines so as to ensure rationale, coordinated and scientific development and utilization of coal resources with effect from 30th May 1973. As a consequence, coal mining in India is dominated by public sector companies and it is only recently that the provisions have been liberalized to allow entities other than the Government companies (like steel companies and power generators) to mine coal only for their captive purposes.

3.1.12 The regulatory framework of the petroleum sector is provided by the Oil fields (Regulation and development) Act 1948 and the Petroleum Act 1934. The former Act regulates, licenses and prescribes the royalty to be charged for the excavation of any mineral oil including natural gas and in this manner regulates the entire upstream sector. The Petroleum Act regulates the entire down stream sector comprising transportation, refining, storage, blending etc of petroleum however its thrust is primarily on the public safety aspect. A bill is also separately under discussion, which will constitute a Regulatory Body for Petroleum and aim to enhance economic efficiency. However it is nowhere close to being enacted.

3.2 Energy Policy

3.2.1 Energy policy is formulated as a part of the planning process, at the time of five-year plans, keeping a long-term perspective in view. The focal institution for energy planning is the Planning Commission, which undertakes this task jointly with the concerned ministries/departments (which provide the key inputs) and consults with various organisations, industrial associations, institutions and experts. This consultation is usually through working groups set up at the time of each five-year plan. The overall energy plan is a composite of sectoral plans (power, coal, oil, new and renewable sources), which are subdivided into major programs and projects; physical targets to be achieved and investments to be made are spelled out in the five-year plans.

Targets for energy savings during tenth FYP (2002-07)

3.2.2 The Tenth Five-year Plan stipulates that programmes of energy conservation would address issues such as pricing of electricity for different categories of consumers, generating awareness of the necessity of energy conservation, and mobilizing resources for funding energy conservation programmes. Table 3.1 gives the potential for energy savings in electricity as assessed by the Planning Commission over the Tenth Plan (based on 16th EPS projected demands). This is equivalent to adding new capacity of about 20,000 MW, assuming projected T&D losses of 20.5% (as given in 16th EPS) and an average all-India PLF (plant load factor) of about 68%.

Table 3.1: Tenth plan energy saving potential

End use electrical equipment	Potential energy savings (MkWh)
Motors and drive systems (industrial and agriculture sectors)	80,000
Lighting (domestic, commercial, and industrial sectors)	10,000
Energy-intensive industries	5,000
Total	95,000

3.2.3 Typically, policy-formulation and the implementation of policies is initiated in the Ministries of the Government of India, on the basis of historical experience, representations from industries, evaluation studies, or expert-group's recommendations. This policy formulation (or policy change) is then discussed with other concerned Ministries (particularly the Ministry of Finance, and increasingly, the Ministry of Environment and Forests), and then sent to the Cabinet of Ministers for approval. If a large number of Ministries have an interest in the policy it may be discussed in an Inter-Ministerial Committee (with representatives from a number of concerned Ministries) and a Committee of Secretaries (who are the civil-service heads of the Ministries) before being sent to the Cabinet of Ministers for approval. National energy policies are executed and implemented by Ministries and agencies of the Government of India. The principal Ministries are those of Power; Coal; Petroleum & Natural Gas; and Non-Conventional Energy Sources. A brief description of the major agencies involved in energy efficiency and conservation is given below:

3.3 Agencies of the Government

3.3.1. The Energy Management Centre was Founded in 1989. It is an autonomous body under the Ministry of Power, Government of India. It was the executive agency for implementation and monitoring of energy conservation programmes in India and providing policy guidance and advice on energy efficiency. In 2001, the EMC was merged with the newly formed Bureau of Energy Efficiency (BEE), which was as set up by an Act of parliament in August 2001. The mission of BEE is to institutionalize energy efficiency services, enable delivery mechanisms in the country and provide leadership to energy efficiency in all sectors of the country. The primary objective would be to reduce energy intensity in the economy. The broad objectives of BEE are as under:

- Provide a policy framework and direction to national energy conservation activities
- Coordinate policies and programmes on efficient use of energy with shareholders
- Establish systems and procedures to verify, measure and monitor Energy Efficiency (EE) improvements
- Leverage multilateral, bilateral and private sector support to implement the EC Act 2001
- Demonstrate EE delivery systems through public-private partnerships

3.3.2 The Petroleum Conservation Research Association focuses on efficiency improvements in the use of petroleum fuels, in the industrial, transport as well as domestic sectors. PCRA activities include conducting studies of the potential for oil conservation in industry and government bus fleets; subsidizing up to 50 percent of the cost of industrial energy audits; sponsoring research and development in fuel-efficient products and fuel additives including the high-efficiency Nutan kerosene and liquid petroleum gas stoves; publishing a monthly bulletin, Active Conservation Techniques; conducting energy-conservation publicity campaigns for rural or widely dispersed users (such as truck operators); and providing policy recommendations to the government on how to promote energy conservation.

3.3.3 The National Productivity Council carries out energy audits, provision of training programs, workshops, and seminars on energy-conservation technologies and practices for industrial personnel; advising government and professional agencies on the establishment and administration of energy-conservation programs; publishing a quarterly journal, Energy Management, and providing a two-year postgraduate program on energy management for engineers.

3.3.4 Development Banks/Financial institutions: The Ministry of Finance (MoF) has three notable development banks, viz., the Industrial Development Bank of India (IDBI), the Industrial Finance Corporation of India (IFCI), and the Industrial Credit and Investment Corporation of India (ICICI), which participate in energy-conservation financing programs by floating schemes and providing loans for energy efficiency improvement programmes. The Ministry of Non-Conventional Energy Sources (MNES) supports IREDA (Indian Renewable Development Agency), which is a public financial institution entrusted with providing credit for promoting renewable energy and energy efficiency technologies. Small Industries Development Bank of India (SIDBI) was also established in 1990 under an Act of Indian Parliament as the principal financial institution for promotion, financing, and development of the small scale industry sector. SIDBI assists the entire spectrum of SSI Sector including the tiny, village and cottage industries through suitable schemes tailored to meet the requirement of setting up of new projects, expansion, diversification, modernization and rehabilitation of existing units.

3.3.5 The Bureau of Indian Standards has formulated about 14,800 standards, of which 200 address energy-efficiency. While some BIS standards are mandatory, the energy-efficiency standards are largely voluntary. That is, manufacturers are not compelled by statute to submit their products to standards inspection but can choose to get certification and then use the ISI

(Indian Standards Institution) mark on their product labels. The Coordination Cell for Energy Conservation in the BIS reviews energy-conservation aspects of the standards and oversees the work of 350 committees that review and formulate standards bearing on energy use. After the formulation of the Bureau of Energy Efficiency (BEE), it is expected that energy efficiency standards and codes of energy performance of end use equipment would be taken over by the BEE.

3.4 Integrated Energy Policy

3.4.1 The complex allocation of legal jurisdiction and authority between the Union, State Governments and possibly in future through devolution, between the State Government and Local Bodies, along with the multitude of Ministries, Departments and State level agencies that are concerned directly and indirectly with energy efficiency indicate the need for integration of the Energy Policy. Energy conservation is an objective in most Government programmes. It is also given implemented by consumers to increase the overall efficiency of their operations and to reduce the cost of energy usage. However, the enhancement of energy efficiency is unlikely if left only to market sources due to the multiple market failures, which have been recorded in the literature. Administrative interventions are needed. However, without appropriate integration, administrative interventions can often work at cross purposes or may function sub-optimally. A Study[23] of options for meeting the incremental power demand of 5278 MW in Maharashtra estimated that if the conventional path of adding new capacity is avoided and instead least cost power planning principles are adopted 40% of the incremental demand can best be met by DSM options, 15% by decentralized generation options and only the remaining 45% would need incremental centralized capacity. The least cost planning alternative would result in a 33% savings in life cycle costs and reduce the use of fossil fuel equivalent to 12 million tones of coal per year.

3.4.2 Similarly meeting the demand for rural energy required that attention be focused not only on the supply aspects of the energy system but also towards demand side management. The rural energy system is an integrated “fuel” cycle from energy sources through energy carriers via transmission/transport to distribution to end users for utilization in end use devices to provide energy services. The thrust must be on energy sources that are renewable, universally acceptable, affordable, reliable, high-quality and safe[24].

3.4.3 At the national level, there are choices to be made with respect to the trade offs between the transmission of electricity at very high voltage as opposed to the physical transportation of secondary energy sources like petroleum products or primary energy sources like coal for the generation of electricity. Similarly, there are choices and trade offs between transportation of coal and petroleum products through rail or via pipeline. Integration of decentralized generation sources is another aspect of energy planning, which requires appropriate policy support. Due to the unequal spatial spread of energy resources, including wind energy and bio-mass, there may be a local gap between the demand for a particular energy source, like renewable energy, and the supply of such energy resources. Meeting this gap may requires appropriate regulations that seek to integrate the costs and benefits of renewable energy at the national and State level. These are some examples, which highlight the need for adoption of an integrated energy model while evolving energy policy and framing energy regulations.

This has been a matter of concern for several committees and groups set up by the Government in the past. The recommendations of the Working Group on Energy Policy (WGEP) constituted in 1979, the Inter-Ministerial Working Group (IMWG) in 1983 and the Advisory Board on Energy (ABE) in 1985 have all emphasized the need for integration of Energy Policy. However, the multitude of legal and regulatory jurisdiction has made the practical evolution of an integrated

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[23] “Least Cost Power Planning: Case Study of Maharashtra State” Girish Sant, Shantanu Dixit, Prayas, Pune in Energy for Sustainable Development, Vol.IV No.1, June 2000

[24] “Goals, Strategies and Policies for Rural Energy” Amulaya K. Reddy in Economic and Political Weekly, December 4, 1999

Energy Policy difficult. The Planning Commission is the only forum where such integration is possible. However, the role of the Planning Commission is somewhat limited essentially to the allocation of plan finances while policy formulation is increasingly with the various Ministries and Departments. The growth of independent regulation and the constitution of various regulatory Commissions has further complicated the regulatory structure. Accordingly there appears to be a need at the Central level for formulation of a long term integrated energy policy which can prescribe the road map and the broad principles for meeting the energy needs of the future. Clearly, this is a complex task and is likely to be criticized by those who favour a reduction in the role of central planning and promote greater freedom for local initiatives and for market based interventions.

3.4.4 It would be a mistake to equate the need for an integrated Energy Policy with the decision making process for technology and scale choice for specific investments and creation of additional capacity. Clearly investment and capacity creation decisions need to be taken by those who will be meeting the cost of such investments, which indicates the need for decentralization of such investments. However, consensus and uniformity in the use of tax policy for promoting energy efficient outcomes, regulatory policy for promoting energy conservation, the evolution of standards for household appliances and end used equipments and the broad direction and thrust of public finance led investments are issues which need to be discussed and decided centrally. Failure to do so will inevitably result in sub optimal policies, regulations and decentralized solutions that do not reflect the full social and economic costs of such decisions.

