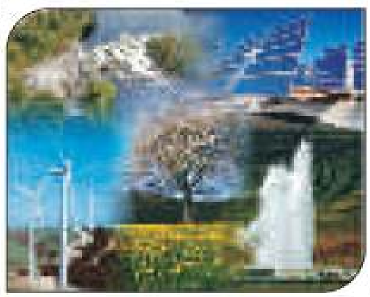
A RENEWABLE ENERGY GRAND PLAN FOR INDIA

G M Pillai

After a decade and a half of teething troubles, renewables seem poised for a breakthrough in India. It is possible that many of the recent positive policy measures have been born out of compulsion, and not conviction. Nevertheless, they are welcome. The second decade of the 21st century seems to augur well for renewable energy development in India. Despite the minimalism of the Electricity Act, 2003, it did pave the way for a change in approach to renewables at least in two areas: setting preferential tariffs for RE technologies and defining mandatory purchase of renewable power by utilities. The reluctant moves of the previous decade seem to be giving way to a host of proactive steps for RE development. Some of the major recent positive policy developments are: favourable provisions in the Electricity Act, 2003; declaration of feed in-tariffs; renewable purchase obligation; introduction of Renewable Energy Certificates (REC); scheduling norms for wind and solar power, generation based incentives for wind power; incentives for photovoltaic manufacturing; special incentives recommended by the Central Finance Commission for states performing well in grid-connected RE capacity addition; creation of the National Clean Energy Fund by levying a cess on coal; the target of 15% RE by 2020 announced in the National Action Plan on Climate Change (NAPCC); the launch of the National Solar Mission; many states recognising RE as a grid-connected option; and entry of major corporate groups into manufacturing of RE devices.



However, these steps are hardly enough. Further the diffidence and reluctance with which the most important of the above steps viz. National Solar Mission is being implemented is not encouraging. India needs an aggressive 'Grand Plan' to develop renewables as the future source of energy or to realise the vision of a hundred percent renewable future. To realise the Grand Plan objectives, many new policy, legislative and regulatory initiatives would be required; these would be dealt with towards the end of this article. The intention here is not to give the details of the Plan; that will require at least a year of hard work and a document with hundreds of pages. What is attempted here is to give the broad contours of such a Grand Plan.

Towards a 100% Renewable Energy System

Containing average global temperature increase at 2^{0}C would require 80% reduction in emissions by 2050. And the single biggest way to achieve such reduction is to create a zero-carbon energy system. At least one region in the world i.e. Europe is moving towards 100% renewable power by 2050. Europe already has over 200 GW of installed capacity of renewable electricity and this is expected to grow to 520 GW, 970 GW, and 2000 GW by 2020, 2030, and 2050 respectively. Almost half of this will be contributed by photovoltaics followed by wind, hydro and solar thermal power. This way by 2050, renewable electricity is expected to provide for 100% of EU's power demand. Many organisations like the European Renewable Energy Council, the Climate Group, Greenpeace, etc, have started working towards this aim and various action plans are being put forth by them. Knowing the dynamics of EU's policy making, one can safely assume that this movement will become EU's official policy soon.

In the United States also, such unofficial plans are being advocated. A significant document is the 'Solar Grand Plan' (Ken Zweibel et.al). The authors of the Grand Plan visualise that solar power plants will supply 69 percent of US electricity and 35 percent of its total energy by 2050. Most of the PV and CSP projects would be developed in south-west United States. Excess day time energy would be stored as compressed air in underground caverns, to be tapped during the night. Newly built HVDC transmission infrastructure would deliver solar electricity across the country. This would require only 46,000 square miles of land dotted with solar arrays, which is about 19 percent of the desert land in the south-west, mostly owned by government. However, the Grand Plan would require $420 billion in subsidies from 2011 to 2050 to fund the infrastructure and make it competitive. This is not a big sum, going by the amounts being spent on economic stimulus packages launched to ride out of the recession. Moreover, the solar infrastructure will displace 300 large coal-fired power plants and all the fossil fuel they would have consumed. The plan would also effectively eliminate all imported oil, thus cutting US trade deficits. The implementation of this plan will also result in reducing CO_2 emissions by 62 percent below 2005 levels by 2050.

