Role of New Renewables in Sustainable Energy Development of India: Environmental Aspects and other Drivers

RAMPRASAD SENGUPTA[1]

INTRODUCTION

The need for transforming the global economy and society to control climate change and clean up the environment at the local and global level has led to a vision of a new industrial era based primarily on the development of renewables and hydrogen to replace fossil fuels in the electricity and the transport sector. The major opportunity of fuel substitution has been in the Indian electricity industry. For example, the shares of coal, oil and natural gas in the electricity industry of India have been 70%, 1.7% and 11.5%, respectively, in the total gross generation of electricity, while shares of the carbon free resources of hydro, nuclear and new renewable in the same have been 13%, 2.3% and 1.5% respectively in 2010.[2] The development of new renewables (i.e., renewables excluding large storage hydro) is slowly emerging not only as a resource of off-grid power generation for supply in remote areas, but also more importantly as a grid connected source of supply. The serious disturbing consequences of the large storage hydro power on river ecosystem and human settlements on the one hand , and the problems of uncertainty and risks of pollution arising from the radioactive wastes from nuclear power led to greater focus on the new renewables. In this chapter we confine ourselves to some selected issues relating to the development of the new renewables

Macroeconomic and Environmental Unsustainability of the Pattern of India's Energy Resource Use

The high dependence of India on fossil fuels – coal, oil and natural gas – for meeting her total energy needs has become unsustainable, not only because of the resultant high carbon emissions as well as total ecological footprint, but also because of macroeconomic implications. India imports all three fossil fuels necessitated by their growing eco-scarcity (Figure 1), while their import prices for India have been rising in nominal dollar and rupee over the period 1989 – 90 to 2010-11 (see Figure 2). While the share of fossil fuels in the total apparent consumption of commercial energy in oil equivalent terms has increased at the rate of 3.25% per annum,