3.5 Section 3 summary

3.5.1 The institutional arrangements for energy conservation and regulation are fairly extensive in India. Starting from the enabling provisions of the Constitution, separate Acts have been enacted to deal specifically with each sub sector of the energy area. Multiple Government agencies are also available to conduct research, manage outreach and impart training. In addition, several not-for-profit institutions (TERI, CSE, Development Alternatives, Prayas, IGIDR, ASCI, etc) also function in the energy area. The onset of independent regulation will give a fillip to the functioning of such non governmental institutions as consumers and suppliers alike seek out expertise in resolving disputes in a transparent and participative manner. The BEE, currently at a nascent stage, is expected to play a central role in this direction. While the Electricity Act 2003 and the Energy Conservation Act 2001 are enabling legislations, the lack of a centralising forum convening all the concerned Ministries and State Governments, inhibits the development of an integrated energy policy. Integration of energy policy would allow optimum results to emerge wherever there is a trade-off between the use of more than one supply option to meet demand. Demand Side Management and Energy Efficiency being the time honoured alternative to incremental capacity enhancement. Decentralised renewable power based generation as opposed to large conventional fuel generation projects, Pit head coal as against demand centre based coal generation, use of coal versus use of natural gas, transportation of petroleum by pipeline as opposed to by rail, building transmission redundancy as opposed to incremental generation, the appropriate shadow price for import substitution keeping in mind security concerns, the need for enhancing the petroleum storage capacity and the role of overseas oil equity are all some examples of such tradeoffs. In the absence of a market based system for making rational choices insightful and light handed central regulation and coordination is key to developing an integrated energy policy. Currently the Planning Commission is expected to play this coordinating role. However, being a plan resource allocating body it cannot be associated with policy advocacy beyond a point. The ideal solution would be the merging of the Ministries of Power, Non Conventional Energy, Petroleum and Coal into a single Mega Ministry. This appears unlikely to be acceptable. Hence the Planning Commission would have to play a far more proactive role in developing an integrated policy agenda for energy. The Planning Commission was a proactive, policy integrating forum in the mid

1980s. This role may perforce need to be revived as an option which is the best of the worst options.

4. Supply side energy efficiency

4.1 Coal

4.1.1 Coal is the dominant commercial fuel in India with reserves estimated to be sufficient for the next 200 years. It meets just under one half of the supply of primary energy. Power generation accounts for about 70% of India's coal consumption, followed by heavy industry. Coal consumption is projected to increase to 600 million short tons (Mmst) in 2025[25], up from 360 million short tons (Mmst) in 2000.

4.1.2 The total geological reserves of coal in India are about 201.9 billion tons or about 6.8% of the total proven reserves of the World. India is the world's third largest coal producer (after China and the United States) making it largely self-sufficient. However, Indian coal generally has a high ash content and low calorific value, with the result that the bulk of the demand for coking coal is met by imports. There are two major interventions, which can significantly improve the efficiency of coal extraction and supply.

4.1.3 The Coal Mines Nationalisation Act bars private investment in the industry though captive mining by actual users like steel plants and power generators is permitted. All the nine large producers of coal are public sector companies. In a study of the period 1984 to 1994 it was found that despite significant investment in the 1980’s the Total Factor Productivity declined by around 50% with the decline being the steepest in Eastern Coalfields Limited of 81%. Surplus manpower, huge unrealized debts, and uneconomic mines under operation were identified as the reasons. The coal industry like the entire public sector seems to have been motivated by the formulation of detailed physical targets for output without concern for cost and efficiency. This behaviour was accentuated by the lack of organizational incentives, inappropriate pricing, lack of penalties and insulation form competition[26]. The situation is no different today as the sector is still oligopolistic and still adopts the command and control pattern of rationing of supplies etc. Opening up the sector to private investment will introduce competition in supply and improve the efficiency of mining and the quality of coal supplied. This will require an amendment to the Act, which has been under consideration for some time now.

4.1.4 The second initiative is the development of coal bed methane. The primary energy source of natural gas is methane (CH_4). Coal bed methane (CBM) is simply methane found in coal seams. It is produced by non-traditional means, and therefore, while it is sold and used the same as traditional natural gas, its production is very different. CBM is generated either from a biological process as a result of microbial action or from a thermal process as a result of increasing heat with depth of the coal. Often a coal seam is saturated with water, with methane is held in the coal by water pressure. Currently, natural gas from coal beds accounts for approximately 7% of total natural gas production in the United States[27]. In a bid to encourage foreign investment the central government in India had identified 10 blocks for exploration and exploitation of CBM gas in 1999. While the West Bengal government gave its consent to the centre’s draft policy on exploration and exploitation of CBM, the Bihar government did not responded. The Madhya Pradesh government demanded a higher royalty on the CBM discovered in the state and said it should be allowed to invite bids for the same. The Gujarat government went a step further and issued two notifications reserving CBM exploration and exploitation rights under the state government which were subsequently withdrawn following the legal opinion given

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[25] International Energy Annual 2004

[26] “A study of productivity in the Indian Coal Sector” Mudit Kulshreshta, Jyoti Parikh, IGIDR, in Energy Policy 29 (2001) 701-713 quoting from Economics of the Public Sector, Stiglitz J.E. 1988, “Performance of the Public Sector in India” Sarma V. 1995, India Macro Economics and Political Economy 1964-1991, Joshi V., Little I.M.D. 1994

[27] Montana Bureau of Mines & Geology 2003

by the Ministry of Law that CBM is governed under the Oilfields (Regulation and Development) Act, 1948, and the Petroleum and Natural Gas Rules. Subsequently Government has awarded 16 CMB blocks through international competitive bidding for exploration and production of CBM. India has 200 billion tonnes of coal reserves having a possible potential for 800 billion cubic metres of CBM resources. Potential production from the awarded blocks is estimated at 23 MMSCMD.

4.1.5 Coal India is also exploring the possibility of in-situ gasification of coal in collaboration with International experts. This method of extraction has significant environmental advantages and will greatly enhance the efficiency of extraction and transportation.

4.2 Electricity

4.2.1 Peaking shortages of electricity are estimated at 13% and the energy deficit at about 8%. Around one fifth of the total consumption is self-generated by the consumers, mostly due to the poor quality and inadequate supply of grid power. Out of around 160 million House Holds there are around 114 million electricity consumers, most of them being domestic consumers. However field level evaluations suggest that no more than one third of rural House Holds are electrified and statistical confusion is created by differing nomenclature on "access to electricity" and "electrification". Power outages are common, and the unreliability of electricity supplies is severe enough to constrain economic development. It has been estimated that the economic cost of electricity outages in the State of Harayana in the manufacturing sectors alone amounts to 1.06% of the State Domestic Product (SDP) in manufacturing and in agriculture amounts to 3.1% of SDP in agriculture. The economic loss in Karnataka is even higher being 2.22% of the SDP in manufacturing and 13.3 % of the SDP in agriculture[28] The situation would be no better in other states which illustrates the extent of the economic loss due to unserved demand. The cost of poor quality power in terms of frequent start ups, interrupted schedules and defective production would be even higher.

4.2.2 It is planned that the existing capacity of around 110,000 MW would be doubled to 216,000 MW by 2011-12. Table 4.1 provides details.

Table 4.1: India's perspective plan for electric power generation

Sl.No.	Power Generation	Coal and Lignite (MW)	NG/LNG/ Diesel (MW)	Nuclear (MW)	Hydro (MW)	Total (MW)
1	Installed Capacity March 2004	65,214	NG:12,104 Diesel: 1,173	3,105	29,556	111,152
2	Capacity addition till March 2012	49,276	18,148	8,995	28,233	104,652
3	Capacity by March 2012	114,490	31,425	12,100	57,789	215,804

4.2.3 Expansion in generation capacity has traditionally been a benchmark for assessment of the performance of the sector. The expansion of generation capacity is no doubt an important aspect of development however it cannot be considered in isolation from other indicators of development like the expansion of transmission capacity, higher efficiency in supply and demand side management since all these factors impact the efficiency of the sector. The lack of commercialisation is another factor which impedes development of this sector. Some of the key issues in the power sector which impact energy efficiency are the following:

4.2.4 Is competition in bulk supply the answer to improving the efficiency of the generation sector or can independent regulation provide the necessary incentives and disincentives? Generation costs being loosely regulated on a cost-plus basis till 1998 appear to have excess margin. How can this excess margin be pared to efficient levels? One option is to introduce competition in the sale and purchase of bulk power as in the UK, Australia, Argentina and parts of the US. The Electricity Act 2003 emphasises the role of competition. Currently generation tariffs

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[28] "Cost of unserved energy" TERI 2000.

are regulated and determined by the Electricity Regulatory Commissions. Is this an in efficient arrangement? The cost norms for generation tariffs were revised in 1992 possibly as a part of the move to facilitate the entry of private generators at that time. Subsequently, they were revised downwards by the Central Electricity Regulatory Commission (CERC) in December 2000 primarily by reducing the incentives paid to generators to make capacity available. The resultant decrease in regulated cost by around 5% was put into a fund to finance future capacity enhancement without burdening customers. The CERC also initiated a review of other costs norms like heat rate, auxiliary consumption, supplementary fuel consumption and operations and maintenance cost. The cost norms have again been revised downwards by 5% in December 2004. This illustrates the proactive role played by the Electricity Regulator in regulating the tariff of generators. Could the introduction of competition have done better?

4.2.5 Competition in bulk supply without adequate surplus capacity and a flexible retail tariff policy can result in a California type crisis. California, unbundled its utilities, transferred transmission to an independent operator and adopted the market pool system for despatch of generation in 1996 in response to the criticism that power rates in California were around 50% higher than in the rest of the US. Competition was expected to bring rates down. Instead in May 2000 bulk power rates increased to $120/mWh and in December 2000 to $400/mWh while regulated retail rates stagnated at $65/mWh. A combination of rising demand fed by the technological boom, in migration of population, inadequate generating capacity addition due to uncertainty of off take, lower hydro generation due to drought and the absence of a retail price response, as retail rates remained capped, all served to increase the demand supply gap. Cartelisation by generators also led to them taking advantage of the demand supply gap and thus sharply increasing bulk power rates despite the operation of a market based system which however was not technologically equipped to regulate gaming. The result was widespread blackouts and utilities going bankrupt thereby forcing the Government to take over electric power supply and provide high volumes of subsidy[29].

4.2.6 The key learning from this experience is that competition in bulk supply is difficult to implement unless adequate safeguards are in place to avoid the build up of market power amongst generators. In a situation of power shortages, as in India, it would be difficult to control gaming and cartelisation. Secondly, a bulk power market may not provide the required incentives for capacity addition due to the uncertainty of return on investment, which is lower under a regulated regime. This is a significant factor in view of the need in India to nearly double capacity in a decade. Thirdly, a bulk power market is unworkable unless accompanied by competition in retail supply and flexible retail tariffs to allow power utilities to pass on price variations.

4.2.7 A flexible retail tariff policy is currently difficult to implement. Retail tariffs continue to be severely distorted. Industrial and commercial customers paid 108% and 122%, respectively, of the average cost of supply in 2000-01. Railway traction paid 128% of the average cost of supply. Meanwhile domestic and agricultural customers paid only 56% and 12%, respectively, of the average cost of supply. The average revenue was only 69% of the cost of supply. The actual position of tariff distortions and under recovery is much worse if the revenue is compared to the actual cost of supply to different consumers. No authenticated data for the real cost of supply to different consumers is available. However estimates for Andhra Pradesh suggest that Low Tension domestic consumers, cottage industry and High Tension Agricultural consumers and Irrigation pay only around 36% of the cost of supply, Low Tension agricultural consumers pay only 5% of the cost of supply while High Tension Industry pays 206% of the cost of supply and Low Tension Industry pays 110% of the cost of supply[30]. In such a situation there will be, for some time, a glass ceiling on major tariff adjustments, which are a major political issue. With sticky retail tariffs, the scope for competition in bulk supply is limited to “competition for the market” with incremental generation capacity being bid out to the lowest bidder, rather than “competition in the market” via a pooled power market. Accordingly, in the short term, sound

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[29] “The changing Global Context for Electricity Reform” Navroz. K Dubash in Power Politics, WRI 2002

[30] “Cost of Supply Study (Distribution), CIDA January 2000

independent economic regulation rather than competition is the key to stabilisation, cost recovery, financial viability and higher efficiency of the power sector at this stage.