A similar Grand Plan is possible for India because we also have large areas of desert in Rajasthan and Gujarat. Fifteen to twenty percent of these desert areas, judiciously planned and developed to generate power from a proper mix of PV and CSP plants, and connected to a HVDC transmission network, can deliver grid power to our cities and industrial areas across northern, western and central India. Most of this land is barren with no competing use value.

It has been demonstrated through various studies and projects across the world that a 100 percent renewable electricity system is technically feasible. University of Kassell in Germany did such a pilot project using a mix of firm and infirm sources of renewable power, storage, dispatch control, etc., to demonstrate that a full renewable power system is feasible. A recent book, '100% Renewable' edited by Peter Droege, illustrates the numerous theoretical studies and model simulations conducted to demonstrate that virtually all countries are capable of attaining a fully renewable electricity and wider energy supply system, using a range of technologies. Once the feasibility of a hundred percent renewable power system is established, the most natural question is whether such technologies are available now and whether it is possible to rapidly scale them up in the next four decades. But before discussing those game changing technologies, it is important to point out some technologies that may not work.

India needs an aggressive 'Grand Plan' to develop renewables as the future source of energy or to realise the vision of a hundred percent renewable future. To realise the 'Grand Plan' objectives, many new policy, legislative and regulatory initiatives would be required.

Some Technologies that may not Work

The Grand Plan articulated here is a realistic vision. So it has to exclude those technologies which are not likely to contribute significantly to future energy security. Phantasmagoric visions are being put forth by some enthusiasts about the possibilities of a future dominated by biofuels, nuclear energy and hydrogen. A technology-wise brief discussion is attempted to show as to why they would not be major contributors to a renewable future; though they may help in adding marginal capacities or developing niche markets and applications.

Biofuels: Biofuels can never replace gasoline because of the sheer volumes involved and the large area of land required to produce them. One example would suffice to prove this point. To meet the 20% blending target of biodiesel in India, we require 22 million tonnes of biodiesel by 2020. To produce that quantity (the jatropha route), we require 31.24 million hectares of land which is almost the same area as wheat sown in India! Even though the biofuel policy talks about utilising wastelands, only about 20 million hectares (out of total 60 million hectares) of wastelands are cultivable. Even these 'cultivable' wastelands do not give enough production to make the investment viable, and these lands have competing demands. The second-generation cellulosic conversion technologies are not yet commercially proven and even they require land to produce biomass. Other RE technologies like wind and solar also compete for land and land is finite. It can be said with some certainty that there is no possibility of biomass production in India meeting more than quite a small proportion of our liquid and gas fuel demand. A future transportation strategy will perforce have to be based on electro-mobility.

Nuclear Energy: Scientific studies have proven that there is far too little Uranium at a sufficient grade to sustain a nuclear era for more than a few years. Thorium could be a substitute in India; but it is far from commercialisation. Breeder reactors pose numerous problems of safety. Construction of nuclear reactors take six to ten years to complete. If all indirect subsidies are considered, nuclear power is extremely expensive. Recent studies from New Orleans in USA report that solar power is already cheaper than nuclear power. The pollution caused by mining (produces one-third of CO_2 emitted by a coal plant), the issue of radioactive waste storage and the possibility of accidents, etc., make nuclear power unsustainable. Even the greatest advocates of nuclear power in India claim only moderate capacity additions in the next two to three decades.

Hydrogen: The first thing to remember is that hydrogen is just a carrier of energy and can only store it; it is not a fuel. Secondly, hydrogen production is a very energy intensive process. Producing hydrogen, storing and transporting it involves formidable difficulties, energy losses, infrastructure requirements and costs. The 'energy return on investment' (EROI) is very adverse. Many of the materials required as catalysts, etc., are rare metals and their large-scale availability is suspect. In addition, commercialisation of a hydrogen energy system is far away. Therefore it seems quite unlikely that we will ever have a large-scale 'hydrogen economy'.

The Game Changing Technologies

Two major RE technologies viz. wind and solar power would be the major contributors to this transition.

Wind Power: The global installed capacity of wind power is now 158 GW. As per GWEC estimates, this will grow to 1000 GW by 2020 and 2400 GW by 2030. Even though the official estimate of wind power potential in India is 49.1 GW, the real potential is above 100 GW. The total installed capacity at the end of September 2010 was 12.8 GW. In the current financial year till March 2011, the Indian market is likely to cross 2100 MW out of which 1000 MW is already on the ground by September 2010. The southern and western states have the maximum potential to produce wind electricity. India is also emerging as a major manufacturing hub for manufacturing of wind turbines. As of now, 17 manufacturers have a consolidated annual production capacity of 7,500 MW. The list continues to grow. As per WISE estimates, the annual wind turbine manufacturing capacity is likely to cross 17,000 MW by 2012–13, if the manufacturers go ahead as per their plans. So wind power is poised to be a major player in the energy market in India.