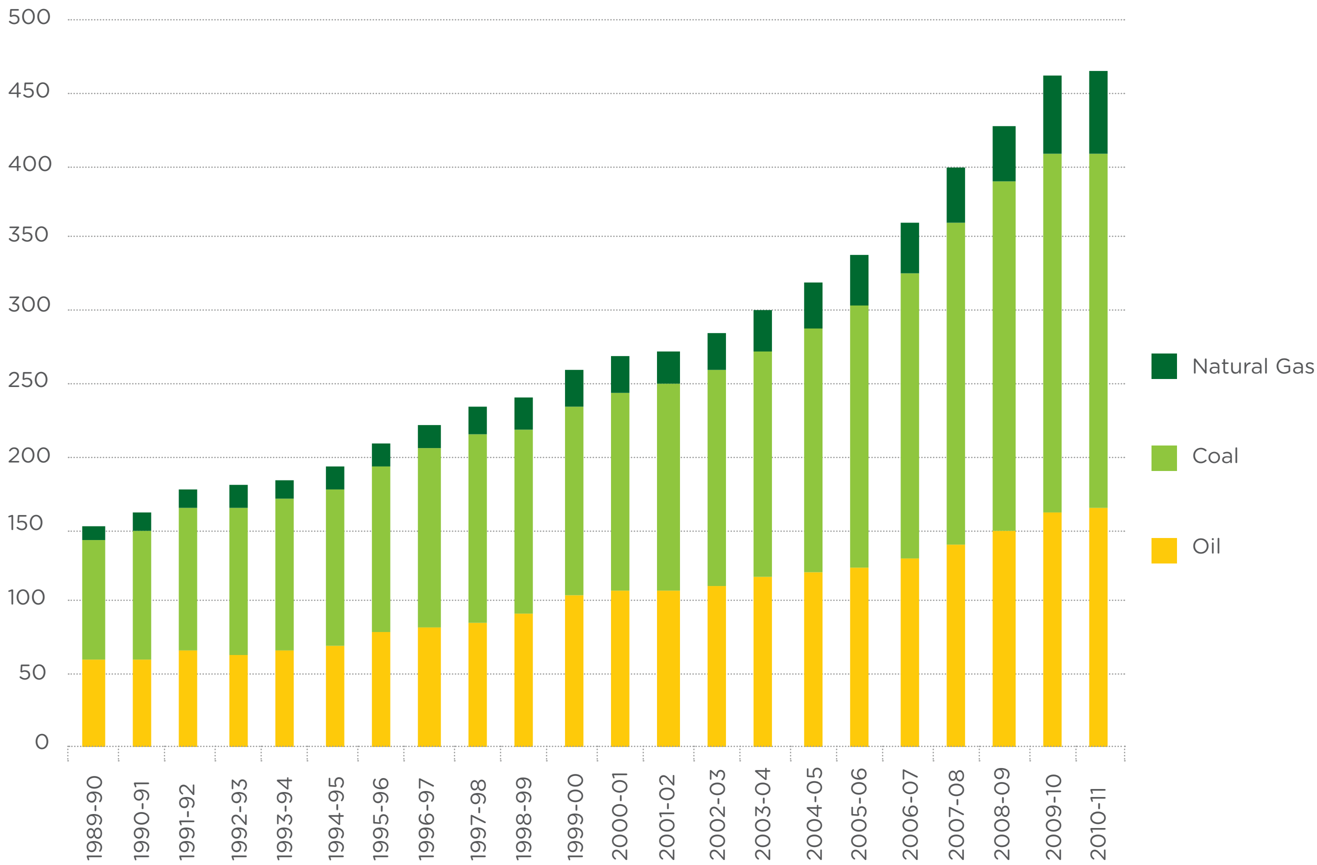
---

[1] *Distinguished Fellow, India Development Foundation, Gurgaon & Professor Emeritus, Jawaharlal Nehru University, New Delhi.*

[2] *While comparative numbers aren't available, the share of RE in generation has recently grown to over 5% in just a few years.*

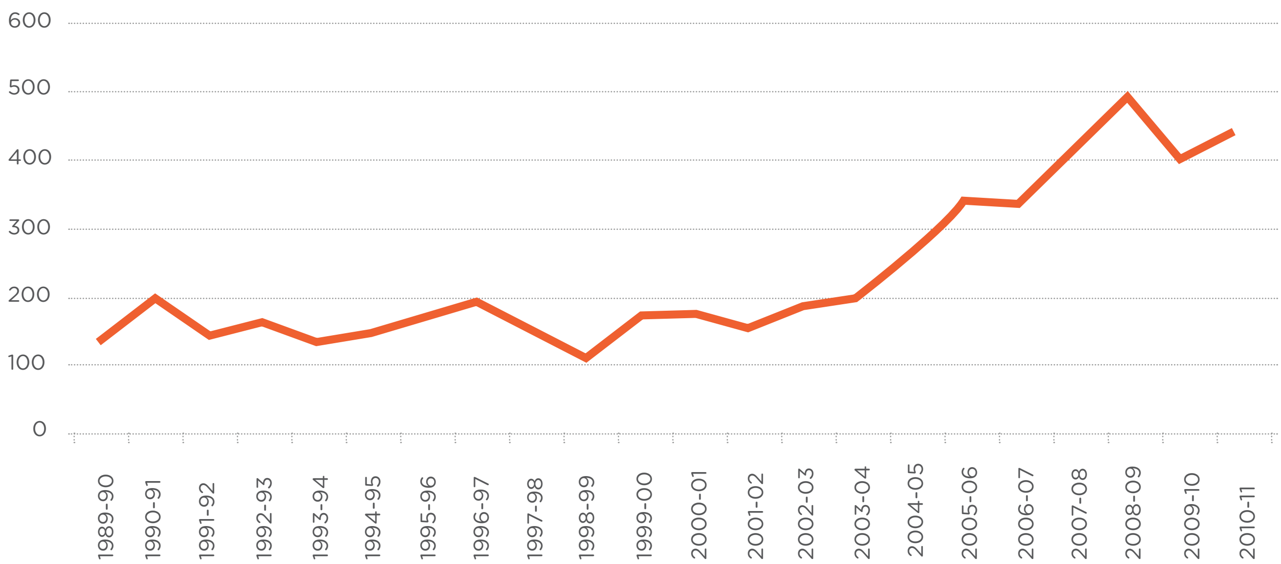
the growth of net imports of all fossil fuels together has been 8.79% per annum during the same period. The unit import price of fossil fuels together in oil equivalent terms has in fact increased in nominal dollar and rupee terms at the rates of 15.05% and 19.92% per annum respectively in the same period (see figure 2).