4.2.8 The track record of independent regulation has been fairly satisfactory. In the four years of their establishment, independent power regulators at the centre and in the States have consistently ruled in favour f a greater convergence between the tariff and the cost of supply, full metering and emphasis on reduction in the T&D losses, a euphemism for theft famously referred to as "Theft and Dacoity" loss by Rangarajan Kumaramangalam, India's Power Minister in the late 1990's. The recovery of costs though tariff has increased from the low of 67.8% in 1999-2000 to 68.6% in 2001-02. There has been a significant improvement in the Plant Load Factors of non CPSU generating plants from 57.1% in 1992-93 to 69.9% in 2001-02. The average T&D loss has come down from the high of 30.8% in 1999-2000 to 27.8% in 2001-02, though inadequate metering arrangements continue to dilute rigorous estimation. The central regulator (CERC) has been particularly sensitive to implementing incentive based regulation and in December 2000 had revised downwards the cost norms for allowing costs on account. This was the first downward revision after a decade, the earlier norms having been determined in 1992. The estimated gain for consumers was to the order of Rs 1800 crores as estimated by the primary power generating company (NTPC). Subsequently, as a result of the review initiated by the CERC of the normative costs on account of Heat Rate, Auxiliary Consumption, oil consumption and O&M expenses per unit of generation there was a further reduction of around 5% in December 2004.

4.2.9 Can adequate transmission capacity be installed to use the untapped Hydro potential n the North East and service incremental pit-head coal based generation capacity? POWERGRID the central Government owned utility is the monopoly supplier of inter state transmission infrastructure though each SEB also operates its own state level transmission grid separately. POWERGRID is the first power utility in the country to be accredited with ISO 9001. There has been an increasing focus on expansion in transmission capacity since 1992. India's Central Transmission Utility (CTU) & National Grid Operator owns about 48,000 ckt. Kms transmission lines with 82 sub- stations having transformation capacity of 46,000 MVA under its operation and expects to add an additional 60,000 ckt. Kms. by 2011-12.

4.2.10 It maintains the transmission system with availability over 99%. POWERGRID completed the first phase of the National Grid in September 2002, establishing an inter-regional power exchange capacity of 5000 MW (around 5% of generation). Commissioning of projects associated with the second phase of the National Grid has already commenced and inter-regional transfer capacity is currently around 8500 MW (around 8% of generation). POWERGRID transferred 22,000 MU of energy across the regions during the year 2003-04, an increase of 70% from the previous year mostly from the power surplus Eastern Region to other regions. Thus, inter-regional transfer of power worth Rs.4,400 Crore was facilitated, which would otherwise have remained unutilised. The pace of implementation of the National Grid is expected to be enhanced with inter-regional power transfer capacity of 30,000 MW by the year 2009-10 (instead of 2011-12 as earlier planned) and 50,000 MW by the year 2014-15 by when a strong National Grid will have a ring of 765 kV lines inter-connecting the Regional grids and high density transmission corridors evacuating power from hydro plants in the North East and thermal pit head plants in Central India to consuming centers. The licensing norms for private sector transmission capacity have been put in place by CERC and of the estimated Rs 70,000 crore investment envisaged during the period 2002-03 to 20011-12, Rs 20,000 crore are expected from the private sector either in competition with POWERGRID or in collaboration with them State level investments in transmission will be additional to the above estimates.

4.2.11 The emphasis on adding transmission capacity has provided significant benefits. Through inter regional trade capacity utilisation can be maximised by meeting time asynchronous load. The improved PLF of central power produces in the Eastern region are an example of these benefits. Similarly better grid discipline and better grid availability has decreased forced outages of generating plants from 16.19% in 1992-93 to 12.6% in 2000-2001. The distribution of Plan resources has also been rationalised. The share of the SEB outlay on Generation has decreased from 56.8% in 1997-98 to 48.8% in 2000-01 the beneficiaries of this resource reallocation being Transmission, Renovation and Modernisation of generation and rural electrification with the share of transmission increasing from 30.4% in 1997-98 to 36.3% in 2000-01[31].

4.2.12 These indicators lead us to believe that transmission capacity addition is now in a phase of self-sustained growth and will match the addition of incremental generating capacity and will be able to build the reserve capacity required for providing access to consumers and evacuation to producers. It will be up to the CERC to introduce elements of competition into the system such that the monopoly structure of the CTU is diluted and private investors allowed to participate on even terms.

4.2.13 What is a rational pricing policy for electricity? Full cost recovery for every category of consumer is a prime input in ensuring the efficient use of electricity by the end user. The agricultural sector is a prime example where electricity continues to be used inefficiently due to a pricing policy, which makes it virtually a free resource. The overuse of water resources and degradation of land and ground water resources are a consequential negative impact. The Draft Electricity Policy of June 2004 identified the following tariff related targets for enhancing the efficiency of the sector: (i) Ensuring the financial viability of distribution utilities through adequate returns though linked to efficiency norms at an improving scale (ii) Subsidisation of poor customers at a level below the average cost of supply (iii) Sustainability of cross subsidisation to be examined after five years (iv) Energy audit within one year to identify technical and commercial loss. (v) Reduction of T&D loss to international levels by 2012. (vi) Differential pricing of peak and off peak power with appropriate metering facilities (vii) Compulsory purchase by Distribution Utilities from co-generators with the minimum purchase quantity to be identified by SERCs by 1st April 2005. This illustrates the multiple objectives of tariff policy in India some of which are in conflict with the objectives of energy efficiency. Subsidisation to levels below even the average cost of supply is harmful for energy efficiency. It is also not clear how the subsidy levels will be contained and “free riders” isolated. Charging the economic cost of supply is fundamental to ensuring efficiency in use and efficiency in the allocation of capital. Establishing the efficient cost of power is a related aspect, which must be dealt with in consumer interest. The formulation of National guidelines and norms on these issues can only assist Electricity Regulators in meeting these objectives within a predetermined time frame.

4.2.14 How can the quality of supply be improved and adequate quantity of supply ensured to avoid the economic cost of outages and voltage fluctuations? The Draft Electricity Policy 2004 has identified that quality parameters like frequency, duration of interruption, voltage parameters, waiting time for complaint redressal are to be built into the regulatory framework by SERCs. The issue here is not so much the development of standards as their effective enforcement. At the aggregate level meeting the demand supply gap is the prime input for improving supply conditions. However this in turn is linked to the financial viability of the sector. As we move towards a market based, private investment or commercially autonomous public investment lead system, incremental capacity will be dependant on the adequacy of returns and the acceptability of the risk profile of investment. This in turn will depend upon the quality of regulation and the pressure on utilities to perform in accordance with expectations and norms. The fact that regulators would mostly have to deal with public utilities is an unfortunate obstacle.

4.2.15 How should minimum standards of supply be enforced on suppliers? The prevalent mode of enforcement till now has been the command and control method in which standards are specified and violation invites regulatory adjudication. An alternative is enforcement based on economic incentives. The Availability Based Tariff (ABT) notified by the CERC in 2000 was the first step in this direction which introduced a price incentive to conserve energy when the quality parameter of frequency was abnormal, by rewarding utilities which backed down load at such times and penalised consuming utilities which drew in excess of allotment. The economic

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[31] Annual Report on the working of the SEBs and Eds, Planning Commission, May 2002

incentives embedded in the ABT have worked well in introducing grid discipline as illustrated by significant improvements in grid parameters. Frequency is a parameter which best illustrates grid discipline. The Grid Code specifies a band of 49 to 50.5 Hz within which frequency is allowed to fluctuate. The Southern Region has for long suffered the consequences of low frequency due to demand exceeding supply with frequency remaining within the band for only 27.4% of the time. This has improved to 98.3% of the time post the introduction of ABT. The position was reversed in the eastern region with generators pumping in power without commensurate demand thereby driving up the frequency beyond the band for 51% of the time. Such instances have reduced to only 5% of the time post ABT[32]. Similar advantages have been seen in the other regions. Some State Electricity Regulatory Commissions (SERCs) have also tried to build in price incentives into the retail tariff. However a systematic approach in this regard is yet to emerge and the traditional command and control method still continues to be prevalent.

4.3 Nuclear Power

4.3.1 The contribution of Nuclear Power to generation capacity in India has been limited. In 2003-04, the total installed capacity at 2770 MW, from fourteen plants, was around 2% of the total installed generation capacity, while energy generated at 19.2 billion KWH was around 3% of the total generation. It is estimated that Uranium reserves are equal in terms of potential energy to around one half of coal reserves. Graduating to a Thorium-Uranium 233 cycle can effectively enhance nuclear fuel reserves up to five times of our coals reserves[33]. India has used a technology, which relies on the use of Uranium without enrichment, since enrichment was earlier considered expensive. Our Pressurized Heavy Water Reactors (PHWR) are of Canadian Deuterium Uranium design (CANDU) and use natural Uranium for fuel with heavy water as a moderator. Despite operating Asia's first nuclear reactor India has fallen behind in harnessing Nuclear energy. Non-accession to discriminatory international conventions, has restricted the transfer of technology from the Nuclear Club. In 1974, subsequent to the Pokharan tests, the task of completing the reactor abandoned by the Canadians was subsequently completed entirely with indigenous research and development efforts.

4.3.2 Eight reactors are under simultaneous construction aggregating to an additional capacity of 3960 MW all of which are expected to be completed by 2008[34]. NPCIL targets an installed capacity of around 7% of the total installed capacity by 2020, or around 20,000 MW. However, independent commentators[35] doubt the possibility of additional capacity addition on this scale and feel that the growth of Pressurized Heavy Water Reactor (PHWR) would be limited by the availability of domestic Uranium. India's domestic reserves of Uranium, which can be recovered at a reasonable recovery price of $ 80 per kg, is estimated to be in the range of 30,000 to 70,000 tonnes. A long term goal is to use the vast reserves of Thorium. However since Thorium is not a fissile material it becomes necessary to use a fissile material; Plutonium, which is a by product of the CANDU reactor. Plutonium can also be bred faster using a Fast Breeder Reactor. Work on a Prototype Fast Breeder Reactor (PFBR) is continuing which will add an additional 4000 MW of capacity. However this technology is assessed to be not commercially available till 2010. It is argued on this basis that the likely capacity addition is unlikely to be significantly different from the existing low share of 2%. The relative non-availability of data and the intermingling of strategic concerns with energy issues have inhibited independent review of the nuclear power sector. Secondly, the non-availability of technology due to international safeguards and the low availability of domestic finance for development of technology have inhibited the optimum utilization of India's nuclear fuel reserves. The situation is unlikely to change considerably in the near future.

4.4 Hydro power

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[32] Annual report CERC 2003-04

[33] "Nuclear Challenges and Beyond: The challenges" Dr. R. Chidambaram in Lalit Doshi Memorial Lecture, Mumbai August 4, 2003

[34] NPCIL Annual Report 2003-04

[35] "India's Nuclear Breeders: Technology, viability and options" Rahul Tongia and V.S. Arunachalam in Current Science Vol 75, No 6 September 1998.

4.4.1 The Central Electricity Authority (CEA) estimates that the optimum mix between Hydro and Thermal power should be 40:60. Hydro contributed 46% of electricity supplied in 1966 which gradually declined, eventually breaching the minimum prescribed level of 40% in 1979. Even if 37,100 MW are added by 2012 the ratio would still be only 27:73. In comparison India ranks fifth in the world in terms of Hydro power potential at 600 billion kilowatt hours of energy annually, equivalent to a nameplate capacity of 1,50,000 MW approximately, out of which only 25,574 MW or 17 % has so far been developed. Environmental considerations, the lack of bilateral and multilateral support, continued emphasis on public finance led development and low levels of commercialisation are some of the factors responsible for the under-development of the hydro-power potential. The adverse Hydro–Thermal balance has implications for the cost of power particularly peaking power, which in the absence of Hydro, is met either from open cycle gas based thermal generation, which however is an inefficient utilisation of scarce gas resources or which requires the backing down of coal based thermal generation, which again is an inefficient utilisation of scarce generation capacity. The association of the private sector in Hydro power development is also yet to be realised in any substantial manner. Geological uncertainties, high capital costs, long gestation periods and environmental uncertainties are some factors, which have inhibited the development of a pricing formula for private power developers. Out of the 33 private projects of 6768 MW commissioned so far only 5 projects of 133 MW are Hydro Power projects of which the 86 MW power plant of Malana Power Company in Himanchal Pradesh, which supplies power to its captive customers in Rajasthan is the largest. The CERC has approved the levy of a 5% surcharge for hydro-power development. This will generate resources for public sector projects. 162 schemes of 50,000 MW have been identified for intensive monitoring. However the past performance is not encouraging. During the decade of the 1980s and the decade of the 1990s only around 6500 MW of incremental capacity was added in each decade. In the first four years of the first decade of the new millennium, till 31st March 2004, the total hydro capacity added was only 5600 MW.