Solar Photovoltaics: Despite the recession, solar power performed well in 2009, as did other RE technologies. An estimated 7300 MW of new solar photovoltaic power capacity was installed globally in 2009, which is 20% more than that added in 2008. At the end of 2009, global installed photovoltaic capacity surpassed 21,000 MW. Analysts say that PV installation will grow by 64% in 2010 crossing 10,000 MW of annual installation. The global installed PV cell manufacturing capacity is now 10,660 MW. In the recent past, photovoltaic module prices crashed, which is good news for investors and renewable energy enthusiasts. Between the third quarter of 2008 and the end of 2009, module prices came down by 50%. From $2.45 per watt in early 2009, module prices dropped to just $1.60 per watt later that year. The trend of decreasing prices is likely to continue in 2010, although at a slower rate. It is predicted that crystalline module prices will fall by 20%; wafer prices will decline by 18.2%; and polysilicon prices by 56.3% (Henning 2010). Grid-connected solar power is new in India. At present, India has only around 15 MW of installed grid-connected PV capacity. But the National Solar Mission has set a target of 20,000 MW grid-connected solar power by 2020, half of which will come from solar PV.

Concentrated Photovoltaics: This is the latest entrant into the RE technology sector. The first megawatt scale installation (2006–09) was done at Puertallano in Spain where a 3 MW CPV based project was undertaken by different companies, mainly for research purposes. The global cumulative installed capacity at the end of 2009 was around 30 MW. Being a new technology, CPV faced many teething troubles. However, the situation seems to be changing. In August 2010, US power company Xcel inked a deal with Cogentrix to buy power from a 30 MW CPV power plant expected to go online in 2012 at Alamosa in Southern Colorado. Another CPV module supplier Solaria has announced a five-year global supply deal with enXco, which is building a 3 MW plant in Spain. Market predictions until 2014 estimate annual growth rates between 35 and 40 percent. Many companies the world over are currently working on developing CPV products. Even though India has one CPV company based in Pune, installation of commercial-scale projects is yet to happen. Because of its high efficiency (30 percent and above), this technology offers huge hope for the future.

Concentrated Thermal Power: Latest reports available as of May 2010 say that the current installed operational capacity of large-scale pilot or commercial CSP plants is 822 MW. About 94% of this relies on parabolic trough technology, while power towers account for 5%, Compact Linear Fresnel Reflectors (CLFR) systems only 1.1%, and dish concentrator with stirling engines less than 1%. About 919 MW of CSP plants are now under construction, in which the shares of different CSP technologies are similar. Approximately 12,500 MW of CSP projects are scheduled to break ground between 2010 and 2013. When this pipeline of CSP projects are developed, the share of parabolic trough will fall to half, while that of power tower and stirling dish projects will rise to about 30% and 18% respectively.

Recent projections by the IEA suggest that global CSP capacity will reach 1089 GW by 2050, with capacity factors reaching a high of 50% (4770 hours per year). Such a high capacity factor is expected through extensive storage and large solar fields. By 2050, CSP will represent approximately 11% of global electricity production. North America (especially south-western United States) would produce maximum electricity from CSP, followed by Africa, India, and the Middle East. Middle East and North America might export their surplus CSP power to Europe through a submarine HVDC network. A plan called DESERTEC has already been prepared for this by the reputable German institute DLR. According to the IEA, India will produce close to 680 TWh of electricity from CSP sources by 2050, and cities near the deserts in Gujarat and Rajasthan will be big beneficiaries of this CSP boom.

The Grand Plan

Any plan of this nature should be based on ground realities. The first question that will come to the mind of anybody reading this is whether renewables can provide enough power to sustain our economy.

The Potential of Grid-connected Renewables: Table 1 shows the breakdown by source of the real potential of grid-connected renewables in India as estimated by WISE. The total potential of 6.62 lakh megawatts in India is a conservative estimate that ignores technological advances, the potential of solar installations in wastelands in states other than Rajasthan and Gujarat, and the huge potential for rooftop applications. Even with this conservative estimate, it is possible to install close to seven lakh megawatts of grid-connected renewable power projects in India. With the low plant load factor of some technologies, that capacity can generate about 2100 billion units of electricity, which is almost three times our current consumption.

