ENERGY FOR SUSTAINABLE DEVELOPMENT

By

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Introduction

I am deeply grateful to the Lavraj Kumar Memorial Trust for inviting me to deliver this year's memorial lecture. I owe Lavraj a great debt of gratitude for bringing me into the bureaucracy, for showing me how to operate within it and for setting a high standard of probity and dedication that was an example

Lavraj belonged to an extraordinary generation of Indians. They are the people who were young adults around 20 years of age at independence. They were old enough to have seen the last phase of the freedom movement when apart from the political struggle against the British there was a ferment of ideas on how independent India should develop. They inherited the idealism and ambition that came with the first flush of freedom and they never lost this sense of promise right through their lives. Midnight's adults I call them for they carried the hopes that were ignited when India made its tryst with destiny. And they never lost this optimism even when the country went through political upheavals, economic set-backs or environmental stresses.

Lavraj, a chemical engineer by training left his well-paid job in an oil company to join what I call Nehru's army of engineers and economists who sought to give expression to his vision of development. He played a major role in the development of the petrochemical industry and later also the petroleum and steel industry. I worked with him when he moved to the Planning Commission to set up the new Project Appraisal Division which brought in not just an economic cost-benefit analysis of public investment projects but also a certain concern about environmental impacts even before environmental impact assessments were made mandatory. After the 1973 oil shock he played a major role in the effort to cope with its impact. In that capacity and later in the ministerial secretaryships he held energy policy was a major part of his contribution to public policy. In recognition of that this lecture is devoted to the theme of energy and sustainable development.

Energy in the broad sweep of history

Economies, societies and even international relations are shaped by energy innovation and development. The driving forces behind this connection are technological innovation both on supply and demand side and resource discovery. Between these two, technological developments are more crucial since they can change the economic value of a resource dramatically. Coal deposits existed and were known for ages and it was the invention of the steam engine that changed their value and so also in the case of the internal combustion engine and petroleum. The most recent example of the impact of technology on resource value is in the case of shale deposits. Technological innovation is the key to the interaction between energy and development and technological competence is more important for energy security than ownership of resources.

Historians of technology and society interaction speak of the age of steam (coal), of electricity and of petroleum. Thus Mumford in *Technics and Civilisation* says "'Speaking in terms of power and characteristic materials, the eotechnic phase is a water-and-wood complex: the paleotechnic phase is a coal-and-iron complex, and the neotechnic phase is an electricity-and-alloy complex"[1]

Preindustrial energy sources like the power of flowing water were location bound. There was a limited potential of draught animals for a mobile source of energy for transportation. Coal was more readily transportable but the high cost of transport relative to the ex-mine value conferred locational advantages on regions with large economical coal deposits - witness the growth of textile industry dependent on coal based steam generation in the north of England. But coal also made steam railway possible and with the establishment of rail networks the locational edge of coal districts was reduced. Thus the textile industry in India, which developed after the emergence of the railways, grew in Western and Southern India, far from coal deposits.

The locational advantages of coal sources virtually disappeared with the emergence of petroleum and electricity. Petroleum is so economical to transport relative to its intrinsic value that there is virtually no comparative advantage for oil producing areas. If there were, the Middle East would have been an industrial power house by now.

With electricity this absence of any significant comparative advantage for source sites is even sharper. But though electricity use is dispersed geographically, electricity production became increasingly centralised as the costs of transmission fell relative to the costs of coal transport creating a competitive edge for pithead based stations. There was always a locational specificity for hydro projects. Economies of scale in generation added to this centralising tendency. However this edge of size and location near the energy source was muted for gas and oil based generation. But the locational advantages of energy supply sources for electricity generation did not create any particular advantage for electricity using activities, with some exceptions like aluminium.

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[1] Lewis Mumford, *Technics and Civilization,* Routledge & Kegan Paul, London, 1934 Pg 110

The link between energy and economic growth is sometimes summarized in the energy use per unit of GDP. This changes as an economy develops, rising first as a country industrialises, and even more so when energy intensive heavy industries are coming up and then falling as the economy moves to lighter high value added industries and services. Other factors like the pace of urbanization also play a role. However this pattern of a rise in energy intensity followed by a fall does not mean that energy availability becomes less central to the growth process. . Energy analysts believe that the growth of trade and technology transfer associated with globalization will lead to a convergence of energy intensity by 2030.[2]

In this broad sweep of the history of energy and development where are we headed? What will be the shape of energy systems say fifty years from now?