FIGURE 1: Apparent Consumption of Fossil Fuels in India (Mtoe)



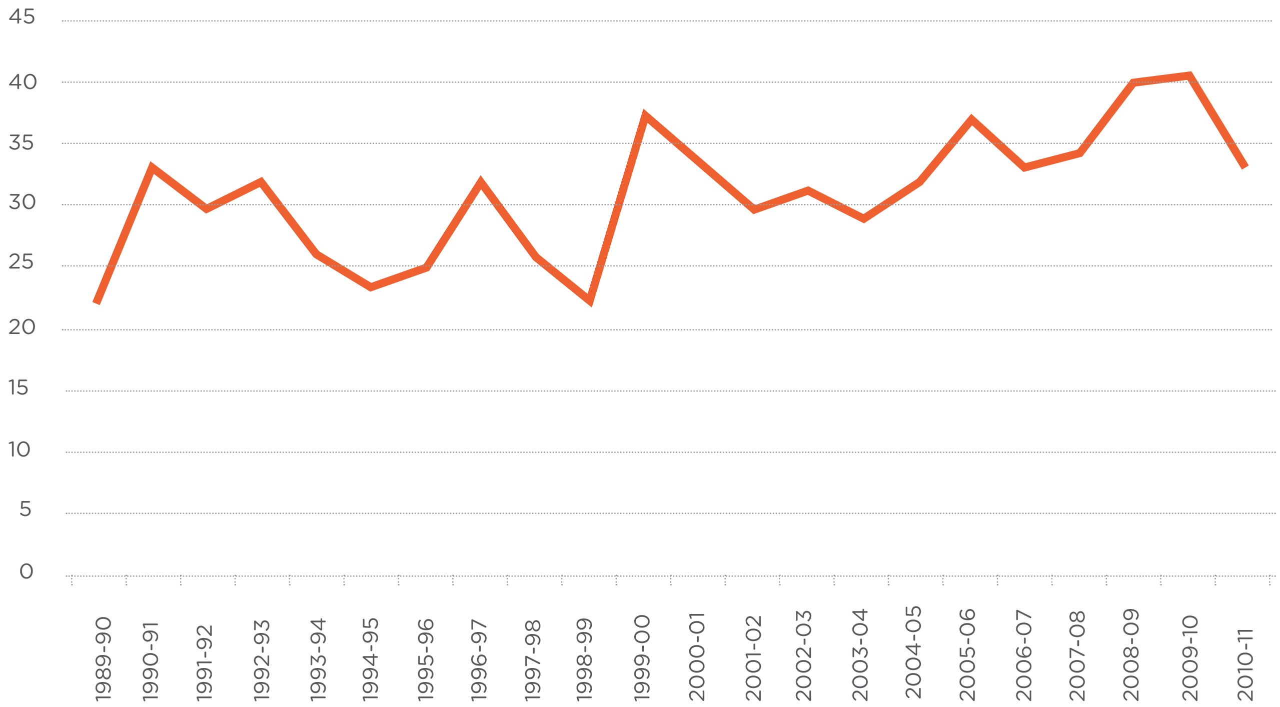
SOURCE: Author's own calculations

FIGURE 2: Trend of Prices per Tonne Oil Equivalent for Fossil Fuels Combined in India



SOURCE: Author's own calculations

FIGURE 2b: Percentage Share of Energy Import Bill in India's Total Exports



SOURCE: Author's own calculations

As a result, India's energy import bill as a share of GDP exceeded 7 percent in 2010-11 current prices. The share of the same in India's total export earningshas also been rising (Figure 2(b)).

This has become a source of concern for the macro-economic sustainability of India in view of a chronic trade deficit - particularly the sharp decline in the rate of growth of IT related service export earnings, down to 10% per annum, and the slowing down of foreign direct investment inflows in recent years. The promotion of growth of exports, including those of services, and attracting foreign investments are thus now critical for strengthening the macroeconomic fundamentals in the interest of sustainable growth of energy use for providing energy security in a high growth economy. It is in fact important that the direct foreign investments be guided through government policies to flow into the renewable energy industry. The issues of macroeconomic sustainability and policy considerations cannot be divorced from those of energy security and sustainability in a heavily energy importing country like India. The substitution of fossil fuels by renewables assumes a greater significance as it would reduce not only the measure of the ecological footprint, but also the pressure of energy imports on the balance of payments and on the currency.

