ENERGY FOR THE FUTURE: INNOVATE OR PERISH

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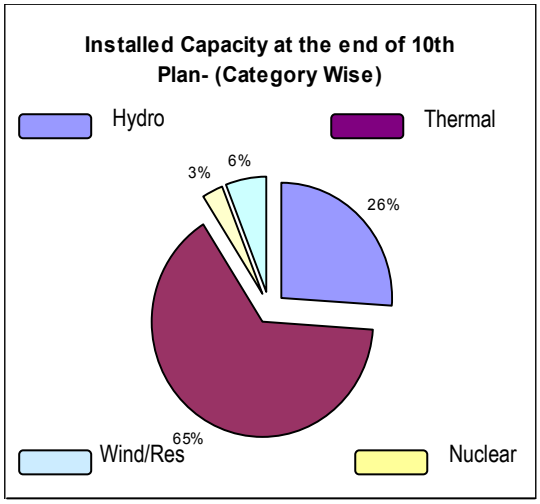
India has the natural resources to build an energy system based on clean energy technologies. What is needed is the will to undertake war-time mobilization to create a low-carbon energy economy and achieve energy autonomy.



India has made rapid economic progress in the last decade. Our current GDP is U.S.$1103 billion, making India the twelfth largest economy in the world. With 9.4% growth in GDP in 2006/07, the Indian economy is one of the fastest growing economies in the world. Energy is the basic engine of economic growth. Growth of electricity generation in India has been phenomenal. From a miniscule 1360 MW in 1947, installed capacity for electricity generation grew to 1,32,330 MW at the end of the tenth Five Year Plan i.e. by 31st March 2007. Out of this, 65% is thermal, 26% hydro, 6% renewable power and 3% nuclear. With accelerated economic growth and increasing population, we are facing serious peaking capacity shortage. Capacity addition is also falling short with achievement in the 10th Plan being only 50% of the target. The inability to achieve targets is not just a case of laggard implementation or red-tapism. There are real and serious resource constraints too.

THE CONVENTIONAL ENERGY ECONOMY IN DECLINE

Worldwide, there is a major transition underway in the energy sector. It is happening due to the following three major reasons:

i) A decline in fossil fuel availability, their predicted gradual extinction in the next few decades and the resultant price volatility due to demand-supply gap.

ii) The need to drastically cut global emissions for mitigating climate change.

iii) The need for energy autonomy.

A fuel-source wise analysis of the conventional sector would clarify the situation.

Oil: Energy security is conventionally understood in terms of the risks of fuel supply disruption and fuel price volatility. Crude oil prices have reached $120 per barrel mark in the recent past, causing alarm among policy makers, fear in the minds of consumers and uncertainty everywhere. In the past two years, oil prices have almost trebled. Unlike the oil crises of the 1970s and 1980s which were politically created, the current price increases are fuelled by supply not matching demand. Despite new finds, the fact remains that 70% of the world's daily supply comes from oil fields that have been drilled for 30 years or more. A very significant study by oil geologists Colin J. Campbell and Jean H. Laherrere clearly indicate that oil production would peak by 2010 and permanent decline in global production will begin then. It is predicted by experts that if only

India and China continue to grow at current rates, the demand for oil will rise by 6% per year. To meet this demand, world output will have to increase by 43% by 2010, which may not be easy to achieve. Prices might then reach the $200 per barrel level. With over 75% of our oil being imported the impact on our import bill and balance of payment will be very serious. Our domestic proven oil reserves at the end of 2006 was 5700 million barrels (0.5% of world reserves) and the production is 294.36 million barrels per year. The reserves/production ratio is of 19 years only! As per Government of India (GoI) projections, by 2031–2032, India will have to import about 3 billion barrels per year. Because of the earlier mentioned peaking of oil production around 2010, this quantity of oil may not be available for import. Assuming availability at the price of $100 a barrel, the import bill will be $300 billion or Rs.13,20,000 crore (@ Rs. 44 = $1). If the oil price shoots up to $200 a barrel, then our import bill will be $600 billion or Rs. 26,40,000 crores!