4.5 Chapter summary

4.5.1 Coal will remain the dominant energy source till 2020. Improvements in the extraction and transportation of coal and technological advance to promote the gasification of coal reserves are therefore critical for optimum utilisation of this resource. Due to the restrictions placed on ownership by the Coal Mines Nationalisation Act the private sector is barred from investing in this sector. This also obviates the possibility of technology enhancing Foreign Direct Investment (FDI) in the sector. The generation of electricity remains constrained by the low levels of commercialisation in the sector. The electricity sector is dominated by Public Enterprises, most of which owned by the State Governments are unviable. Independent regulation of the sector has made progress since 1998 and tariffs are being converged to costs and utilities incentivised to improve the efficiency of operations in generation and reduce T&D loss. As a result, generation efficiencies have improved and T&D loss has decreased. The inability to develop the Hydro-power potential beyond 17% needs to be urgently addressed in the interests of optimum functioning of the power system and to reduce the volatility in the cost of whole sale power. Like Hydro, Nuclear power also reduces dependence on the imports oil or gas and hence addresses the issues of National Security. The slow development of Nuclear resources, constrained by the lack of international cooperation in technology transfer and the paucity of domestic public financial resources is another area of concern but near term solutions are not visible. The development of a power transmission network has made rapid progress under POWERGRID. Interstate transfer of power has increased allowing the transfer of excess electricity from one region to another and thereby laying the infrastructure for a future power market. Incentive regulation by CERC has introduced Grid discipline and the quality parameters of grid power have improved. However excess demand, sticky retail tariffs and nascent regulatory systems indicate that for the present the need of the hour is strong, independent, economic regulation.

5. End use energy efficiency

5.1 Manufacturing sector

5.1.1 The share of manufacturing sector consumption in total commercial energy consumption declined, at a rate of 0.68% per year, from 56% in 1972-73 to 48% in 2001-02. However, while the share declined, the nominal manufacturing sector energy consumption, including for non-energy uses, grew from 30 mtoe in 1972-73 to 98 mtoe in 2000-01[36]. Table 5.1 gives the energy consumption by type of fuel for the sector from 1970-71 to 2000-01.

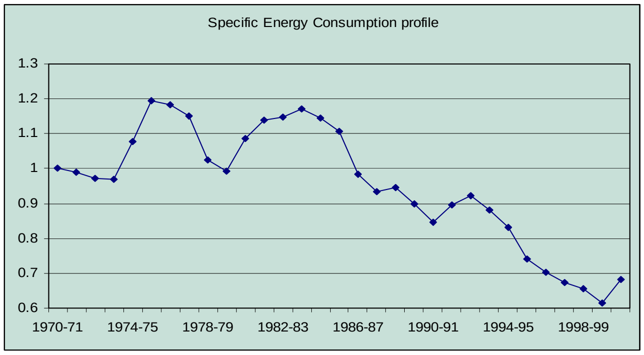
Table 5.1: Share of various types of fuel in the total industrial sector (%)

Fuel type	1970-71	1980-81	1985-86	1990-91	1995-96	2000-01
Coal + Lignite	73	61	60	60	58	56
Electricity (grid + self generation)	27	27	28	29	30	32
NG + Oil products	NA	12	12	11	12	12

Source: TEDDY 2002-03

5.1.2 Coal has a dominant share in the total energy consumed in the manufacturing sector. The share, however, declined progressively from 73% in 1970-71 to 56% in 2000-01. The declining share mirrors international developments where, driven by environmental considerations and technological change, electricity and natural gas have gradually replaced coal usage. The increased use of electricity and natural gas has contributed significantly towards enhancing the energy efficiency of the manufacturing processes.

5.1.3 The overall specific energy consumption (SEC) of the sector, defined as energy consumption per unit of physical output, declined sharply post the oil shock year of 1974 till 1980 with a subsequent increase till 1984 upto nearly the 1974 level followed by a secular decline till 2000-01. The overall decline being about 32% since 1970-71, as is illustrated in Figure 1 below.



Source: TEDDY 2002-03 and CSO

5.1.4 Energy efficiency levels vary significantly across Indian manufacturing. The fertiliser industry is very competitive with the average energy consumption of Indian gas based plants being 9.16 Gcal/t, which is lower than that of US industry average consumption of 9.94 Gcal/t. Similarly, the best reported energy performance figures for India is 69 kWh/t of cement and 665 kCal/kg of clinker, which is very competitive with the world best of 65 kWh/t of cement and 650 kCal/kg of clinker. However, this favourable scenario is restricted to some progressive sub-sectors only. In the case of Aluminium industry, the best Indian energy consumption values are

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[36] TEDDY 2002-03

still about 22% higher than the best international values. The energy consumption of the Indian Iron and steel industry is about 37% higher as compared to Japanese and South Korean industry. The lower turnover of capital equipment and the older vintage of manufacturing equipment also reduces the average energy efficiency levels. However in the last two decade, since 1985, liberalisation, facilitation of the private sector, import tariff rationalisation and competition have induced industry to become more competitive and energy efficient.

5.1.5 Inter Fuel Substitution: The Fertiliser Industry and more specifically the manufacture of Ammonia based fertiliser, which accounts for 80% of the total energy consumed by this industry, is a good example of the advantages of Inter Fuel Substitution. Switching from coal to oil products/natural gas and further to electricity has enhanced the efficiency of the manufacturing processes and the end use efficiency of the equipment. During 1999-2000 natural gas met 45.4% of the energy requirement and was the largest source for the manufacture of Ammonia based fertiliser while naphtha accounted for 30% and fuel oil only 10%. Naphtha based plants constructed in the 1970s have a design energy consumption in the range of 11-12 Gcal/t, while newer generation Naphtha plants have a design energy consumption of less than 7.8 Gcal/t. The design energy consumption of Natural gas based plants is only 7.4 Gcal/t. Similarly, the consumption of ammonia per tonne of urea has reduced from 0.6 to 0.56 tonne. Simultaneously, the stream sizes of urea plants have also grown, thus reaping the benefits of economy of scale. Average energy consumption of ammonia based plants improved from 12.48 Gcal/t in 1987-88 to 9.30 Gcal/t during 2002-03, an improvement of 25%. This is equivalent to a saving of around 5 million tonnes of fuel oil by the industry over the 1987-88 consumption level for the current production level[37]. Table 5.2 gives the specific energy consumption for various feedstock used in the industry.

Table 5.2: Specific energy consumption of ammonia (Gcal/t)

Feedstock	1987-88	1990-91	1991-92	1992-93	1993-94	1997-98	2002-03
Gas	10.22	9.6	9.6	9.5	9.5	8.86	8.65
Naphtha	12.79	11.9	11.7	11.7	11.5	10.95	9.40
Fuel oil	13.92	15.1	13.5	13.9	14.0	13.31	12.78
Coal	33.05	39.1	39.7	42.7	42.9	48.13	-

Source: FAI Statistics 2002, TEDDY 2002-03

The SEC declined for all petroleum based fuels but increased in the case of coal. This can be explained by the fact that coal usage became increasingly confined only to the plants with the oldest technology and in many cases such plants were neglected with less than adequate maintenance and up-gradation, possibly due to the cost plus administered pricing regime operating in the fertiliser industry.

5.1.6 The benefits of economies of scale: The Sugar industry is another example of a highly regulated industry. The prices of its raw material; sugarcane are administrated and regularly revised upwards every year primarily due to political reasons. A share of the production, presently 15%[38], is required to be sold to the government at a pre-determined low price for meeting the needs of the pubic distribution system. This squeezes profit margins and hence the availability of funds for modernisation of technologies. The sugar technology fund, set up by the government has helped industry to adopt the latest technologies to increase the size of operation and cut costs. Energy is a major factor in the production cost, accounting for about 15% of the cost of production and energy efficiency is dependent on the scale of production. Most sugar companies have reduced the specific energy consumption by enhancing the plant capacities while modernising the technology. The average size of plants increased from 1000 tcd (tonnes of cane crushed per day) in 1980s to 5000 tcd by late 1990s. Cogeneration has also been promoted by the government in this sector, encouraging sugar mills to utilise their surplus thermal energy by co-generating electricity for internal use and to supply surplus power to the grid. These measures

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[37] Technology assessment report for the fertiliser industry, TERI, 2004.

[38] Web site of the ministry of consumer affairs, food and public distribution, Government of India.

have resulted in a progressive increase of energy efficiency with steam consumption reducing from 55% of cane crushed in 1970s to 50% in 1980s and further to about 45% presently[39].

5.1.7 The benefits of liberalisation: The beneficial impact of economic reforms, initiated by the Government since 1991, is illustrated by the case of the Steel industry where licensing of incremental capacity was abolished, the industry opened up for private investment and up to 100% foreign equity investment put on the automatic route. Price and distribution controls have been removed from January, 1992, with a view to make the steel industry efficient and competitive. Restrictions on external trade, both in import and export have been removed. Import duty rates have also been reduced. Reduction in import duty of capital goods, convertibility of rupee on trade account, permission to mobilise resources from overseas financial markets and rationalisation of the existing tax structure have also benefited the Indian Steel Industry[40]. These initiatives have facilitated growth of the private sector in the steel industry. While the existing units are being modernized and expanded, green-field steel plants have also come up based on modern, cost effective, state of-the-art technologies.

5.1.8 Operations of the furnaces in the industry are being improved through injection of auxiliary fuel in the blast furnace, which reduces the demand for coke substantially. As coking is a highly energy intensive process, other ongoing efforts for improving coke making, such as blending, briquetting, preheating, stamp charging and selective crushing, are will improve energy efficiency[41]. In the iron making process, a new COREX technology using smelt reduction has been implemented in some private sector plants. With smelt reduction, use of coking coal becomes unnecessary avoiding the significant problems associated with domestic coke. Similarly in the steel making process the changeover of the conventional OH (open hearth) furnaces and twin hearth furnaces to BOF (Basic Oxygen Furnace) steel making which will provide substantial energy efficiency gains[42].

5.1.8 The benefits of Competition: The Indian cement Industry is another example where liberalization, competition and facilitation of the private sector has improved the energy efficiency of the industry. The Indian cement industry, which was dominated by the public sector has been gradually liberalised and price and distribution control removed since 1982 and was completely decontrolled in 1992. With decontrol there was significant capacity expansion with 10 million tonnes capacity being set up in 1995-96 itself by the private sector. The share of the more efficient dry-process cement manufacturing has increased from 22% in 1970 to 33% in 1980 and to about 89% in 2001 along with an increase in the scale of operations of each plant with several plants exceeding one million tonnes per day installed capacity. As a result, the Indian cement industry has become internationally competitive. Table 5.3 compares the energy performance of the Indian cement industry with various South-East Asian countries.