POTENTIAL OF GREEN POWER IN INDIA

The potential of new renewables based power generation in India has been researched as a continuing project in various institutions at home and abroad. Without entering into their assumptions, we present in Table 1 the potential of power generation by the alternative resources of solar, wind and other new renewable energy technologies based on WISE 2014 and the Planning Commission reports. Table 2 on the other hand provides capital and generation costs of such new renewables based electrical power. Table 1 thus shows that only a miniscule share of the potential has yet been realized. However, one may raise the issue that if all the new renewable resources are environmentally sustainable then what kind of pressure it may create on the ecosystem, which we deliberate on in the following section.

TABLE 1: Potential of New Green / Renewable Power (GW)

TECHNOLOGIES	POTENTIAL GW	CAPACITY FACTOR	GENERATION BILL. KWH	CUMULATIVE CAPACITY GW March 2012
SPV	850	0.2	1489.2	1.58
SPV Pump & Panel Over Banks of Canal	322	0.2	564.14	
Wind Onshore	2006	0.25	4393.14	15.86
Wind Offshore	15	0.25	32.85	
Biomass	18	0.6	94.61	3.99
Congeneration from Bagasse	5	0.6	26.28	
Waste-to-energy	7	0.6	36.79	0.07
Other sources: Geo Thermal and Ocean	16	0.2	28.03	
Small Hydro <25 MW	15	0.2	26.28	2.96
Total New Renewables	3254		6691.32	24.49
Large Hydro >25 MW	150	0.2	262.8	38.99
Total Green Power	3404		6954.13	63.48

SOURCE: WISE 2014

TABLE 2: Cost of Power for Various Renewable Resources (March 2012)

	ESTIMATED INITIAL CAPITAL COST	ESTIMATED COST OF ELECTRICITY GENERATION
	(Rs Crore/MW)	(Rs/KWh)
Small Hydro	5.50 - 7.70	3.54 - 4.88
Wind Power	5.75	3.73 - 5.96
Biomass Power	4.0 - 4.45	5.12 - 5.83
Biogas Generation	4.2	4.61 - 5.73
Solar Power	10.00 - 13.00	10.39 - 12.46

SOURCE: CERC Regulation regarding tariff determination dated March 2012[3]

[3] *Solar power is the technology for which periodic updates are most likely to show differences, in this case, lower prices. The focus isn't on the exact numbers but the broad differentials between technologies.*

NATURAL RESOURCE REQUIREMENTS AND THE PRESSURE ON ECO-SYSTEMS

Land Use

All modes of power generation involve some use of land, which is a scarce and politically sensitive natural resource in India today. However, land requirement of coal thermal projects has been substantively greater than that of the new renewables based power generation technologies. The saving of land requirement by switching to renewables from coal thermal is an important environmental benefit from such fuel substitution. The land requirement would vary between 0.25 ha to 0.4 ha per MW of coal thermal power generation for the project site itself. Given the projected growth of capacity addition at 8% growth in per annum, the total future cumulative requirement of land for acquisition over the 20 year period 2012 to 2032 would thus be 112.6 thousand hectare, as worked out by WISE 2014. Such estimates do not include any share of land requirement for coal mining and transportation for supply of coal to the power plant. The renewable energy based generation has, on the other hand, much less land-use when we compare the total life cycle requirement for the different technologies. Besides, new renewable energy based generation of power causes no irreversible damage of land as in the case of mining, and land can be re-used after the life of the project in 25 years, with the same level of primary productivity, and land with wind turbines can actually find dual use to some extent.

Unlike coal thermal generation, abiotic resource based power generation- solar or wind have no environmental impacts like those of emissions, deforestation, damage to crops, grasslands or forests and no additional lands like coal-handling at ports, transport, townships etc. As renewable energy based generation, like wind or solar, is modular, it does not require contiguous pockets of land. Rooftop solar generation or solar pump sets would not require additional land. Even if we think of scaling up the solar or wind generation, we may focus on harvesting the resources of solar radiation or wind at a large scale for conversion into electricity in areas where they are more abundantly available. For example, environmental and social cost of solar power development in arid and semi-arid areas would be low where population pressure is low, and opportunity cost of land-use diversion is low due to low primary productivity of land in such areas. In case of wind one has to identify location, season and timing of the day with abundant wind flow – onshore as well as offshore - which may have low opportunity costs in terms of diversion of land-use, warranting scaling up of wind generation. It may also be noted that as modern IT permits the operation and maintenance of such renewable energy technology projects from distant locations, no additional land is required in any significant scale for housing and the attendant infrastructure. Besides, as renewable energy generation takes place in small dispersed units, there is no large scale requirement of acquisition of land involving diversion of its use and ownership causing a source of social tension.[4]

Impacts on Water, Forests and Pollution

Renewable energy based generation of power- particularly based on solar and wind- does not require any significant quantity of water as compared to the requirements of coal thermal. Wind power is water-neutral, while water is required for cleansing solar PV panels, but such a requirement is small except in desert areas where dust pollutes the panels.