The energy systems of the future will be radically different as fossil fuels will become increasingly unacceptable as the threat of catastrophic climate change comes nearer and becomes dominant in shaping public policies. One must also factor in the impact of resource depletion and rising costs of supply of fossil fuels.

The impact of climate concerns is quite uncertain at the moment as the global negotiations on this issue are ensnared in contentious debates about equitable burden sharing. However the accumulating evidence of the speed and scale of the impact, highlighted in the recent IPCC Report, will generate a sense of urgency and generate pressures for action. This is already evident in the growing number of fund-managing entities that are forswearing investment in fossil fuel companies.

At present the global agreement is supposed to put the world on a path of emission reduction that would contain the expected global warming to an increase of not more than 2 degrees centigrade. This goal looks increasingly distant but if implemented it would require that by 2050 the world's carbon emissions would have to roughly halve, even though GDP will be about five times higher - which implies a tenfold increase in carbon productivity. Existing and potential fossil fuel technologies technologies cannot do this; a massive shift to renewables and non-carbon energy sources and a radical improvement in energy use efficienc is the only way to attain this goal or anything near it.

Petroleum-based liquid fuels and natural gas constitute over 50 per cent of global primary energy supply. They are the foundation of the motorised, urban economy. Some analysts argue that world crude oil production is near its peak and with the increase in reserves falling short of the increase in consumption, reserves will decline and lead sooner or later to a decline in production. This assessment is based on the fact that the new finds are nowhere near the giant fields like the Saudi

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[2] BP World Energy Outlook 2035, British Petroleum, January 2014

Arabian Ghawar field of 140 billion barrels. A part of the pressure will be relieved by gas, particularly shale gas, as a transitional fuel. But by 2050 this will have played out.

These two trends, the growing pressure to replace fossil fuels with non-carbon energy sources and the depletion of low cost fossil fuel resources will pull in opposite directions in their impact on energy prices and global energy politics. At present fossil fuels sell at well above their marginal cost of production and the producers earn substantial rent on the resources they own. However the headroom is getting reduced as the newer finds of conventional oil come from off shore and deep sea reserves or reserves in distant and difficult places like the Arctic. Moreover most supply projections assume a growing contribution from non-conventional sources like tar sands where the costs of extraction, processing and environmental management may well be over $80-100 at the margin.[3]

The real pressure on fossil fuel resources in a longer time frame to say 2030 will come from the emergence of alternatives like nuclear and renewable energy power as cost effective substitutes. Renewables are already creeping up under the radar and the supply price gap is narrowing. In India for instance the bids that have been received in the first phase of National Solar Mission sought a weighted average feed in tariff of Rs.12.17/kWh in the December 2010 round which fell to Rs.8.77/kWh in the De ember 2011 round. The second phase in February 2014 shifted to viability gap funding to make the project viable at a tariff of Rs. 5.45/kWh. The bids that won sought weighted average viability funding of Rs.10.67 million/MW in the open category and Rs.20.19 million/MW in the domestic content requirement category, which is 15-30% of the benchmark capital cost of solar power set at Rs.69.10 million by the CERC.[4]

The feed in tariff bids that are being received separately by State Governments are even lower - Madhya Pradesh recently received a bid for supply of solar power at Rs.6.5/kWh which is quite close to the Rs.5.7/kWh rate at which the Delhi utilities buy power. Looking ahead, a Ernst & Young study projects that between 2011 and 2020 the cost of conventional power will nearly double from Rs.3,75/kWh to Rs.7/kWh , of wind power will go up from Rs.4/kWh to Rs.6.24/kWh and of solar power.will go down from Rs.11.24/kWh to Rs.6/kWh.[5]

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[3] "A report by Carbon Tracker says companies are committing $1.1 trillion over the next decade to projects that require prices above $95 to break even. The Canadian tar sands mostly break even at $80-$100. Some of the Arctic and deepwater projects need $120. Several need $150." Fossil Industry is the Subprime Danger, By Ambrose Evans-Pritchard, Daily Telegraph online 09 Jul 2014

http://www.telegraph.co.uk/finance/comment/ambroseevans_pritchard/10957292/Fossil-industry-is-the-subprime-danger-of-this-cycle.html accessed 26-10-2014 at 3.00 pm IST

[4] CERC Order dated 15 May 2014 on Determination of Benchmark Capital Cost Norm for Solar PV power projects and Solar Thermal power projects applicable during FY 2014-15.