Table 5.3: Average specific energy consumption–international comparison (1999-2000)

Country	Electrical (kWh/t cement)	Thermal (kCal/kg clinker)
Japan	95	690
Korea	99	710
Taiwan	98	730
Thailand	103	720
India	105	750

Source: Cement Manufacturers' Association

5.1.9 The pitfalls of protection: Protecting nascent industries from overseas competition has for long been a developmental tool. Along with the reservation for small-scale industry several other industries, like the Aluminium industry, have also enjoyed such protection from overseas competition. After being under government control for about 18 years, the Aluminium industry was decontrolled in March 1989. While import duties on aluminium ingot were removed, the excise duties were raised from 18% to 20% plus Rs. 2500 per tonne to mop up the shortage

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[39] Proceeding of the seminar on energy and environmental technologies in sugar industry, CII 1997.

[40] Web site of the ministry of steel, Government of India.

[41] India's iron and steel industry, LBNL, October 1998

[42] Technology assessment report for iron and steel sector, TERI, 2004.

resulted from import duties with effect from March 1989. This led to a spurt in import of aluminium leading to re-imposing custom duty for primary aluminium during Oct 1989 @ 5% ad valorem plus Rs 2500 per tonne. Subsequently aluminium was shifted from OGL (open general licence) to limited permissible list[43]. These changes raised the effective rate of protection of the aluminium industry. The protection did more harm than good as far as energy efficiency is concerned for the domestic aluminium industry. In the absence of competition from overseas markets, domestic industry had very little incentive to reduce production costs or improve the efficiency of its operations. Today, the average energy efficiency of Indian plants is about 22% higher when compared with best plant operated in the world[44].

5.2 Energy Efficiency in Small Scale Industry

5.2.1 While large industry has improved its energy efficiency, essentially by purchasing the latest technologies available in developed countries small industry which contributes a significant share of total industrial output does not have such opportunities. With the policy of reservation for small scale manufacture prevalent in India, several industries, which cannot be globally competitive, due to inadequate economies of scale are artificially kept commercially active to provide employment and disperse economic growth. So long as this developmental model persists it becomes essential to conduct intensive research on how best the energy requirements of such small-scale industries can be met. Specific technologies to improve their energy efficiency will have to be developed in India since these have no market in the developed economies. Outmoded technologies and poor operational practices have led to lower efficiency of operation of a majority of small-scale units. Technological solutions suited for SSI units must have a high degree of innovation and local adaptation and differ significantly from technological interventions suitable for larger industries. TERI, with the partnership of SDC (Swiss agency for development and cooperation), developed local technological solution for the small-scale foundry sector. The DBC (divided blast cupola) technology in place of the conventional cupola was demonstrated and later replicated in several units resulted in efficiency improvement of 25%. The capital investment required for this intervention is paid back in less than one year[45]. Out of 41 energy-intensive small scale industries casting and forging units are the most energy intensive followed by manufacturers of edible oils and fats, and manufacturers of glass tiles. These combined accounted for more than 70% of the total energy use within the 41 sub-sectors chosen. Three small-scale sub-sectors - iron foundries, brick-making units, and ceramic units, where technological development is lagging in particular, have the energy efficiency improvement potential in the range of 10% to 30%[46].

5.2.2 The TERI case study on improving the energy efficiency of the glass industry in Firozabad is an example of the kind of local interventions needed for the small scale sector. Firozabad, also called the glass capital of India, is a small town in the state of Uttar Pradesh 40 km from Agra. The cluster accounts for roughly 70% of the total glass production in the small-scale sector. There is a large agglomeration of small-scale units engaged in the manufacture of hollow wares, decorative items, glass beads, bulbs, headlight covers, bangles, etc. The inadequacy of imported ready-made solutions for the small-scale glass making industry necessitated a dynamic design process in which the local industry played a central role. An important element of the intervention strategy to design and demonstrate an energy-efficient pot furnace was competence pooling, with synergies among the various actors resulting in an appropriate solution. The demonstration pot furnace, using natural gas as fuel, was commissioned in February 2000. The plant has been in operation since then. There has been no deterioration in the plant performance, in terms of specific energy consumption, over this period.

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[43] Report of the collaborative research project: a resource-oriented overview of the material flow of metallic raw materials-aluminium, FZJ, Julich, Germany. Oct 1999.

[44] Technology assessment report for aluminium industry, TERI 2004.

[45] M H Patel et al. Proceedings of the 53rd Indian foundry congress, pp 191-195, January 2005.

[46] Identification of small-scale industrial clusters for CDM (Clean Development Mechanism) projects - a baseline study, TERI Report No. 2002IE45, prepared for NEDO (New Energy and Industrial Technology Development Organisation)]

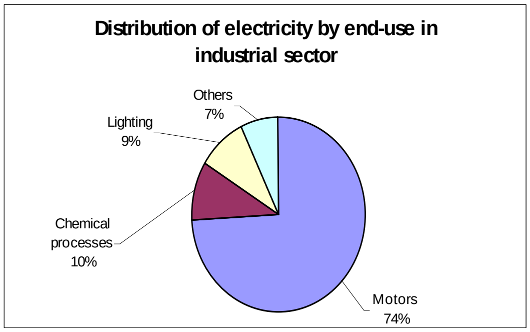
While specific energy consumption for the conventional furnaces was found to be about 5860 kcal/kg of glass, for the TERI furnace it was found to be 2460 kcal/kg of glass, a reduction of nearly 60 %.

5.2.3 Brick-making is an energy-intensive process. In India, the fuel costs alone account for almost 30-40% of the production cost. The conventional practice of firing clay bricks in rural country clamps and BTKs consumes huge quantities of fuel in terms of coal, firewood, and other biomass fuels. It is estimated that the Indian brick industry consumes more than 24 million tons of coal annually, in addition to several million tons of biomass fuels. Kilns are also notorious as highly polluting establishments, affecting not just the flora and fauna, but also posing threats to human health. Higher energy costs and inability of the industry to meet the environment standards has raised serious concerns about the survival and well-being of the industry. The Indian brick industry, which is the second largest producer in the world next only to China, has more than 100,000 operating units producing about 140 billion bricks annually. The industry has an annual turnover of more than Rs 140 billion. Brick-making is a traditional, unorganized industry, generally confined to rural and peri-urban areas. It is one of the largest employment-generating industries, employing millions of workers. Brick industry in Indo-Gangetic plain differs from brick industry in peninsular plateau and coastal India. The Indo-Gangetic Plains accounts for about 65% of the total brick production. Punjab, Haryana, Uttar Pradesh, Bihar and West Bengal are the major brick producing states in this region. Brick kilns (approximately 30,000 BTKs) generally of medium and large production capacities (2 million to 10 million bricks per year) are located in clusters around major towns and cities. Coal is the main fuel for firing bricks.

5.2.4 TERI studied the operations of 21 Brick Kilns. Guidelines for better operation and design of fixed-chimney BTK were evolved which reduced the energy consumption by 10 to 20% and the emissions of SPM (suspended particulate matter) by 50% in fixed-chimney BTKs. The improved performance resulted mainly from improvements in fuel feeding and kiln operating practices. An energy-efficient and sustainable alternative to the traditional brick kilns is VSBK (vertical shaft brick kiln). This technology, which originated in China, results in an energy saving of about 50% compared to clamps and 20 to 30% compared to BTKs. The kiln is very compact; for the same production capacity, VSBK needs about 25 to 30% of the land required by BTKs. As a part of ‘India Brick Project’, TERI, Development Alternatives, Gram Vikas, MITCON Ltd. and Damle Clay Structurals (P) Ltd are carrying out the task of VSBK demonstration and dissemination. The first VSBK was demonstrated in May 1996 in Datia (Madhya Pradesh), which was followed by construction of kilns in Uttar Pradesh, Madhya Pradesh, Maharashtra, Orissa and Kerala. During 2000-01, TERI constructed a VSBK at Varanasi in collaboration with Int Nirmata Parishad.

5.3 Energy efficiency of major electrical equipment in the industrial sector

5.3.1 Industrial consumption accounts for 31% of the total electricity consumption in India. Industry uses electricity for four main purposes: electric motors, lighting, chemical processes such as electrolysis, and miscellaneous uses such as electric-heating. An indicative distribution of electricity by end-use in the industrial sector is shown in Figure 2.



Figures 2

5.3.2 Electric motors are the single largest electricity-using device in any industry accounting on average for 74% of all industrial electricity use. If further segmented, 3-phase squirrel cage induction motors dominate, accounting for 70% of all electricity consumed in motors. Energy efficiency is therefore a function of the increased penetration of energy-efficient motors and improved motor rewinding practices. In India, motors are manufactured in both the organized and unorganized sectors. The efficiency of motors produced varies significantly. Several manufacturers have two ranges of motors—standard range and high-efficiency range. High efficiency motors produced in India are 2-5% more energy-efficient than those of standard efficiency motors. These motors cost 25%–35% more than standard motors and are not available at ratings less than 10 HP due to the limited demand. Energy-efficient motors account for a very small percentage of motor sales in India. Failure of motors due to burnout of the stator windings is a common problem in industries due to overloading, under-voltage, and single phasing with around 10% of the motors failing annually. Almost one half of the stock of motors is estimated to be of the rewound type. Since the rewinding cost of a motor ranges between 14% and 18% of the cost of a new one, rewinding is a common practice in industries. However, poor motor rewinding practices lead to a significant reduction in its efficiency. The drop in efficiency varies with the size of the motor and is about 10% in smaller motors (2–3 HP), 5% for medium-sized motors (5–10 HP), and 2%–3% for larger motors. Savings of 100–119 TWh or 20%–25% of the 477 TWh of electricity demand projected for motors and drive systems by 2009/10 for India, is estimated to be possible, if energy-efficient motors and driven systems were to be adopted by consumers[47].

5.3.3 Lighting accounts for about 13% of the total electricity consumption with a share of 9% in the industrial sector. Four types of lighting systems are widely used-incandescent, fluorescent, mercury vapour, and sodium vapour. Table 5.4 indicates that 80% of the incandescent energy use is in the domestic sector; over 90% of fluorescent energy use is in the industrial, commercial, and miscellaneous sectors; and over 60% of mercury and sodium lamp energy use is in the industrial sector.

Table 5.4 Lighting electricity use by sector and lamp (TWh)

Sector	Incandescent	Fluorescent	Mercury	Sodium
Domestic	7.4	0.3	0	0
Commercial and Miscellaneous	1.2	6.2	0.1	0.1
Industrial	0.3	6.5	1.2	0.8
Public lighting	0.2	0.9	0.2	0.3
Total	9.1	13.9	1.5	1.2

Source: TERI book on demand-side management from a sustainable development perspective-Experiences from Quebec (Canada) and India. 2003, pp 177

There are several options for improving the energy-efficiency of lighting systems in the industrial sector. Some of these are slim line tubular fluorescent lamps, compact fluorescent lamps, HPSV (high pressure sodium vapour) lamps, metal halide lamps, voltage stabilizing, electronic ballasts, high-performance reflectors, advanced lighting controls, and the possibility of retrofitting existing system with more efficient ones. Since colour rendition is not required in most areas of an industry, HPSV lamps present a good opportunity for energy conservation. In energy audits conducted by TERI for different industrial units, it has been found that replacement of HPMV (high pressure mercury vapour) lamps by HPSV lamps had a payback period of 3 to 3.5 years. It is estimated that by 2005, the total lighting consumption load for all types of consumers would be

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[47] 'Efficient Energy Use for Motor Drive System' prepared by the National Productivity Council (NPC), India

65.5 billion units, representing more than 30 000 MW[48], while the saving potential is estimated at 9600 MW at end-use if appropriate alternatives are fully implemented.