While the coal-based thermal projects get delayed because of the constraint of forest clearance for the development of linked mines, there is no environmental impact on forests for solar or wind based generation. These projects can be located outside forests as these have no externalities of pollution, noise or thermal effects creating any damaging impacts on wild-life and habitats. In case any such projects are developed inside a forest, the adverse impact may be controlled by conditionalities of the grant of forest clearances. In the case of wind turbines, there would be some requirement of such clearances for transportation of large blades and heavy-duty cranes for the setting up or dismantling of the plant.

[4] *(WISE 2014) World Institute of Sustainable Energy (2014), Coal in India: Time for a Verdict, World Institute of Sustainable Energy, Pune.*

The counterpart requirements for setting up solar PV panels are minimal or negligible. The environmental impact of any large solar thermal electricity projects for power generation would also be of much smaller order as there would be no requirement of transportation of energy resources like coal or evacuation of wastes like fly ash, hot water etc. Besides, renewable energy based technologies can supply power to forest based commodities through micro-grids which would have no adverse impact on the forest eco-system.

Air Pollution

Finally the renewable energy based technologies have no environmental impact through air pollution in the cases of solar PV, solar thermal, wind or small hydro. In the case of biomass combustion or gasification based power generation, there would be some adverse impact on air quality. This can be controlled if there are non-overlapping areas of biomass supply. Besides, there are technologies like bio-methanation which have far lower particulate emissions as in the case of natural gas based power generation. Also, these compare favorably with fossil fuels because of their by and large carbon neutrality due to recycling of the carbon emitted.

One of the major environmental cum financial benefits of substitution of fossil fuels by new renewables is going to be in the form of substantive reduction in the requirements for transportation of fossil fuels

Saving Financial Costs as a Relative Advantage of RE Technologies vis-á-vis Coal

One of the major environmental cum financial benefits of substitution of fossil fuels by new renewables is going to be in the form of substantive reduction in the requirements for transportation of fossil fuels by railways and road transportation therefore, resulting in substantive savings of capital investment for the development of mines, railways, ports, etc. that would have been otherwise required. Besides, the secondary fuel requirement of oil for the current 116,000 MW of coal thermal power generation yielding 693 Billion units of electricity, requires an expenditure of Rs. 6,300 crores per annum only on oil at an assumed subsidy rate of diesel at Rs. 45 per litre, while the renewables do not require any such secondary fuel. The savings out of such costs of transport and oil are in fact important benefits of such substitution which are not recognized in the current methodological practice of cost benefit analysis. This becomes particularly important when the pricing of oil and railway tariffs contain substantive subsidy elements since the tariff of power based on such subsidized input prices would not reflect the true cost of the concerned technology.

HOW TO COMPARE THE TRUE RESOURCE COSTS OF TECHNOLOGY OPTIONS?

The correct methodology for the choice of technology among alternatives does in fact require the comparison of the true socio-economic costs of power generation, i.e., the one that does not contain any hidden subsidy and internalises all costs of environmental externalities over the life time of the projects which are substantive in the case of coal vis-á-vis any RE technology. It is in fact the stream of net differences between the true costs of coal thermal and any competing alternative RE technology which is to be considered as the stream of net savings of costs or net benefits arising from the technology substitution over the life of the project. The net present value of the stream of such cost savings at an assumed rate of discount (say 10% or 12%) is going to be the deciding criterion of merit ordering between the two. By all such binary merit comparisons we can finally arrive at the complete merit ordering of all RE options along with coal thermal technology, the latter being the dominant generation technology of power in India today.