[5] Cited in Economic Times 21 September 2014 pg 19.

This experience is repeated in other parts of the world and hard-headed financial analysts are increasingly worried about the viability of the huge investments that are going into coal and oil based power generation. The IEA estimates that if the climate negotiations succeed in getting carbon reduction commitments consistent with the 2 degree goal, two-thirds of the reserve assets of fossil fuel companies would have to remain in the ground unused. The oil companies would be left with stranded assets of $19 trillion mainly in the high cost non-conventional sources they are investing in now.[6] An energy company that does not have a presence in the renewables space will lose out and not just they but also the oil sheikhs of the Middle East are moving into this space.

An energy economy based increasingly on renewables and nuclear will consume a much larger proportion of its energy through the electricity route. Electricity driven vehicles will be a major element in this transition. But this will require a radical redesign of our cities and electricity distribution systems.

At present our grid system is designed to deliver power from a few generating stations to a large number of consumers. Renewables are a form of distributed generation where, in options like roof top solar, the consumer can also be a supplier of electricity back into the grid. Moreover even the commercial entities producing solar or wind power can be very dispersed geographically. Our present power distribution system meets load fluctuations essentially by adjusting generation. With a growing proportion of energy use being met through electricity it will also be necessary to adjust demand to cope with such fluctuations. This is possible with todays technologies as smart appliances can be asked to switch off or on by the distribution system if it has a capacity for two way communication between power users - the so called smart grids that require smart appliances, smart metering and smart generation. The electricity system of the future will involve hundreds of independently managed mini grids linked in a regional and national network and a higher order of interaction between users and producers in managing the flow of power in the grid.

The impact of a substantial shift from fossil fuels to renewables will have a profound impact on global energy politics. A command over energy resources, particularly if they involve high extraction costs, will not be as central for strategic policy as competence in the development and use of new energy technologies. In a medium term time frame these strategically important technologies will include those that reduce the cost of renewables, facilitate energy storage , bring about quantum improvements in the energy efficiency of appliances, make electric vehicles cheaper and more convenient, reduce the risks associated with nuclear power, help to capture and store carbon from fossil fuel use,

How well prepared are we in India for this new energy world where energy efficiency will matter as much as access in demand management, where energy supply systems will be far less centralised than now, where environmental concerns will be as influential in shaping outcomes as financial and

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[6] Ambrose Evans-Pritchard, *Op.cit.*

economic factors where a command over energy technologies will be as or even more important than a command over resources?

Demand management

The central problem of energy demand management at the household level in India is that we actually need not one but three different policies - one for a small percentage of the population that has a level of consumption comparable to that in the developed countries, a second for a much larger percentage who are aspiring consumers who have moved well beyond subsistence and a third for the majority of the population who are energy poor and for whom the focus of policy has to be on affordable access.

Household use energy mainly for cooking, lighting, transportation. An indication of the distribution of energy consumption can be derived from data on the amenities they have access to for these purposes. Data from the Population Census of 2011 that throws some light on this is presented in the table below:

Distribution of energy using amenities 2011

	Percentage of households using		
	Total	Rural	Urban
Vehicle ownership			
--No vehicle	29.52	37.24	13.07
--Bicycle	44.81	46.16	41.94
--Two-wheeler	21.02	14.34	35.24
--Four-wheeler	4.65	2.26	9.75
Cooking fuel			
--Firewood etc	65.79	85.75	23.29
--Gas & Kerosene	31.44	12.13	72.56
--Others	2.77	2.12	4.15
Lighting source			
--Electricity	67.25	55.31	92.68
--Kerosene	31.43	43.15	6.48

--Other	1.32	1.54	0.84

Source: Census of India, Houselistng and Housing Census 2011, Table HH-14

We can reasonably assume that all those who depend on firewood or cowdung as a cooking fuel fall into the third category and that all those who own cars are in the first category, then, as an approximation we can say that 5% of our population are high energy consumers, 30% are in the modern energy system but have a modest level of energy consumption and that 65% are energy poor with limited access to modern energy.