5.4 Energy efficiency of the Commercial sector

5.4.1 Electricity is the major form of energy used in India's commercial sector and approximately 60% of electricity is consumed in lighting and 32% in space conditioning. Trends show that the electricity consumption in the commercial sector is increasing at a rate of 8.22% per year. The energy consumption rates and energy-use patterns in buildings vary considerably due to climate, architectural design, the systems used, the operational and maintenance schedules, and the occupants' behaviour. Till recently, most buildings were designed with aesthetics, functional requirements, and lower initial cost as major design factors. Omitting energy-efficiency as a design consideration has led to an over-sizing of energy systems usually designed for peak conditions. However, the peak conditions seldom occur and the systems operate at the part-load or low efficiency most of the time. Appropriate building design presents a significant potential for energy conservation and load reduction if bio-climatic features are kept in mind and the energy system designed integrating renewable energy technologies, with energy-efficient end use equipment. HVAC systems, heat pumps, load management systems and control, refrigeration systems/freezers, high-efficiency boilers, building control, insulation, window coating and films, power factor correction systems, and combined heat and power plants are some of the technologies for energy conservation. Energy audit studies conducted in several hotels, hospitals, and office buildings indicate the techno-economic potential of energy saving of different activities, and are summarized in Table 5.5.

Table 5.5 Commercial sector potential savings (%) estimates

End use	Energy-efficiency measures	Technical potential savings estimate (%)
Lighting	De-lamping; low-wattage fluorescent lamps; compact fluorescent lamps; high-pressure sodium lamps; electronic ballasts; aluminium and silver film reflectors; daylight dimming; occupancy sensors; day lighting design ion new buildings	20-50
Cooling	Heat pumps; high- efficiency chillers; chillers capacity modulation and downsizing; window treatment; radiant barriers; economizers; proper equipment operation and maintenance	≥ 15 without efficient lighting measures; 80 with efficient lighting measures; average is 30
Ventilation	Variable air volume systems; low-friction air distributions designs; energy-efficient motors; variable speed drives; heating; cooling and lighting improvement; proper equipment operation and maintenance	50
Heating	Building shell improvements; window treatments; heat recovery; proper operation and maintenance; heat pumps integrated with water heating system	15-40
Refrigeration	Multiplex unequal parallel compressors; advanced compressor cycles; variable-speed compressor controls	15-40
Water Heating	Low-flow devices; insulation; heat traps; heat pump water heaters; heat recovery systems; integrated heat pump systems (with space conditioning equipment)	40-60
Miscellaneous	High-efficiency office equipment; high-efficiency motors and adjustable speed drives for elevators and escalators	10-30

Source: TERI report on DSM, 2002. Compiled for the working group on power for the formulation of the Tenth Five Year plan 2002-07.

5.4.2 Energy efficient building design and city planning are preconditions for managing the future incremental energy demand from the commercial and residential sectors. Building design is still regulated principally from the view-point of safety and energy efficiency is still not a consideration. The potential for energy savings is best illustrated by the case study of the TERI Retreat in Gual Paharai, Gurgaon. Built on a 36 Hectare site the complex is completely self sufficient in electricity. Photo voltaic solar panels mounted on the roof top met around 10.5 kW of load while another 50 kW is met by a duel fuel generator which uses diesel and biomass gasification. The use of biomass reduces the diesel consumption by around 70%. The biomass is

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[48] World Bank Study Report on electricity end-use in India (1991)

generated from the more than 10 million trees, plants and shrubs, which have been planted here over the last decade. If harvested exclusively for electricity generation a 3 Hectare plot would be sufficient to meet the biomass needs of this gasifier. The cost of electricity from the duel fuel gasifier is around Rs 4.50 per kWh which is comparable with the delivered cost of grid power. The building provides accommodation for 72 persons and conferencing facility for 100 participants. The normal load for a conventional building would be 180 kW which has been reduced to one third due to the innovative use of skylights, maximizing the use of natural light, and CFL bulbs to reduce the lighting load. Solar chimneys and an underground air tunnel supplemented by absorbtion cooling, powered by LPG (to be replaced eventually by producer gas from the gassifier) in humid conditions and air washers in dry season, reduce the air-conditioning load. The effluents are treated in a root zone treatment pond, which reduces the BOD content of the waste water to acceptable levels for irrigation purposes. Energy efficient interventions are normally thought to be prohibitively capital intensive. The incremental capital cost of this building is estimated at 25 %, which is paid back within 6 years due to the savings on power consumption. The associated environmental benefits are incremental. Incorporating the lessons of the Retreat into building design regulations can effectively improve the energy efficiency of large commercial buildings and can also be extended to community based systems for a colony or block of flats. This is not the only example and more than forty building exist in India which have incorporated the best practices in energy efficient architecture[49]. The challenge is to incorporate these lessons into meaningful regulations, which will transform the energy efficiency of the capital stock of buildings in India.

5.5 Energy Efficiency of the Residential sector

5.51 Lighting accounts for 35% and space conditioning for 30% of the total electricity consumed in the residential sector. Approximately 13% of the electricity consumed is by refrigerators and 8% in water heating. The use of electricity for the pumping of ground water and for boosting municipal supply to higher levels has gained importance in recent years. This is an outcome of inadequate municipal supply of water. Only one per cent of electricity is consumed in cooking. Trends in consumption pattern reveal that electricity consumption is increasing at a rate of 10.6% per year in the residential sector. Major end uses are lighting, fans, refrigerators, air-conditioners, washing machines, and water heaters. The potential for electricity saving in the residential sector is given in Table 5.6.

Table 5.6 Residential sector savings estimates

End use	Energy-efficiency measures	Technical potential savings estimate (%)
Lighting	Compact fluorescent lamps	20-50
Cooling/ventilation	High-efficiency fan motors; whole house fans; programmable controllers	15-50
Refrigeration	High-efficiency refrigerators	15-40
Water Heating equipment	Efficient water heater tanks; increased tank insulation; low-flow devices thermal traps; heat pumps and solar water heaters	20-30
Electric ranges/ovens	Increased insulation; seals; improved heating elements; reflective pans; reduced thermal mass; reduced contact resistance	10-20
Miscellaneous equipment (television sets)	Solid state television sets that use efficient electronic devices	10

Utility-supported DSM programmes for lighting efficiency can be very attractive. A case study for the Delhi area shows a savings potential of about 35% (roughly 294 MW) in lighting alone[50]. Similarly, in an energy conservation study for a 5-star hotel, it was found that about 14% of the present energy consumption could be saved[51]. Installation of efficient lighting applications is very marginal and continues to be hampered by a variety of factors, including high cost of applications,

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[49] "Energy Efficient Buildings in India" Ed. Mili Mazumdar, TERI/MNES 2002.

[50] Demonstration project on load management by energy efficient lighting,1999. Sponsored by Delhi Vidyut Board. TERI report number 1999pg63.

[51] TERI energy audit report for Maurya Sheraton hotel and towers. 2002. Report number 2002ie62.

inadequate domestic production in some cases, and a substantial tariff on their import, and, more importantly, because electricity for lighting use is generally under priced and there is little economic incentive to incur the higher capital cost of improved lighting systems, particularly for domestic users.

5.6 Energy Efficiency of the Agriculture sector

5.6.1 In the early 1970s Agriculture consumed 9%–10% of the total consumption of electricity. Its reported share in 2000-01 is 26.8%. In addition the high T&D loss of distribution utilities is often attributed to illegal use or to the inadequate metering of supplies to agriculture. The actual consumption in agriculture is therefore a matter of conjecture[52]. The increase in the share of electricity consumption is attributed to large-scale rural electrification programmes launched by the government which led to an increase in the number of electrical pump-sets for irrigation. Out of nearly 20 million pump sets in India, about 60% are driven by electric motors and the rest by diesel engines. Approximately 0.6 million electric pump sets are added every year. Hence inductive motive power and pumps characterize the agriculture load. The motors used in agriculture are generally of poor quality and efficiency. The initial high cost of energy-efficient motors, the poor quality of power supply which aggravates the instances of failure of the motor winding, the low cost of power, flat rate charges irrespective of actual consumption and in some areas the supply of free power for agriculture and the absence of property rights in ground water are factors which encourage a short term perspective in capital investments and inhibit the adoption of energy efficient pump-sets.

Retrofitting in pump sets

5.6.2 On average an irrigation pump set in India consumes 4500 kWh in a year. A saving potential in the range of 30% to 35% through major and minor retrofitting measures listed below has been estimated to be achievable[53]:

- substitution of high friction GI/MS pipes by low friction PVC pipes,
- use of low-resistance foot-valves,
- improving the efficiency of the pump and the prime mover,
- replacement of undersized pipes and fittings,
- proper sizing of motors and pumps, and
- use of efficient couplings between motors and pumps.

The average system efficiency before any rectification of 27% was found to increase by 7% post rectification. The average energy saving due to minor and major rectification was 277 and 310 kWh per HP per year, respectively. The potential for improvement through pump rectification measures is given in Table 5.7.

Table 5.7: Saving potential in agriculture through retrofitting

Code	Scope of rectification	Reduction in energy consumption (%) (kWh per pump per year)
R1	Low resistance foot-valve and low friction suction pipe of proper diameter	20%-25% (1000-1250 kWh)
R2	R! + low friction delivery pipe	30%-35% (1500-1750kWh)
R3	R@ + replace pump by one of higher efficiency	40%-45% (2000-2500 kWh)
R4	R3 + replace motor by one of lower rating	50%-60%

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[52] See "How reliable are Irrigation Pumpsets data" Shantanu Dixit, Girish Sant in Economic and Political Weekly April 12-18.1997 for an early exposition on the inadequacy of data on electrical consumption in agriculture in Maharashtra. The situation in other States would not be significantly different.

[53] TERI DSM in agriculture sector of Uttar Pradesh-investment strategies and pilot design. 1996. TERI report code: 1995em52. 1996

	(2500-3000 kWh)

Source: DSM applications: scope and potential in India, TERI, 2003, pp 182.

Power factor correction

5.6.3 Agriculture pump sets, which operate mostly at a power factor of about 0.7 or below, increase line losses and voltage drop of the line and also draw more reactive power. A power factor of 0.9 or more can reduce these effects significantly. An adequate power factor can be obtained either by using good quality motors or providing reactive power compensation in the transmission lines. The improvement in power factor would not only lower the losses but would also result in availability of more kVA capacity of transformers, and the reduction of kVAr requirement. Considering the economic benefits, the reactive power compensation by switched or fixed capacitors at the consumer or sub-stations end offers the most cost-effective way of avoiding new generation capacity.

It has been estimated in a pilot project[54] for the installation of LT (low tension) switched capacitors on a sample of distribution transformers supplying power to agriculture pump sets in Punjab and Tamil Nadu that there is considerable scope for improving the power factor, which would result in lower line losses.

5.7 Energy efficiency in Transportation

5.7.1 The income elasticity of demand for transportation is estimated at 1.25. Hence, the demand for transportation will grow at a higher rate than GDP well into the future. The sectoral share of rail transport has been constantly declining while road transport is gaining in market share. In 1984-85, the share of rail in freight traffic was 53%, which came down to 33% in 1998-99. A similar decline is seen in the share of rail in passenger traffic, which came down over this period from 23% to 16%. Indian rail is one of the largest rail networks in the World. However, the decline in market share can be attributed to irrational pricing policy, which “taxes” freight movement to cross-subsidize passenger traffic, the slow development of an integrated multi-model system which causes congestion and delays and the low levels of commercialisation. The drop in the market share of rail has been even more significant over the period 1950-51 to 1998-99 when its market share of freight traffic dropped from 89% to 33% and its share in passenger traffic dropped from 80% to 16%. This shift from rail to road has significant adverse consequences for energy efficiency and energy intensity.