A Renewable Energy Grand Plan for India would necessarily require the deployment of a basket of technologies even including large hydro, as

Table 1: Potential of Grid-connected Renewables in India (Estimated by WISE)

Source	Capacity (MW)	Assumed PLF (%)	Annual Generation (billion kWh)
Wind	1,00,000	25	219.0
Small Hydro	15,000	45	46.0
Bagasse	5000	60	26.3
Biomass	16,881	60	88.72
Large Hydro (existing & future)	1,00,000	60	525.6
Large Hydro in Bhutan	16,000	60	84.1
Waste-to-Energy	5000	60	26.28
*Solar CSP based Power Generation	2,00,000	35	613.2
Solar PV/CPV based power generation	2,00,000	20	350.4
Geothermal	10,000	80	70.1
Total	**6,62,881**		**2049.70**

* Only 10% of the desert area considered

Note: Resource potential of other sources including offshore wind, wave, tidal, biogas is not considered

shown in Table 1. Just that large hydro projects will have to be developed to 'human-scale' and 'eco-scale'. Their impact on the environment or humans and wildlife habitations should be minimal. We should not take up large hydro projects which are not environmentally and socially sustainable. Renewable fuels like wind and solar are infirm in nature and hence a mix of firm and infirm power would be necessary for grid stability. Solar or wind power can also be made 'firm' or despatchable using storage technologies. More about them later. Besides this, substantial loads can be taken off the grid by constructing self-powered buildings that use a mix of different versions of photovoltaic technology, solar thermal systems, biodiesel-based on-site generation, fuel cells, and hybrid systems. In addition, energy conservation offers a rich potential to reduce energy consumption.

Off-grid Generation: One major factor significant to a renewable power system is that the obsession with grid and centralised power generation will have to go. On-site and decentralised generation of power would be essential and is possible using wind/solar systems, fuel cells and hybrid technologies. They can spawn independent power systems for domestic and commercial buildings. The benefits from such on-site generation are: risk reduction through increased system resilience, avoided transmission and distribution grid investment, highly reduced gestation periods, economies of scale in production of smaller, modular generation units such as combined-cycle gas turbines, wind turbines, photovoltaic panels and fuel cells. The internationally acclaimed energy expert Amory Lovins makes the following prediction: "The central power plant, like much bulk electric transmission, will soon become a white elephant, uneconomic to run, and difficult to sell. Such plants are unlikely to survive in significant numbers by 2030 in any market economy. Unpleasant vulnerabilities built into the architecture of brittle highly centralised systems could accelerate this trend toward smaller and more localised electricity generation." Lakhs of megawatts of electrical load would thus be taken away from the grid.

The national and regional grids would increasingly cater to the cities and industry. In such a scenario of a completely different architecture of the power system, extrapolated calculations of unlimited requirement of grid power would become obsolete. In a post-oil, post-virgin material world or recycled economy, development will move more and more to a steady-state economy. Cancerous growth will be a thing of the past. Hence, even a 700 GW capacity grid comprising a mix of renewable technologies will be sufficient to provide us with the energy needed to pursue civilised existence. The era of energy profligacy will have to end. The Renewable Energy Grand Plan would essentially complement a sustainable economy.

The Role of Solar Energy: As was evident from Table 1, solar energy would play the most significant role in a hundred percent renewable energy economy. Since India has more than 2,00,000 square kilometers of desert land in the states of Rajasthan and Gujarat, it is eminently possible for us to develop large number of projects using CSP technologies with storage. Much of this land is uninhabited and owned by the government which makes the task even easier. Certain other parts of India like eastern Tamil Nadu are also suitable for CSP project development. Even if 20 percent of such land in India is developed for solar thermal power generation, we can generate much more than the 200 GW shown in Table 1. The land required for each megawatt of solar energy produced in these regions would be less than that needed for same capacity of coal based power, if we factor-in the land required for coal mining also.

Wind Power: Wind power is the other major game-changing technology. Most wind power would be generated in south, west and north-west India. The southern and western wind generation can be absorbed in the local grids. Whereas wind generation in Gujarat and Rajasthan along with massive solar power generated in these states will have to be made despatchable to the load centres using storage, forecasting and smart grids.