Coal: Coal has a similar story, but may be available for a longer period of time. India produces above 60% of its electricity from coal-based thermal power projects. India has extractable reserves of 52.24 billion tones of coal. Annual production now is 407 million tonnes and the rate of growth of production is going to be very big. The Integrated Energy Policy prepared by the Planning Commission, Govt. of India, predicts complete depletion in 40 years. The key factor is not depletion but peaking of production which is expected by 2015 in India. A recent study (Energy Watch Group, Germany) predicts global peaking of production of coal by 2025. As per Govt. of India (GoI) figures, we will have to import 609 million tonnes of coal by 2031. At $60 / tonne (the price is already above $100 per tonne), the import bill will work out to $36.54 billion or Rs.1,60,776 crore! Even if we have the money, coal may not be available for import in adequate quantities considering the fact that we are creating huge additional coal based power generation and coal liquefaction capacities.

Natural Gas: The known reserves of natural gas in India is now around 1.08 trillion cubic metres only i.e. 0.6% of world reserves. Our annual production and consumption (including flaring) in 2002–2003 was 31 billion cubic metres. This will increase substantially in the next few years. The Reserves / production ratio for our domestic natural gas is 33 years. Import of liquefied natural gas has become prohibitively costly (upto $12/mmbtu) and we are unable to get any long-term contracts. Even world natural gas production will peak in the next 15 to 20 years.

Nuclear Power: Prof S P Sukhatme, former Chairman, Atomic Energy Regulatory Board once observed that our uranium reserves (50,000 tonnes of proven recoverable reserves for power production) would be adequate only for meeting the requirements of 10,000 MW of nuclear power capacity for about 30 years. As of now, we have about 4120 MW installed capacity of nuclear power. The Nuclear Power Corporation of India plans to add 4660 MWe during the eleventh plan i.e. by 2012. The 'Vision 2020' for nuclear power envisages addition of 20,000 MWe by the year 2020. New uranium mining sites in the north-east are facing stiff resistance from local people. It is true that India has vast reserves of thorium, but thorium-based reactors are yet to be installed and not yet proven. Also, due to the problems of nuclear waste disposal, and with the threat of Chernobyl type accidents looming large, nuclear power is not a preferred option in the world. Countries like Germany plan to decommission all their nuclear plants by 2025 and replace them with wind turbines.

Hydro Power: Theoretically speaking, India has a huge hydro power potential estimated at 1,50,000 MW, of which only about 33,000 MW has been channelised so far. But hydro projects are facing serious resistance from environmentalists and have displaced people all over the country. With environmental destruction, the run-off in rivers is decreasing year-by-year. It is true that our neighbouring countries like Bhutan and Nepal have enough surplus, unharnessed hydro potential and they can sell this power to us, once harnessed. In a post fossil-fuel era, hydro

power is extremely important for base-load management. Just that hydro power projects have to be planned and executed in human-friendly and nature-friendly mode. It will then compliment renewables in the grid system.

Imagine this: By 2031–2032, our annual import bill for only oil and coal together even at current prices will be Rs.14,80,776 crore or $350 billion! Our current foreign exchange reserves is only $225 billion and we already have a trade deficit of $5.68 billion. Our current annual budget of the GoI (Plan & Non-Plan together) is only about Rs.6,40,521 crore! In a post-oil future, consumer goods manufacturing will shrink substantially and will erode government revenues (of which sales tax and excise form the major sources) significantly. So, from where will we get $350 billion every year for import of only coal and oil? India faces a peculiar predicament of depleting internal resources, shrinking import capability and galloping prices of imported fuels. Along with this, the looming threat of serious climate change would caution us on pushing too much ahead with a coal-based electricity generation strategy. We are really at cross roads, as far as the future of our energy system is concerned. Innovative thinking and bold measures for a transition to a low-carbon energy system is extremely imperative for energy security, energy autonomy and to mitigate climate change.