5.7.2 It has been estimated that the energy intensity per passenger kilometre (PKM) in the case of Mumbai varies from a low of 0.02 MJ/PKM in the case of railways to 0.2 for buses and 1.44 for cars and 1.14 for two wheelers. Studies[55] have shown that road infrastructure consumes 2.5 times more energy per kilo-meter than comparable rail infrastructure. A comparison of Mumbai and Bangalore transportation system illustrates the dramatic reductions in energy intensity, which can be achieved by moving from road transport infrastructure to one, which optimizes various transportation services through a multi-model system as in the case of Mumbai. It is estimated that the average energy intensity of passenger transportation in Bangalore is 0.56 MJ/PKM which is 3 times higher than that for Mumbai being 0.19 MJ/PKM. The reason for the difference in energy intensity can be explained by the fact that in the case of Bangalore, road vehicles account for nearly 90% of the total energy consumed while in the case of Mumbai, the number of passengers carried by rail is almost equal to the number of passengers carried by bus services while the share of private vehicles, taxis and auto rickshaws is only around 10%.. Moreover, since rail carries passengers over a longer distance, the passenger kilometre travelled is 5 times the traffic carried by buses.

5.7.3 The poor condition of Indian roads and highways and congestion further reduce the energy efficiency of road transport. It has been estimated[56] that the economic losses due to poor maintenance of main roads and highways is of the order of Rs.20,000 to Rs.30,000 crores per

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[54] TERI study to work out the requirement of capacitor banks, 1990. Report number 1990PG61. Sponsored by the Ministry of Power, Government of India

[55] ‘Urban transportation in India: a tale of two cities” B. Sudhakara Reddy, IGIDR, Mumbai in Energy for Sustainable Development, Volume IV No 1, June 2000

[56] “Integrated transport” G. Raghuram in India Infrastructure Report 2001

annum during the late 1990s, which is around 2% of the GDP. A truck in India averages only 250 kms per day, while in the developed countries, the average is closer to 600 kms per day. Inefficiency in operations is also clearly reflected in the railways, where the average turn around is 8.2 days of which only 28 hours was the revenue-earning run over an average rate of 559 kms reflecting the congestion and lack of coordination at terminals. The average speed for trains is also considerably lower than the achievable maximum, which is another indication of road congestion and inadequate maintenance etc.

5.7.4 Technology is a significant determinant of efficient transport infrastructure, particularly, in the case of rolling stock. Electrification of railways significantly improves the energy efficiency of carriage of goods and passengers. The proportion of electrification has increased from around 6% in 1970-71 to 25% in 2001-02. However the pace of electrification is slow and thus constrains further efficiency gains in the railways. The net weight of a commodity carried to the weight of the vehicle is amongst the lowest in the world in India. Against an international ratio of 1:1 in a standard truck and a ratio of 3:1 in multi-axle trucks, in India, the best multi-axle trucks have a ratio of only 2.5:1. Similarly, the best railway wagons in India have a ratio, which is slightly higher than 2:1 as compared to a ratio greater than 4:1, which have been achieved in container flats internationally. The typical bus in India uses the same chassis as a truck, which is designed to carry 10 tonnes though the passenger load is unlikely to exceed 4 tonnes. These inefficiencies result in excess consumption of fuel, greater wear and tear of the road and hence an over-all lowering of energy efficiency. Managing a shift from road transport to rail and from private road transport to public transport are the twin challenges before city and transportation planners.

5.8 The role of standards in energy efficiency

5.8.1 Standards apply mainly to household appliances and use equipment while regulations are used for buildings and automobiles. Advanced economies use them in conjunction with labels. However, labels simply inform, compulsory minimum standards can determine market access for products by barring those that do not meet certain minimum efficiency requirements. Design of standards requires considerable technical knowledge. They need to be flexible in order to adapt to technological advances, and they should increase rather than dampen incentives for industry to develop more energy-efficient technology. Standards for home appliances, electric motors and lighting equipment, are in force in at least 34 countries. Standards are reputed to have led to a 75% reduction in energy use in refrigerators in the United States[57]. National standards may affect traded products beyond national borders. They can help to improve energy efficiency in export-destination countries and act as import barriers against exporting countries with lower or different standards.

5.8.2 In India the determination of standards has been the task of the BIS. Around 200 standards have been specified for various products which address some aspect of energy efficiency, all of them are voluntary in nature. Most standards are revised on a decadal basis after review. It was estimated[58] in 1996 that upward revision of BIS standards for minimum pump efficiency would reduce pump consumption by 12 to 14%. The benefits of improved suction characteristics and flattening of head-efficiency curve would be added benefits. The additional savings for improvements in pump standards were estimated at 15%, while installing pipe sizes as per BIS standards could reduce the electricity consumption by 20%. After improvement of BIS standards, flange sizes would be the same as the optimum pipe sizes. These improvements would cost around Rs 2000 per pump-set. The benefits are estimated to be six times the cost, a cost benefit ratio of 1:6. BIS standards have subsequently been revised upwards but their adoption is voluntary. With the constitution of the BEE, which is specifically charged to promote energy efficiency and is authorised to determine codes and standards, which will have the force of law the initiative with respect to energy efficiency standards will shift to the BEE.

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[57] Improving Energy Efficiency, IEA

[58] "Agricultural Pumping Efficiency in India; Role of Standards" Girish sant, Shantanu Dixit, Energy Group Prayas *Energy for Sustainable Development*, the Journal of the International Energy initiative, Volume III, No.1, May 1996. .

5.8.3 Electric motors are the single largest electricity-using device in any industry accounting on average for 74% of all industrial electricity use. Energy-efficient motors account for a very small percentage of motor sales in India. Failure of motors due to burnout of the stator windings is a common problem in industries due to overloading, under-voltage, and single phasing with around 10% of the motors failing annually. Almost one half of the stock of motors is estimated to be of the rewound type. However, poor motor rewinding practices lead to a significant reduction in its efficiency. Improving the efficiency of induction motors would be critically dependent on compulsory minimum standards not only for motors but also to regulate rewinding.

5.8.4 The automobile sector is a good example of the impact of regulations on improving the standards of energy efficiency. Emission norms were specified for the first time in 1991 for vehicles under the Environment Protection Act 1986, The Air (Prevention and Control of Pollution) Act 1981 and Central Motor Vehicle Rules 1989. These were later revised in 1996. In 2000 Bharat Stage I norms (Euro I equivalent) were introduced. In 2001 these were upgraded to Bharat Stage II for select cities to be extended to all areas by April 2005. The implementation of Euro III and IV norms is now under consideration. One result of the introduction of these compulsory emission norms and stringent check of idling emission levels has been a reduction in the average age of the vehicle fleet. Regulations coupled with economic liberalisation and the introduction of competition led to the development of more efficient automobiles to capture market share through product differentiation. This was supported by a rapid expansion of consumer finance, which contributed to the churn in the capital stock by increasing the effective purchasing capacity of the consumer and thus raising the demand for automobiles. In the eight large Indian cities the weighted average age of commercial vehicles is 5 to 9 years, for cars 4 to 6 years, for auto-rickshaws 2 to 6 years and 4 to 5 years for two wheelers[59]. A reduction in the fleet age has meant technology up-gradation, with four stroke engines replacing two stroke engines in two wheelers and electronically controlled, efficient, Multi Point Fuel Injection systems replacing traditional fuel injection systems in cars. A hybrid electric car is also being manufactured and distributed in limited numbers. Table 5.8 charts the improving energy efficiency of automobiles in India.

Table 5.8: Energy efficiency of automobiles in India

	Pre 1991	1991- 96	1996- 2000	2000- 2005	2005- 2009	2010	2020
TW:2 Stroke (km/litre)	44.4	44.9	45.3	46.2	46.7	47.1	48.0
TW:4 Stroke(km/litre)	-	65.0	66.3	67.0	67.6	68.3	69.6
Car: Gasoline (km/litre)	9.4	9.8	10.1	10.66*	10.94**	11.3	13.2
Car: Diesel (km/litre)	8.9	9.2	9.7	10.1*	10.28**	10.6	12.4
3 Wh: 2 stroke (km/litre)	20.4	21.2	22.0	22.5	22.9	23.5	24.5
3 Wh: 4 stroke (km/litre)	-	-	-	23.0	24.8	25.3	26.0
Taxi: Gasoline (km/litre)	9.4	9.8	10.09***	-	-	11.3	13.2
Taxi: Diesel (km/litre)	8.9	9.2	9.7	10.1****	10.28xx	10.6	12.4
Std. Bus:Diesel (km/litre)	3.3	3.3	3.4	3.5	3.5	3.6	3.6
LCV	8.0	8.1	8.2	8.6	8.7	8.8	9.2

Notes: * for the period 2000-2004, ** for the period 2004-2007, *** for the period 1996-1999, **** for the period 2000-2004, xx for the period 2004-2007

Source: B P Pundir (1994); R K Bose(1998); Auto India (August 1999); World LP gas Association

Table 5.8 illustrates the significant improvements in energy efficiency due to the switch from two stroke to four stroke engines for two wheelers, the improvements in the efficiency of diesel cars and light commercial vehicles. Most significantly, efficiencies will continue to improve into the future driven by tighter regulations and competition.

The efficiency of buses however has stagnated, principally due to stagnant chassis design, which is based on the truck chassis and thus heavily over-specified for the loads carried by buses.

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[59] Report of the Expert Committee on Auto Fuels Policy, Government of India, August 2002

5.9 Section summary: Traditionally industry has faced “penal” tariffs for energy and has cross-subsidised other energy consumers. Hence energy prices for industry have always been high. It is significant that this was not sufficient to drive improvements in energy efficiency since producers were always able to pass through the energy costs to consumers either under a cost plus regime of administered pricing for their products, as in the case of the Cement industry prior to decontrol, or due to the lack of effective competition as in the case of Aluminum. Licensing barriers to the import of technology and for scaling up production to reap economies of scale, as in the case of Steel prior to liberalisation and prohibitions on innovation in the product mix, as in the case of the Sugar industry which is tightly regulated, were further disincentives under the scheme of centrally planned development. Experience shows that liberalisation and competition, as in the case of cement, coupled with proactive and focussed schemes for technology up-gradation and development, as in the case of sugar, have worked well in improving the energy efficiency of Indian industry. In the case of the small-scale sector, which accounts for around 40% of manufacturing output, technological interventions to enhance energy efficiency are not available off-the-shelf in developed markets. Hence technological development would have to be financed and organised indigenously, though such technology may eventually find markets in other under developed economies. The role of compulsory minimum standards in improving energy efficiency is best illustrated by the automobile sector, where compulsory emission standards have driven energy efficiency. In comparison the lack of compulsory standards in electric motors has resulted in poor efficiencies, especially of rewound motors which constitute one half of the stock of motors. It is significant that low levels of energy efficiency prevail despite the fact that energy prices in general for industrial, commercial and large residential users, who are the consumers for electric motors are fairly high and not subsidised. Lax collection and billing of power may however provide an opportunity to evade paying the rateable price of power and hence dilute the economic incentive to use energy efficiently. Improving energy efficiency in the domestic and commercial sectors is strongly dependent on the design and architecture of our buildings. The lack of building codes, which conserve energy, is a serious constraint, which the BEE is addressing. Improvements in the energy efficiency of our transportation system would depend on integrating the concern for energy conservation into urban development and planning. A switch from road transportation to rail and within rail, to electric traction, the substitution of personal transportation with public transportation and facilitation of the humble bicycle as a efficient mode of transportation for short distances are system wide changes which need to be incorporated into our scheme of planned development.