Hidden Costs of Subsidy of Coal

The real challenge involved is the estimation of both the hidden subsidy in coal thermal power and in replacing technology, on the one hand, and the costs of environmental and social externalities of the different power generation technologies. The subsidies in a technology route may take the forms of underpricing of the fuel input, capital subsidy, tax waiver, or concessional tax rate on capital equipment, etc., by way of government interventions and regulations (eg., price control) in the fuel, finance capital or equipment market. As the range and forms of subsidy – direct and indirect – is quite large in India it is a difficult task to ascertain the hidden subsidies precisely. The World Institute of Sustainable Energy (WISE) at Pune made an attempt to calculate the hidden subsidy for 19 thermal power projects in India (WISE 2014) by comparing the cost of coal thermal power without any benefit of subsidy and the cost as it is.

For the current installed capacity of coal thermal power generation the estimated hidden subsidy is ~Rs. 561 billion per annum excluding subsidy to the railways for coal transportation

For the 19 power projects considered by WISE, the weighted average subsidy was estimated to be Rs. 0.68 per kWh of gross generation. For the current installed capacity of coal thermal power generation the total amount of hidden subsidy would work out to be Rs. 561 billion per annum or roughly US$10 billion per annum without taking any share of subsidy to the railways for coal transportation.

Costs of Environmental Externalities

The monetization of the cost of environmental externalities is however difficult because of the non-traded character of the concerned eco-services whose gain or loss is to be captured in such costs. In recent years some international studies like Extern–E [5] made some progress in this direction particularly in the context of power generation. Paul Epstein and his co-authors showed the methodology of working out the costs of environmental impact over the entire life cycle of coal from the stage of coal mining, extraction, transportation, washing and combustion for power generation, causing damages to the landscape, massive deforestation, degradation of air quality due to emissions of methane, NOx, SO2, PM2.5, CO2 and mercury and other carcinogenic emissions. Besides these, there was damage to the local hydrology due to the effluents containing sludge and drainage of other highly acidic wastes in the case of coal thermal power.

All these externalities identified as per Extern E methodology are then classified into three categories: (a) quantifiable and monetisable, (b) quantifiable but difficult to monetise, and (c) finally those which are qualitative. Different methods are employed for estimating these damage impacts of the different types. These impacts are further grouped into two groups: (i) impacts on climate and (ii) impacts on public health. The cost implications of these two types of impact, in value terms of loss of income or asset, are worked out which are finally internalised to obtain the true resource cost of coal thermal power generation. All the public health impacts due to mortality and morbidity are to be estimated using the mortality adjusted disability and disability adjusted statistical value of life.

Epstein and his colleagues[6] have found the estimate of the cost of environmental externalities of coal thermal power generation in 2008 US $ to be in the range of

---

[5] Bickel P and Friedrich R (eds). 2004. ExternE: Externalities of Energy-methodology 2005 update. Luxembourg: Office for Official Publications of the European Communities. 270 pp. http://ec.europa.eu/research/energy/pdf/kina_en.pdf p. 53.

[6] Epstein P R [and 11 others]. 2011. Full cost accounting for the life cycle of coal. Annals of the New York Academy of Sciences 1219: 73-98.

Rs. 9.36 / kWh to Rs. 26.89 / kWh. In the Indian context Shukla and Mohapatra (2008),[7] on the other hand, estimated such costs of externalities only due to air pollution and water pollution in coal thermal power generation over the life cycle of coal to be Rs. 3.15 per kWh, the components of air pollution and water pollution damage costs being Rs. 2.09 and Rs. 1.09 per unit of kWh respectively.

Although the results have varied across studies for a range of countries, there is broad agreement among the results of various studies with respect to the dominance of the cost of health which has been found to be the single largest element in the total cost of externalities. This has serious implications with respect to relative prioritisation of the issues of public health and climate change in the policy context.

Table 3 provides the estimate of true cost of coal thermal power along with its build up following the application of the methodological principle as discussed (see WISE 2014) and assuming a range of coal blend varying between all domestic coal and 90% imported coal in the blend. This is found to be between Rs. 8.79 to Rs. 19.09 per kWh. The component of cost of environmental externalities thus constitutes a major share of 50% to 66% of the economic resource cost of power generation (See Table 3).