Renewables offer a direct means of dealing with these concerns: they are foreign exchange neutral, they are dependent on our own natural resources, they will never become extinct. India's future energy planning will necessarily have to strive for energy autonomy and will have to include future damages costs to life and the economy from Climate Change and the likelihood of national emissions cap in the future. Presently planned conventional energy plants create technological lock-in for 30-40 years. With renewables set to become cheaper than conventional energy in the coming years, flexibility to change is greatly reduced. Renewables are already cheaper than conventional energy in some cases and areas and more so once all social and environmental externalities of conventional energy are accounted for. The issues relating to their integration, high initial costs and investments required can easily be tackled through innovative legislative, policy, and financial mechanisms, as discussed subsequently in this article.

RENEWABLE POWER: STATUS AND POTENTIAL

Table 1 gives the Ministry of New and Renewable Energy's assessment of the potential of different grid connected RE technologies and achievements as on date. Renewables offer a basket of technologies for various applications like grid connected power, off-grid application of lighting, pumping, thermal energy or heat generation, and transportation. In addition to an estimated 133 GW grid-connected potential, 50 GW potential exists for distributed power generation through biomass and energy recovery application, bringing the total present assessed potential to 185 GW. This may further increase by few hundreds of GW in case we consider marine renewable energy technologies like offshore wind, ocean thermal energy, tidal energy potential and land-based geothermal energy sources, for which full scale scientific assessment has not been carried out as yet.

Table 1: Grid Connected Renewable Potential and Achievement in India (As per MNRE, GoI)

Source / Systems	Approx Potential (MW)	Achievement (MW)
Wind Energy	45000	7884.57
Small Hydro Power	15000	2045.61
Co-Generation, Bagasse	5000	719.83
Bio-power (woody biomass)	61000	605.80
Waste-to-Energy	7000	55.20
Solar Photovoltaic Systems	20 MW/Sq. Km.	2.12

4-7 kWh/Sq.m/day		
Total (Grid Interactive)	**133,000**	**11,273.13**

(Potential & achievements till December 2007)

The 45,000 MW potential of wind is a conservative estimate and with the growth in unit size of turbines, greater land availability, and expanded with resource exploration, this potential should go up significantly up to 1,00,000 MW. The possibility of technology leapfrogging in the renewable sector is also considerably great.

The new solar power generation technologies like Concentrating Solar Thermal Power (CSP) and Concentrating Photovoltaics (CPV) which are being commercially develops worldwide now, opens up new opportunities for large-scale power generation from the sun. Concentrating solar thermal power technology applied in an area of 60 x 60 sq. kilometers in the deserts of Rajasthan can produce 100000 MW of power! And we have a desert area of 208110 sq. km. in Rajasthan and Gujarat. Thousands of megawatt capacities of CSP have already been contracted in countries like U.S.A., Spain etc… It would be surprising to note that India's present electricity production of 700 billion units per year can be met with only CSP technology of approximately 200 GW production size, which offers up to 40% plant load factor with 7 hours of storage facility. In fact, the Solar Tres Project in the Andalusian region of Spain will have a 15 hour-molten salt storage system and will generate power at 74% capacity utilization factor. In CPV technology, using optical lenses, sunlight is concentrated on multi-junction solar cells with higher efficiencies of upto 40%. These high efficiency solar cells clubbed with concentration ratios in the range of 500-1200 generated DC power and heat, giving solar to electric conversion efficiencies upto 22%-25%. The DC power can then be converted into AC using power grid quality inverters and fed into the grid directly. CPV has just begun its commercialization journey in Spain.

The current assessment is extremely conventional and does not take into account these new technologies. Revised estimates made by WISE as given in **Table 2** shows that India can generate more than 7,14,000 MW grid-connected electricity from renewables, i.e. five times our current installed capacity.