The challenge of energy demand management in India is to devise policies to contain the demands of the top 5%, meet the rising demands of the aspiring 25% in a sustainable manner and incentivise modern energy use by the 65% who are energy poor. To a limited extent the differentiation required can be secured through differential pricing implemented through direct cash transfers or a progressive system of slab pricing. Effective differentiation will require closer attention to service delivery systems and incentives for appliance innovation.

It is useful to begin at the bottom of the pyramid. The greater proportion of these are in rural areas where the primary energy demand for household use is for cooking. Some indication of the cost of alternatives is presented in the table below:

Household Use of Cooking Energy: Cost of Alternatives						
	Efficiency	Energy use	Energy use per year	Price per unit	Energy cost per year	CO2 emission per year
	%	Actual units	Giga Joules	Rs/unit	Rs/year	kg/year
Traditional wood stove	13	1500 kg	24.0	7/kg	10500	2520
Efficient wood stove	35	500 kg	8.0	7/kg	3500	840
Traditional kerosene stove	30	280 litres	9.8	15/litre	4200	690
Efficient kerosene stove	45	186 litres	6.5	15/litre	2790	459
LPG stove	60	165 kg	7.5	65/kg	10725	464

Source: Technical parameters from B Sudhakara Reddy. Economic and Social Dimensions of Household Energy Use: A Case Study of India in Ortega.E & Ulgiati. S (editors) Proceedings of IV Biennial International Workshop "Advances in Energy Studies", Unicamp, Campinas, SP Brazil, June 16-19 2004, pages 460-477 Energy prices for firewood and kerosene from Average Monthly Consumer Prices of Selected Article for Industrial Workers, August 2014, Labour Bureau, averaged over 76 centres; LPG price from cost of non subsidised cylinder in Delhi in August 2014

The cost of cooking with firewood is based on the price of firewood in urban markets. Much of the firewood, cowdung and crop residues used in rural areas is collected by the household. If adult labour is used then one can argue that with access to MGNREGA employment there is an opportunity cost that would be close to the annual cost listed above. If child labour is used than the opportunity cost is the loss of education. The cost of LPG is at the non-subsidised price; at the present subsidized price it would be roughly half of the cost given in the table. Given this, what this table demonstrates is that modern energy sources make economic sense for the energy poor. The problem is the upfront capital cost and a service delivery system for LPG and kerosene that does not reach into every village.

The use of firewood in traditional stoves is also a major health hazard, particularly for women who use these stoves i enclosed spaces and small children who are often in the same enclosed space with their mother. The carbon monoxide content in the lungs of children in this situation has Ben measured and amounts to the equivalent of smoking 7 cigarettes a day.[7] The programme to supply improved stoves has been around for a long time. But it has had a very limited impact.

The most useful and sustainable way of helping the energy poor is to focus attention on the last-mile infrastructure for the delivery of LPG and kerosene. Local production of health and environment friendly bio-energy from animal and crop wastes must also be promoted. For energy needs other than for cooking rural electrification and off-grid solar for remote areas are necessary. Price subsidies may well be justifiable in order to reduce deforestation and diverting bio mass into more productive channels.

The key to effective demand management for the aspiring class of consumers lies in the promotion of appliance efficiency. This has already been taken in hand by the Bureau of Energy Efficiency and a system of star rating has been introduced for several appliances. There is clear evidence of a shift by households towards more energy efficient air conditioners, refrigerators colour TVs and

[7]Smith K.R. Health impacts of household fuelwood use in developing countries, FAO Corporate Document Repository,http://www.fao.org/docrep/009/a0789e/a0789e09.htm, accessed 27-10-2014 6.00pm

ceiling fans. An innovative programme to exchange standard bulbs for CFL bulbs with the exchange being financed by carbon credits led to a more than ten-fold increase in the sale of CFL lamps from 36 million in 2003 to 408 million in 2012. It has been estimated that these trends in household energy use can lead to a 30% reduction in energy use relative to business as usual with no loss of amenity.[8]

At the top end the issue is not just more efficient consumption but policies that will reduce the demand for the services like personal transportation and space cooling that require energy use. The answer has to be sought not just in energy prices but also in the tax levels for energy using appliances like cars and air conditioners.