Storage of Electricity: Numerous options for storing renewable electricity are now emerging, besides conventional battery storage. Some of them like pumped storage, compressed air storage, molten salt storage have been demonstrated on commercial scale. Compressed air storage can be used for wind and photovoltaic power also; whereas technologies like molten salt where energy is stored as heat are good for CSP projects. Other storage techniques using fly wheels, hard rock storage, hydrides, etc., are also being attempted. Interesting possibilities under study such as capacitors and advanced batteries are yet to be commercialised. In any case they cannot rival thermo-chemical storage or compressed air storage for very large-scale use. Suffice to say that storage of renewable electricity would be an essential strategy that would be required and deployed in the future. That would be critical to realising the vision of a Renewable Energy Grand Plan.

HVDC Lines and Smart Grids: Most of India's grid-connected CSP generation would be in north-western India i.e. in Rajasthan and Gujarat. The existing system of alternating-current power lines won't be able to carry this DC power to load centres in northern and western India. Hence it would be essential to build a high-voltage direct current (HVDC) power transmission network. HVDC line losses are much lower than AC lines, they are cheaper to build and require less land area than equivalent AC lines. The HVDC network would radiate from north-west to load centres in the north, north-west and western India. The lines would terminate at converter stations where the power would be switched to AC and sent along existing regional transmission lines that supply customers.

A smart-grid is an 'umbrella' terminology covering modernisation of both transmission and distribution networks. It is a marriage of electrical, communication and information technologies to create a modern grid for achieving a set of disparate goals. Predominant of such goals are energy conservation and providing for absorption of infirm power. In short, a smart grid implies adding the capabilities of monitoring, analysing, controlling and communicating to the national electricity delivery system in order to optimise usage of the system while reducing energy consumption. The implementation of the Grand Plan would require establishing a smart grid network, with HVDC lines wherever required.

Three–Phase Implementation: The Grand Plan can be implemented in three phases lasting up to 2050.

Phase I (2010–20): The NAPCC has set a target of 15% renewable power by 2020. Computation by WISE shows that additional RE capacity (over and above existing installed capacity) of around 90,000 MW will have to be installed by 2020 to generate 15% RE power (247 billion units which is 15% of the projected consumption of 1643 billion units by 2020). This is much more than the planned capacity under the 11th, 12th and 13th Five-Year Plans and the National Solar Mission. The restrictive policies pursued under the JNNSM is hardly conducive to such large-scale capacity addition. Much of the new 90,000 MW capacity will have to come from wind and solar power. Since solar is still limping, the focus in this first phase will have to be in scaling up wind power. As predicted by GWEC, in an advanced scenario, it could grow to 65 GW by 2020. This would require many urgent measures which would be dealt with later. Meanwhile, 'human-scale' hydropower development will have to continue to create a grid capable of absorbing large quantities of renewable power. Renewable power installed capacity in India would cross 100 GW by 2020 providing 247 billion kWh of electricity.

Successful implementation of Phase I would require support from the government, in the form of generation-based incentives and infrastructural development for wind and solar power. The recently constituted National Clean Energy Fund should be utilised to support these game changing technologies to enable them to achieve grid parity and be fully commercialised by 2020.

Phase II (2020–30): During the decade 2010–20, solar energy would have gone through a severe learning phase and numerous pilot projects covering various technologies would have been established. Solar would have achieved grid parity by 2020. Fossil fuel prices would have escalated to edge out fossil fuel-based generation from the market. Coal availability would become increasingly scarce. Wind power would have utilised much of the best wind sites in India. So this second phase would be the time to unleash the power of solar energy across India, by rapid scaling up. Wind power will continue to open up green-field sites and go for repowering of old sites with higher capacity turbines. Other RE technologies will also be deployed suitably. The state governments would, by then, have recognised the importance of renewables for energy security. A firm policy and regulatory framework would have been established in most of the states. The real mainstreaming of renewables would happen during this decade. If GWEC projections are accepted, wind power installed capacity in India could grow to 160 GW by 2030. Grid-connected solar PV could grow from 10 GW in 2020 to 68 GW in 2030 (EPIA advanced scenario), and CSP could increase from 10 GW in 2020 to 30 GW in 2030 (IEA projections). The total installed capacity of grid-connected RE in India could cross 250 GW by 2030.