TABLE 3: True Cost of Coal Thermal Power

	RANGE OF GENUINE COSTS OF COAL-BASED ELECTRICITY		
	Lower Limit	Upper Limit	Mean Value (unweighted average of min. & max.)
Share of Imported Coal (%)	0	90	
Variable Cost (Rs./kWh)	2.44	4.65	
Fixed Cost (Rs./kWh)	1.75	1.84	
Total estimated cost based tariff (Rs./kWh)	4.19	6.49	5.34
Variable Cost as % of Tariff	58.22	71.64	66.00
Hidden Cost of Subsidy on Sample observation of 19 power projects (Private ownership basis), discount rate 10%, (Rs./kWh)	Min. over sample	Max. over sample	
	0.59	0.73	0.66
Cost of externality (Rs./kWh)	5.71	16.40	11.06
Total true cost (Rs./kWh)	10.49	23.63	17.06

Assuming 1 US$ = Rs. 61 (wherever conversion was required to be used)

[7] *Shukla P R and Mahapatra D. (2008). Fuel life cycle for India. 10 pp. Costs Assessment for Sustainable Energy Markets, Deliverable No D 7.1, Project No 518294 SES6.*

A comparison of the true costs of coal with the CERC tariff of new renewables based power, which are based on social costs for new renewables as assessed by the regulator after correcting financial costs for the problems faced by the emerging technologies due to non-level playing fields and also netting out the benefits of their dynamic externalities, makes it clear that the new renewables based power technology should be the preferred social choice as it involves substantially lower socio – economic resource costs. The major reason behind this true cost competitiveness of renewables based power is the opportunity of saving substantive costs of externalities, if not also hidden subsidies of coal thermal generation that is offered by such substitution oftechnology and also those of coal transportation and secondary fuel costs. However, it is to be admitted here that we need to carry out more in-depth research on the estimation of socially unwarranted hidden subsidy costs and costs of environmental externalities.

We need to carry out more in-depth research on the estimation of socially unwarranted hidden subsidy costs and costs of environmental externalities

CONCLUSION

How soon can India's power industry become low carbon and the economy macro economically sustainable? The author in a separate study developed a projection model for electrical energy and CO2 emission to find out if it is feasible for the Indian economy to achieve the goal of raising the share of new renewables in power generation alternatively to 17.7% and at a higher accelerated rate to 30% by 2031-32., i.e., that of green power (i.e., including the share of large hydro) to 30% and/ or 43% of gross generation requirement for 8% GDP growth rate. The latter scenario of accelerated introduction will in fact permit India to attain a share of Green power of 75% by 2050. The summary results are given in Table 4 which assumes combining alternative growth of real price of energy with the GDP growth beyond the base of 2009 as well. A comparative reference to Table 1 for these results makes it clear that it should be possible for India to achieve such targets of a green power sector much faster than the business as usual trend, provided appropriate policies are in place for the implementation of such a big bang change. This will require on the one hand removal of the constraints on the development such as the lack of entrepreneurship in the deployment of such capital and technology, that of institutional support at the grass root level, poor focus on training and management for using and maintaining such new technologies and the lack of awareness of rural community regarding these new technologies which are small scale decentralized ones. Besides, substantive upscaling of R & D efforts is required on both the technologies of generation and transmission of both electricity and information through smart grid, introduction of renewable technology education and inventorisation and analysis of data on RE resources and environmental and social externalities for continued and better assessment of power technologies.

TABLE 4: Future Projections of CO2 Emissions (billion kWh) and Growth Rate (%)

	WITH 0% ANNUAL REAL ENERGY PRICE RISE			WITH 0% ANNUAL REAL ENERGY PRICE RISE		
	Baseline Share of New Renewables		Accelerated Use of New Renewables	Baseline Share of New Renewables		Accelerated Use of New Renewables
	Gross Generation Electricity (Billion kWh)	CO_2 (MT)	CO_2 (MT)	Gross Generation Electricity (Billion kWh)	CO_2 (MT)	CO_2 (MT)
2009	979.87	1,002.78	1,002.78	979.87	1,002.78	1,002.78
2031	2,577.99	1,650.88	1,284.68	2,057.70	1,317.70	1,025.41
CAGR*	4.50%	2.30%	1.13%	3.40%	1.25%	0.10%

*CAGR: Compound Annual Growth Rate of CO2 emissions

Acknowledgements: *The Author would like to thank the Director of the India Development Foundation, Gurgaon, for providing infrastructural support and Dr. Somit Dasgupta of the Planning Commission and the experts of the World Institute of Sustainable Energy (Pune) for helping with data and information. The Author also thanks Ms. Chetana Chaudhury (Ph.D student) and Ms. Moumita Deb (IDF) for their research assistance.*