A programme to promote energy efficiency and reduce the demand for energy using services has to reach out beyond households to the enterprises that design and provide these services. Thus promoting energy efficiency in buildings,which is a stated goal of policy, has to influence property developers, builders, architects and building material manufacturers. An energy efficient building has higher upfront costs that are recovered through lower energy costs later. A house buyer needs convincing evidence from an independent entity that certifies the potential saving. . We also need ex-post analysis of actually realised savings in completed buildings not just to keep the ratings honest but also to learn and revise the building norms aimed at energy efficiency.

The present systems of green rating for buildings developed by the Bureau of Energy Efficiency, by the Indian Green Building Council and TERI and the mandatory standards incorporated in the Energy Conservation Building Code serve this purpose to a certain extent. But to be effective we need a great deal of capacity building in municipalities and State administrations to monitor the implementation of the code.

Demand side management in the use of energy in transportation and industry is already happening with fuel efficiency standards for cars and hopefully soon fir heavy vehicles and the Perform, Achieve and Trade system for energy efficiency in industry. But the mandatory norms need to be reinforced by prices that reflect the full costs of energy, a matter we turn to later in this paper.

The most recent projections of energy demand growth are in the report of the Expert Group on Low Carbon Strategies for Inclusive Growth. They are summarised in the table below:

Energy Demand 2030				
Item	**Units**	**2007**	**2030 base**	**2030 low carbon**

[8] Final Report of the Expert Group on Low Carbon Strategies for Inclusive Growth, Planning Commission, Government of India, April 2014, pg 46

Primary energy demand	mtoe	400	1146	1108
Power demand	billion units	837	3371	3466
Coal demand	million tonnes	556	1568	1278
Crude oil demand	million tonnes	156	406	330
Natural gas demand	billion cum	43	187	208
CO2 emissions	million tonnes	1429	5271	3830
Per capita CO2 emission	tonnes	1.3	3.6	2.6
Source: Final Report of the Expert Group on Low Carbon Strategies for Inclusive Growth, Planning Commission, Government pf India, April 2014, pg. 31-32				

These projections are based on an average rate of GDP growth of 7% upto 2030. The projections for low carbon growth require major policy shifts and an additional investment $834 billion at 2011 prices, which is about 50% higher than the energy investments in the base scenario. The 27% reduction in carbon emissions is primarily a result of a change in the supply mix to low carbon options like wind, solar, hydro and nuclear power. Note also the increase in electricity demand in the low carbon projection.

Supply management

The demand and supply scenarios projected for low carbon growth by the Planning Commission Expert Group involve major shifts in the structure of the energy business. In a planned economy where the energy infrastructure is largely in the public sector, the shift can be secured by the Central and State governments diktats about fuel-mix, investment in generating stations, coal mines, oil and gas fields, linkages between input suppliers and users, pricing of energy inputs and outputs, technology choices, location etc. But we are no more a centrally planned and managed economy and the private sector is expected to play a major role in sectors that were once reserved for the public sector.

The role of the private sector in the energy industry has expanded, initially in the petroleum sector and later in power and coal. Private sector involvement in power generation has grown and now accounts for nearly 30% of thermal generating capacity and 87% of the renewable power capacity excluding large hydro, which along with nuclear is largely in the public sector. In petroleum the three private sector refineries account for nearly a third of total refining capacity. Coal is natioanlised and private investment here is basically for captive use, However the recent announcements by the Government on the e-auction system for the allocation of coal blocks whose earlier allocations have been set aside by the Supreme Court opens a window for commercial production of coal by the private sector

But though the private sector has a growing presence in the production of power and petroleum products the distribution channels for these are still largely n the public sector. Power distribution is still largely in the hands of the State Electricity Boards despite the very visible private discoms in metropolitan areas. Petroleum product distribution is handled by the public sector oil companies and the private refineries are predominantly export oriented. They withdrew from distribution when price controls were reintroduced in 2004 after international oil prices shot up, undoing the price deregulation of 2002. The recent deregulation may go the same way unless the Government has a game plan for coping with the pressures for restoring price controls which will arise when crude oil prices go up from the present low levels.