Phase III (2030–50): This is the phase when renewables will begin to be recognised as the main source of power generation in the country. The global 'spike' in fossil fuels—both in terms of availability and prices would have happened. Tremendous leapfrogging of RE technology in all areas – efficiency, storage, cost-reduction, etc., would have occurred. Renewable power will be installed in ever larger quantities and the journey to a 100 percent RE power system by 2050 would have begun. Any attempt to quantify the annual additions at this stage is not relevant. Maximum addition of renewable capacity would be done. The installed capacity of 700 GW producing over 2100 billion kWh can be achieved by 2050.

Substitution of coal and nuclear power with renewables can also avoid the huge environmental destruction caused by mining in the form of deforestation, land degradation, pollution of water bodies, etc. Implementation of a Renewable Energy Grand Plan will bring all-round benefits in the social, economic, and environmental spheres.

Revamping the Policy and Legal Framework

Removing Policy Contradictions: With the new developments, the Integrated Energy Policy (IEP) has become obsolete. The two main assumptions made by the policy, namely that (a) renewables may account for only 5% to 6% of India's energy mix by 2031–32, and (b) renewables would be critical to India's energy independence only beyond 2050, have been repudiated by the recent policy measures. The IEP also makes an unvalidated presumption that "coal shall remain India's most important energy source until 2031–32 and possibly beyond." This undue optimism about availability of fossil fuels goes hand in hand with the refusal to acknowledge latest technological developments, technology leapfrogging, and projections of reduced costs of renewables. The IEP also directly conflicts with the NAPCC which stipulates a dynamic minimum target of 5% of the total grid purchase from renewables in 2009–10 and increasing 1% each year for 10 years, to reach 15% by 2020. Since both documents have been approved by the cabinet, it is necessary to overhaul the IEP to bring it in tune with the latest policy of the government as enunciated in the NAPCC and the JNNSM, or to scrap it altogether.

Rationalising Fiscal and Financial Incentives: During the past four decades of serious environmental discourse and the development of environmental economics, it has been recognised that shifting of taxes and incentives to promote environmentally benign activities is essential for engineering change. Some examples of such taxes are a tax on coal or other fossil fuels that incorporates the increased costs of health care associated with mining coal and breathing polluted air and the massive cost of mitigating the massive adverse impacts of climate change, a cess on electricity produced from polluting sources, a tax to cover damages from acid rain, and congestion taxes in cities.

Shifting the Subsidies: As in the case of tax, there is also a case for shifting subsidies. In a world facing the threat of climate catastrophe, subsidies to expand the burning of coal and oil can be no longer justified. Shifting these subsidies to the development of such climate-benign energy sources as wind, the sun, biomass, and geothermal power will help stabilise the earth's climate. Shifting subsidies from road construction to rail construction could increase mobility in many situations while reducing carbon emissions.

Legal Empowerment: The JNNSM document, while elaborating on the policy and regulatory framework, says: "Although in the long run, the mission would seek to establish a sector-specific legal and regulatory framework for the development of solar power, in the shorter time frame it would be necessary to embed the activities of the mission within the existing framework of the Electricity Act, 2003. The Electricity Act provides a role for renewables but given the magnitude and importance of the activities under the mission, it would be necessary to make specific amendments." Legal empowerment of the activities of and targets for the RE sector would go a long way in helping to achieve the NAPCC targets. The experience of China after it enacted the RE law is noteworthy. It is high time that India enacted a renewable energy law.

Regulation: Overhauling the Cost-plus Methodology

The cost-plus methodology adopted by Indian electricity regulators is a progressive and forward-looking method of determining tariffs. However, it is time to overhaul this methodology by considering the following additional factors viz. the cost of externalities of conventional power generation, multiple cost curves, and risk-adjusted pricing of conventional fuels.

Externalities of Conventional Power Generation: Conventional power continues to enjoy various hidden subsidies. The cost of environmental, social, and health externalities caused by these hidden subsidies is not factored into the price of conventional power. The findings of a University of Bath study indicate that the health costs alone work out to Rs.3/kWh. A comprehensive study on environmental, social, and health externalities needs to be undertaken in India and the quantified results of such a study should be factored into the price of conventional power.