6. Conclusions

6.1 Institutional Arrangements for an Integrated Energy Policy:

6.1.1 A signification portion of system-wide energy efficiency is dependent on the making of optimum choices with respect of fuels, technology, scale of operations, pricing of energy resources, design of habitations, buildings and transportation systems and the standards for end use energy applications. Optimizing these choices is often the result of an enabling policy environment. The need for integration of energy policy has been emphasized by various governmental committees since the Working Group on Energy Policy (1979) which recommended the formation of a Ministry of Energy or alternatively an Energy Commission. However, the multiplicity of regulatory agencies in the Central and State Governments and local bodies has defined any meaningful attempt towards this end. The only point at which energy policy is considered in a holistic manner is during the allocation of plan funds by the Planning Commission. However, the functions of the Planning Commission are limited and cannot intrude into the area of legislation, policy making or the framing of regulations which guide the routine investment and consumption related decisions, of suppliers and consumers. The Energy Conservation Act 2001 aims at an integrated approach to energy conservation and the Bureau of Energy Efficiency set up under the Act has wide ranging powers with respect to the conservation of all forms of energy. However, the scope of functioning of the Bureau is limited to the recommendations of norms and standards, labeling of equipment, designation of consumers, formulation of energy services building codes, dissemination of awareness of information, developing testing and certification procedures and facilities, promotion of energy efficiency and innovative finances for energy efficiency projects etc. While the Bureau can establish specific regulations with respect to products, processes and building it would have no role in administration, facilitation of investment or in determining the direction of public investment. Nor does it have the powers to coordinate the varied responsibilities of different governmental agencies.

6.1.2 Accordingly, Government may like to consider constituting an Empowered Group of Minister (EGOM) consisting of the Ministers of Finance, Petroleum, Power, Non-Conventional Energy, Minister for Water Resources and Vice Chairman Planning Commission supported by an Inter-ministerial Group of Secretaries for consideration of all cross sectoral matters dealing with energy policy for effective coordination and rationalization of the individual polices and regulations framed by separate departments and agencies, which impact energy policy. The deliberations of the EGOM would be binding and would constitute Government Policy.

6.1.3 The power sector already has independent regulators. It is possible that this may be emulated in petroleum and coal also. It would be ideal if a single energy regulator, on the pattern of the Federal Energy Regulatory Commission (FERC) of the US could be created to consolidate the regulatory arrangements under one roof. Even if this is not possible, for reasons of institutional inertia or departmental independence, a common Appellate Authority should be considered which would replace the jurisdiction of the High Courts in hearing appeals from the orders of the Regulatory Commissions. In view of the developments in the case of the Competition Commission where erosion of the judicial oversight has been a concern it would be appropriate to house such an Appellate Commission within the structure of the judiciary but with the proviso that lay members from the professions of public policy, management, finance and engineering would need to be co-opted onto the Commission which could be Chaired by a judge of the Supreme Court or Chief Justice of a High Court. The jurisdiction of this Appellate Authority should be extensive to enable effective intervention, both on law points as well as substantive issues of regulatory policy.

6.2 Energy Intensity as an index of sustainability

6.2.1 Energy efficiency is very specific to end use applications or particular systems. However, on an aggregate economy wide basis, energy efficiency does not provide a useful measure for comparison due to variations in the structure of energy supply and the end use energy applications. For this purpose, Energy Intensity, which relates the physical use of energy to economic output is a far more useful measure. Energy intensity can usefully be used to measure the overall efficiency with which an economy uses energy to create additional output. Changes in energy intensity can be brought about by changing the structure of the economy as for example by promoting industries and services with low energy intensity and by planning for the development of urban habitation that reduce the requirement of primary, secondary and final energy sources without compromising on the level of useful energy services. Reduction in energy intensity is a part of the sustainable development programme since it is closely linked to the management of climate change. Energy intensity in India has declined at the rate of 2% per year measured in PPP $ over 1980 till 2002. It is useful therefore to determine targets for the next 15 years, which would provide an aggregate check for assessing the success of energy efficiency programmes.

6.2.2 The decision to adopt energy intensity as a milestone measure would need to be supported by the development of a database which maps the base line levels of energy consumption in different sectors across varying end use applications. This data would need to be fit into a energy intensity model which would extrapolate results based on data collected through sample surveys and would aggregate this data at the national level. A database of this nature would also be extremely useful in determining the level of energy emission and, therefore, can be used in common for both the energy efficiency as well as emission control objective.

6.2.3 Energy efficiency can be used as a parameter for the allocation of the plan funds. State-wise targets could be prescribed, keeping in view the developmental needs of each State, which would have to be met for access to the earmarked funds. States could in turn earmark energy intensity targets at the sub-State level and would have the flexibility of designing their developmental schemes in a manner that met the energy intensity targets.

6.2.4 The question can be raised as to why India needs to constrain the use of energy since along with other developing countries it is exempted from any binding constraints under the climate change conventions. There are principally three reasons why a developing country, like India, needs to be concerned about the efficiency of energy use. Firstly, energy efficient economies are also competitive economies and improving the competitiveness of the Indian economy is a prime concern. Secondly, so long as our energy systems remain dependent on the use of fossil fuels, there is a direct link between environmental degradation and energy use. While there may be no legal international compulsions on controlling energy emissions, national environmental considerations, in a continental sized economy, dictate prudence in management of the energy system. Thirdly, non-commercial energy resources form a significant portion of our energy supply. Increasing the efficiency with which these resources are used has a direct impact on poverty alleviation and improvement in the life style of the poor, since non-commercial energy, in traditional end-use applications, is inefficient and highly polluting. Active management and dynamic calibration of the Energy Intensity levels are justified on economic, environmental and equity considerations.

6.3 Supply side efficiencies

6.3.1 The regulatory structure governing the supply of energy continues to be dominated by intrusive administrative interventions and control. The coal sector is almost entirely publicly owned and managed and is tightly regulated by the Government. The petroleum sector is dominated by public sector entities in the extraction of oil and gas, transportation of gas, oil-refining and marketing. The power sector is similarly dominated by PSEs in generation, transmission and distribution though private participation in generation and distribution is increasing. The power sector is however independently regulated by regulatory commissions unlike the other energy sectors. The low levels of private investment and management, lack of competition and the pervasive control of Government over the energy sector restrains the over all efficiency of operations. Consumer prices are distorted in all sectors resulting in less than optimum resource utilization and capital allocation. Low levels of commercialization in the power sector and the continued uncertainty in the financial viability of the retail sector have restrained private investment. As a result, incremental capacity addition is strongly reliant on additional public investment, which in turn, is constrained by the fiscal deficit. Less than adequate investment has generated operational inefficiency, constrained modernization programmes and has generated shortages and poor quality of supply. This highlights the need for greater commercialization of the energy sector with a clear cut time bound programme for phasing out administrative interventions in the determination of prices, phased targets for privatization of existing public facilities or alternatively the induction of incremental private investment in green field projects, better definition of the regulatory environment to reduce regulatory risks and increase certainty for investors and the time bound implementation of investment programmes, to improve the efficiency and capacity for transport of energy resources through pipelines instead by rails or road and for further developing the national power grid.

6.3.2 Introducing independent regulation in petroleum and coal would greatly assist in commercialization of these sectors, which in turn would have direct beneficial consequences on the efficiency with which energy is supplied in India.

6.3.3 The Government must rationalize the prices of petroleum products by a phased reduction of subsidies in Kerosene and LPG and remove the duty differential between petrol and diesel. Artificially high prices for petrol drive the consumers of even light personal vehicles towards heavier diesel run vehicles, which is inefficient. Secondly the real cost of diesel is disguised leading to inefficient and excessive use in irrigation pump sets, in heavy vehicles and in power generation. Artificially lowering the prices of kerosene results in adulteration of diesel with adverse effect on the fuel quality.

6.3.4 In coal private investment in coal mining along with liberalization of the FDI regime permitting 100% FDI in coal mining and coal washeries would greatly improve efficiency of coal supply and improve the quality of coal. The ongoing initiatives for in situ gasification and for extracting Coal Bed Methane should be actively pursued.

6.4 End use energy efficiency

6.4.1 Around two third of the total energy is lost while converting primary, secondary and final energy into useful energy services. Improving the energy efficiency of end-use applications is, therefore, key to further reducing the Energy Intensity of the economy. Till now improving the energy efficiency of endues applications has primarily been the function of market forces, assisted, in some cases, by formulation of standards by BIS or by emission control regulations, as in the case of the automobile sector. However, it is well recognized that the Indian consumer market is extremely price sensitive as a result of which consumers have a short-term perspective and prefer lower initial capital outlay to optimization of life cycle costs. The formulation of minimum energy efficiency standards and their rigorous implementation, therefore, becomes key to moving the market in the direction of enhancing the efficiency of energy use. The lower efficiency of rewound motors, which constitute nearly 50% of the capital stock in the low and medium capacity range, is a good example of a price sensitive sector where the lack of compulsory energy efficiency standards has generated inefficient options. Accordingly rapid development of compulsory energy efficiency standards for end use applications by the Bureau of Energy Efficiency is necessary.

6.4.2 Experience shows that liberalization and competition, as in the case of cement industry, coupled with proactive and focused schemes for technology up-gradation and development, as in the case of the sugar industry, have worked well in improving the energy efficiency of Indian industry. In the case of the small-scale sector, which accounts for around 40% of manufacturing output and employs 27.3 million people, technological interventions to enhance energy efficiency are not available off-the-shelf in developed markets. A significant part of the small scale sector is operational only because industrial policy prohibits the entry of larger companies (unless they undertake an export commitment of 50%) into the manufacture of 670 products. Technological development for industries which are not commercially viable on a small scale will always only have a limited market within India and that till the policy of “reservation” continues. However for other products, which are in any case commercially viable on a small scale because they cater to niche markets, technological development would have to be financed and organized indigenously, though such technology may eventually find markets in other under developed economies and thus provide a commercial thrust to technology development for small-scale industries.

6.4.3 Energy used in the domestic and commercial sector, particularly for water heating and climate control is strongly dependent on the manner in which our buildings are built and the nature of materials used for the purpose. Currently, there are no building codes which prescribe minimum energy efficiency standards for buildings. The Bureau of Energy Efficiency is currently considering the formulation of these standards, which are essential for making the building sector sustainable and efficient.

6.4.4 Less than adequate thought has also been given to the planning and lay-out of urban habitations with a view to reduce the transportation demand and the energy intensity of civic amenities and to maximize the facilities for public transportation as opposed the private transportation. Similarly higher levels of electrification in the railways can increase the energy efficiency of transportation of freight and passengers. These, however, are system-wide changes which have a long gestation period and can be implemented only if the concept of energy intensity is integrated into town planning and architecture. It is expected that if energy intensity is adopted at the national and sub-national levels, as a planning milestone, it would provide an automatic incentive for Governments and Local Bodies to review the nature of urban development with the intent of improving the efficiency of energy use.

6.5. Non commercial energy

6.5.1 Non-commercial energy accounts for around 42% of the total energy losses. The energy efficiency of non-commercial energy resources in traditional increase applications is less than 10% where as it can be double by gasification and by improved end use applications. Technology is being developed which can extract these efficiencies. However, the pace of implementation is slow. It is significant that non-commercial energy resources continue to be dominant fuel used by the urban poor and in rural areas. Hence improvement in the energy efficiency in this area has significant equity considerations. Non-Commercial energy resources can be commercialized into decentralized energy systems which are accessible to the local people, relatively technologically unsophisticated and which can be locally managed. The development of an integrated rural energy planning would be strongly dependent on our ability to improve the efficiency, which these locally available natural resources are used. Currently there is no effective system for transfer of the avoided costs of a centralized energy system to be transferred to the stakeholders of a decentralized energy system. Such transfers need to be systematically quantifying and mechanism established for monitising the transfer. The lack of a unified regulatory structure governing all forms of energy is a clear handicap in meeting this objective. Accordingly such transfers can best be implemented today through a system of financial incentives provided either by the Government or, in future, if Regulation takes root, by levying a charge on energy supply utilities for relieving them of their obligations to supply energy in rural areas on the pattern of the Access Deficit Charge levied in the telecom sector on private providers for financing the extension of rural telephony by BSNL.