The scale of the expansion envisaged in the projections is beyond the managerial and financial capacity of the public sector, particularly since so many of the State Electricity Boards are burdened with huge accumulated losses which would prevent them from accessing resources from the capital market. The Government expects private sector to provide half the infrastructure investment, and energy is the biggest item in this. It is also wooing foreign investors who can bring in not just capital but also managerial and technical innovations. Hence the first requirement that the energy policy regime must meet is that it be market friendly.

Renewables like solar and wind are expected to play a major role in the decades ahead. Recently the Government has upped the goal for solar power from 20GW by 2022 to 100MW by 2019. A National Wind Mission is under consideration and, given the recent studies that suggest that

India's wind power potential is nearly 750 GW at 80m height as against a current installed capacity of 20 GW, one can expect a similar increase in ambition in this area. These renewable options require not just a market friendly policy framework but also a far greater scope for decentralized grid and supply management. Hence a second requirement for energy policy is that it create space for decentralized generation and distribution of power.

These two requirements mean that the Governments in the Centre and the States have to shift their attention from traditional public investment planning to regulatory and fiscal policies that can influence private investments in the desired direction. They must also deconstruct the vertically integrated utilities in the power sector and open up the energy distribution system to private players.

The most important determinant of private sector interest in the energy sector is profitability. The most critical factor in determining profitability is the structure of input and output prices. In this we are miles away from a market friendly system. Power tariffs, coal prices, gas prices and many petroleum product prices are set by the government directly or by regulators. Decisions about these prices are highly politicised and because energy is a near universal input in all economic activity and a major part of household budgets these political pressures invariably lead to tardiness in adjusting prices to cost increases. This leads to accumulating losses or mounting budgetary subsidies.

With the exception of a couple of petroleum products, one can say that practically all energy prices in India are lower than what the free market price would be. Clear evidence for this is available in the difference between the Rs.1600/tonne average price of coal supplied as part of the designated linkages and the Rs.2200/tonne average price for the coal sold through auctions. Power tariffs for consumers are set at a level at which it is sometimes cheaper for distribution companies (discoms) to not buy power and shed loads. Consumers have to cope with this uncertainty in grid power by using high cost diesel generators with a per/kWh cost which is three to four times the power tariff. In effect we have privatised power supply by forcing users to invest in 90,000 MW of captive generation capacity. (This is the capacity of captive gensets rated over 100kva. The number would be even larger if smaller gensets are included).[9]

A market friendly system will require that energy prices be determined by the forces of market demand and supply. The key to this lies in creating competitive wholesale markets in energy products where price discovery can take place. The different energy products are so interlinked that price reform for one is not possible without doing the same for the other products. Thus coal and gas prices and power prices have to be looked at simultaneously and deregulating one without deregulating the other is inviting trouble. Rationalisation of energy pricing to reflect market

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[9] Powell Lydia, *The Personalisation of Power Generation in India,* Energy Monitor, Observer Research Foundation http://www.orfonline.org/cms/sites/orfonline/modules/enm-analysis/ENM-ANALYSISDetail.html?cmaid=71182&mmacmaid=71183

conditions is a huge challenge as the present system of de facto administered prices has run up huge subsidy burdens that will take years to shake off.

A market friendly price system must rest on effective competition between suppliers in the market so that the need for intervention by the regulator to protect consumer interests is minimized. In the case of power a certain amount of open market trading takes place. Distribution licensees are required to purchase power through competitive bidding for long-term supply contracts. But this price discovery process for long term supply contracts is only partially market-friendly as the tariffs the discoms can charge are constrained by the regulator and even more so by Government policies to subsidise power supply to specific categories of consumers. The short term or spot market, mainly for the day ahead supply, reflects market conditions better and accounts for about 11% of total supply. However it is volatile and does not provide a clear signal to investors

Competition in the market for power must involve not just competitive bidding for markets but competition in markets so that users have a choice of suppliers. It appears that there is a move towards this with the proposal to separate the distribution network at the local level from the supply responsibility. Multiple suppliers could then compete in the market with common access to the independently owned and run distribution network.

The transmission and distribution grids will remain monopolies. But they must be run by public agencies that have no stake in generation or distribution markets. Designing an effective market based supply system for electricity is a challenge that will involve some experimentation and will have to be steered step by step by the regulator.