Table 2: Revised Estimate Projection for Grid Connected Renewables in India (Projections by WISE)

Source	Capacity (MW)	Assumed PLF	Annual Generation (billion kWh)
Wind *	100000	25	219.0
Small Hydro	15000	35	46.0
Biogasses	5000	60	26.3
Biomas	61000	75	400.8
Large Hydro (existing & future)	100000	60	525.6
Large Hydro in Bhutan	16000	60	84.1
Waste to Energy	7000	20	12.3
Solar CSP based power generation*	200000*	35	613.2
Solar PV/CPV based power generation*	200000*	20	350.4
Geothermal	10000	80	70.1
Total	**714000**		**2347.7**

From the above table, it is very clear that in a post-fossil fuel era, India can generate its grid-based electrical energy needs through renewable energy technologies. This will have to be accompanied by drastic measures for energy conservation and many consumption sectors like buildings, agriculture etc… going off the grid through stand alone renewable electricity generation. Depending on how CSP and CPV technologies develop and costs are reduced, we can further expand the programme without any limitations. As global volumes of these two technologies cross 5000 MW each, initial capital costs will fall significantly and generation costs will go down to 7 to 4 dollar cents per kWh. By not joining the global initiative, India is loosing the experience of the learning curve. We should begin focusing on these technologies right-away, so that we are able to deploy them competitively in the next decade. Besides, off-grid renewable technologies like solar water heating, biogas, PV-based lighting systems, etc., also hold huge potential and need to be deployed on a large scale.

INNOVATE OR PERISH: ACT NOW

The world is in the throes of a paradigm shift towards sustainability. Innovation is the key for transitioning towards a sustainable energy economy. The developed world has taken heed and is abuzz with innovative initiatives to herald change. 'The State of the World 2008' report published recently by the Worldwatch Institute says: "We come away from this project with a strong sense that something large, perhaps even revolutionary, is struggling to be born…. much innovation has been unleashed by the wave of concern about climate change that has broken across the world in the past year…" Policy makers, researchers, entrepreneurs, venture capitalists, business leaders and the civil society are innovating to design the architecture of a new world. At the core of this is a transition to clean energy technologies.

Many developed and some developing countries have laws facilitating an accelerated transition to a clean energy economy. Many of them have also introduced eco-taxes, feebates (a combination of fees and rebates to promote clean technology), congestion pricing in cities, etc. China, in 2006, enacted a Renewable Energy Law which has transformed the sector. Sweden is another good example of a country innovating at a fast pace. The country charged a fee on power plants in the early 1990s for emitting nitrogen oxide and redistributed the revenues to least polluting plants. In 2006, a special Commission appointed by the Swedish government recommended a plan for making Sweden oil-free by 2020. Australia pledged early in 2007 to ban incandescent light bulbs before 2010 and replace them with CFLs and LEDs. The U.S. and Europe are developing renewable technologies at breakneck speed. Even the oil exporting countries in the Gulf have begun the transition to renewables.

Is India innovating enough? Sadly, no; we are still treading the beaten track. We are obsessed with unsustainable double digit growth rates, and see securitisation of external supplies of fossil fuels as the route to achieving the same. That is why we continue to acquire foreign oil, coal and gas fields – all fossil resources whose production is predicted to peak soon and then decline. Foreign purchases are now extending to acquisitions (by IOC, BPCL and HPCL) of sugarcane fields in Brazil to produce ethanol! It is well known and well established that such acquisitions are highly unsafe and unstable, because, as the resource crunch tightens and as governments change, foreign investors are thrown out mercilessly. Venezuela has done it recently. Such external securitisation strategies may help in the short-term, but will only add to our long-term energy insecurity.

India should try to achieve the goal of a transition to a renewable energy system by working on a target of 10% by 2012, 20% by 2020 and 50% by 2050 (or even earlier) of RE power in the mix of power generation. For this, there is a need for strong policy and regulatory initiatives.

Legislative actions like a renewable energy law are urgently required. Mandatory targets need to be fixed for the country as well as for states considering the RE potential in each state. India needs to evolve RE power plans for each state to accommodate these sources in their portfolios. Worldwide, policy measures like preferential feed-in-tariff, mandatory quotas of purchase of renewable power through RPS targets supported by effective legislation have made huge changes in this sector. We just need to change our mindset, and embark on war-time mobilization of research, commercialization, policy measures and financial resources to achieve this much needed transition.