Multiple Cost Curves: It should also be recognised that when nascent renewable technologies are compared with entrenched conventional technologies, multiple futuristic cost curves come into play. First and foremost, the historical escalation in the cost of conventional power due to the variable cost of fuel should be considered. This cost escalation curve will only accelerate in future as the reserves of fossil fuels are depleted. The other cost curve of great significance is the technology and efficiency curve across renewables, which will help reduce their costs in future. Conventional power sources do not have any such advantage. Besides multiple cost curves, there is also the 'experience learning curve'. When new RE technologies are commercially developed, they go through an initial pilot learning phase. Thereafter they mature commercially. This needs to be factored-in.

Risk-adjusted Pricing: Scientific assessments have shown that coal production will peak in India by 2015 and globally between 2020 and 2025. Thereafter price and availability could become a problem. In fact even today, if the approving authority and the regulators insist that project developers guarantee the supply of fuel for the 30 years of project life, many of the coal-based ultra-mega power projects (UMPP) would not qualify for approval. Electricity regulators need to consider risk differentials of technologies resulting from risks inherent in the supply and prices of fossil fuels. Today fossil fuels invariably provide a high-risk cost stream. Like oil, coal prices have also moved into the volatile realm as supply pressures mount, carbon taxes or cess are imposed, and global demand peaks. Therefore the cost of electricity is better understood only in terms of the risk differentials of different technologies.

Rapid Scaling-up is Possible

The kind of pessimism about renewables found in India's Integrated Energy Policy stems from a belief that a long gestation period would be required for large-scale penetration of renewable power. To counter this misplaced belief, it is best to quote the late Hermann Scheer: "The thesis that there is an enormously long time requirement for introducing new kinds of energy is a misapprehension that energy experts derived from the history of conventional energy systems. This experience is based not so much on the long construction time required for large power plants, as it is on the even more time-consuming process of completing the wide ranging transportation and distribution structure needed to supply conventional energy. With few exceptions, this is precisely what renewable energy renders technologically unnecessary and economically meaningless. The fundamental technological-economical assumption behind the excessive time requirement, therefore, is also untenable." (*Energy Autonomy*, Hermann Scheer).

Solar and wind power plants are modular and can be erected in a matter of few day or months, depending on the size of the project. Experience of wind power in India has proven that when it comes to adding new capacity, decentralised energy has a clear time advantage. From 2000 to 2010 the state of Maharashtra added 2078 MW of wind power, during which period no significant conventional power capacity was added in the state sector. Given the right policy, regulatory and financial environment, solar power can excel the experience of wind power in quick modular addition of grid-connected power capacity. Says Hermann Scheer: "The real time problem for renewable energy is truly neither technological nor economic, but rather political and mental; the political problem takes the form of countless arbitrary administrative hurdles, and the mental problem lies in the need for change in attitude." Rapid deployment of renewables offers a developing country like India the chance to transgress from the unsustainable western model of development handed down to us as a colonial legacy and move directly into a sustainable and energy secure economy by 2050.

The Social, Economic, and Environmental Benefits

A sustainable energy economy offers not just ecological benefits, but social and economic benefits too. This is in direct contravention to the huge social, economic and environmental externalities created by conventional power projects. The foremost benefit of deployment of RE technologies is employment generation. The renewable energy industry offers a variety of highly skilled and semi-skilled jobs and the sector is highly employment intensive. In India, if we sincerely implement the 15% RE target set by NAPCC, we would have to add 90,000 MW of additional renewable power up to 2020. At an average of 20 jobs per MW (both direct and indirect) addition of 90,000 MW of renewable capacity can create 1.8 million jobs. Energy security and autonomy would be the major economic benefit due to freedom from fossil fuels. Import dependency exposes us to major price risks since fossil fuels are globally traded commodities. It also makes us vulnerable to any disruption in supply. These risks are real, judging from events from the recent past. The biggest advantage of renewables is that there is no risk of fuel price volatility since the fuel source is a freely available natural resource. If by 2020, we have to produce 15 percent of our electricity requirements from renewables, we will have to generate 246 billion units of electricity (15% of 1643 billion units in 2020, as per CEA projections). This would facilitate avoidance of approximately 24.6 million tonnes of CO_2 emissions per year. Substitution of coal and nuclear power with renewables can also avoid the huge environmental destruction caused by mining in the form of deforestation, land degradation, pollution of water bodies, etc. Implementation of a Renewable Energy Grand Plan will bring all-round benefits in the social, economic, and environmental spheres. A sustainable future is not one of the choices facing us, but it is our only choice to ensure sustainable modernity.