It will require market oriented reforms in coal production and pricing also. The present system of coal marketing involves bilateral linkages between major users and specific source mines. The user does not really have the option of going to an alternate supply source. The difficulty here is the monopoly of the nationalised coal industry. If denationalization is not possible then some semblance of market based price discovery can be established by expanding the quantities sold through auction. Since imported coal is going to play an important part another way of introducing a competitive element is to permit merchant importation and trading in coal.

Gas pricing is also controlled and here too transactions are basically bilateral deals between the supplier and the buyer. For a proper gas market to emerge investments to create a supply grid through pipelines will be needed so that gas can be delivered to users throughout the country, the most obvious example of this being the need for a gas grid. This grid, like the power transmission and distribution network must be run independently of suppliers and should be available to all suppliers. In the case of petroleum products the market is becoming closer to a competitive one with the deregulation of prices.

Competition in the energy sector also means competition for the natural resources like coal and gas. Licenses for these resources should be given on the basis of competitive bidding. This is now normal in petroleum exploration and extending it to coal should not be difficult. The terms of the licenses should be designed to maximise resource recovery and make private and social incentives compatible by allowing private lease holders to take a long term view of resource recovery.

A market based energy supply system may focus its efforts mainly to meet the energy needs of the 35% of the population that is in the modern energy system. The challenge of reaching modern energy to the 65% who are outside it cannot be left simply to market forces. It will require interventions by the government like universal service obligations in the licensing terms, explicit cross subsidization, continuing public investment in rural electrification, support for off-grid solar, mini-hydro, micro-grids and other similar options that provide power to remote areas, for solar lamps and other appliance innovations directed at the bottom of the income pyramid micro grids. A market-based energy system that allows energy producers to earn a fair return on their supplies to the top 35% of the population who are in the system will be better able to reach out to the 65% who are not at present in the system.

Energy production, distribution and consumption have a major impact on environmental quality. The major areas of concern will be climate change, local air quality, forest cover and forest quality, loss of agricultural land, water availability and quality. With regard to the last four there are extant laws which apply to al projects and energy projects would have to comply with them. The challenge is of implementation rather than of policy reform. However the impact of energy development on the risks of climate change is a different matter. Averting climate change is not a stated goal of any law though there is a National Action Plan on Climate Change which includes several components which impinge on energy policy.

The Planning Commission Expert Group on Low Carbon Strategies for Inclusive Growth was set up as a response to growing pressures for action on climate risks. The report of the Expert Group contains recommendations on energy policy built around the twin pillars of energy efficiency and a shift towards lower carbon energy sources. The pressures for reducing carbon emissions will continue to mount as the evidence about climate risks becomes more and more alarming. Many of the actions required to reduce carbon emissions have collateral benefits. Thus replacing inefficient wood stoves with efficient ones or with LPG will not only reduce carbon emissions but also reduce risks to the health of women and children and conserve forests. A shift in primary energy away from fossil fuels to renewables will reduce carbon emissions and enhance energy security. Energy efficient appliances will be good not just for climate but also for household budgets.

Conclusion

Sustainable development was defined by the Brundtland Commission as development that meets the needs of the present without compromising the ability of future generations to meet their needs. In India the needs of a large part of the population are not being met at present. Hence sustainability requires a focus on present needs. At the same time the manner in which the energy system caters to the smaller part of the population whose needs are being met is creating an ecological debt that is a tax on future generations.

Sustainability in a business sense involves a narrower focus on whether the returns earned by the business allows it to continue operating without requiring the injection of subsidies from outside. In this narrower sense India's energy business is not sustainable as is clear from the accumulated losses of the electricity boards and the under recoveries in petroleum product sales that required subventions from the budget.

Sustainability in the context of growth means the ability to generate the resources required for investment either from profits or by attracting funds from the capital market. On this ground too one could argue that India's energy system is not sustainable.

Hence energy for sustainable development requires major changes in the policy regimes for pricing and natural resource allocations for coal, petroleum, gas and renewables. It requires the deconstruction of production and distribution systems to create room for competition. It has to bring into the modern energy system the 65% of the population who today are left out. It requires explicit consideration of a reduction in carbon emissions as a goal of policy.