Alternative energy in the world and India – Is it the end of the oil age?*

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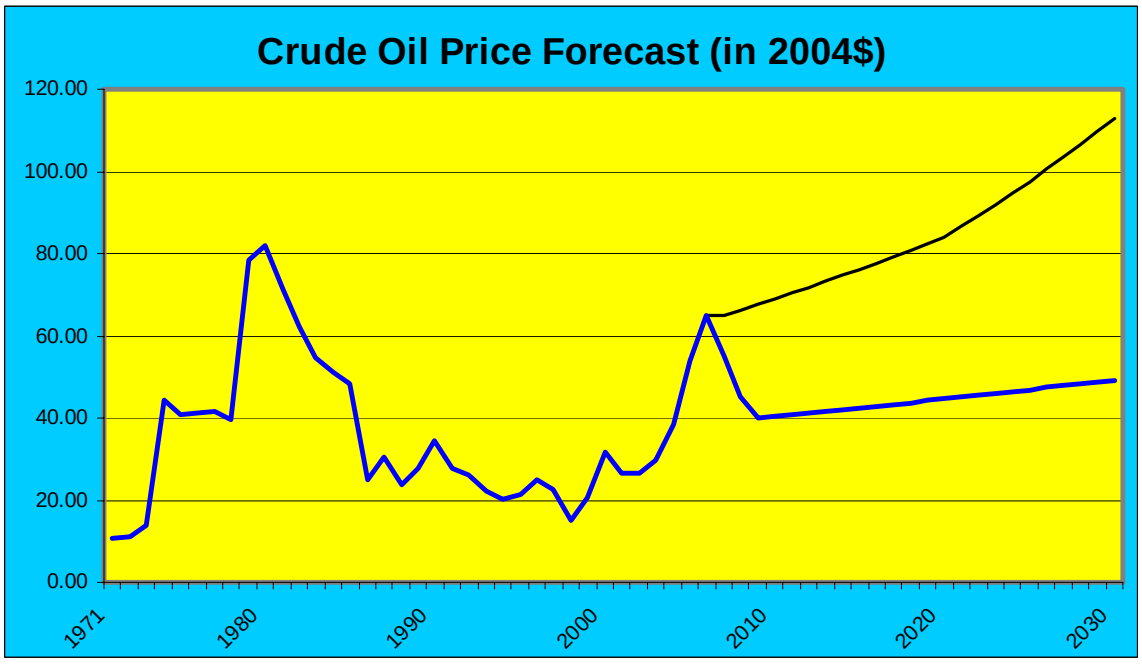
World crude oil price has been steadily increasing since 2002. It reached a historic high of $75 per barrel (not in terms of real dollars) in the first quarter of 2006. In this background of higher oil prices, another race of alternate energy sources (AES) and new energy technologies (NET) to win the grand prize of larger share of the world energy market has started. The world energy market had seen such a race soon after the first oil shock of 1973 which was further reinforced by the second oil shock of 1979-80. These oil shocks were caused first by the Yom Kippur war, then the Iranian revolution and the Iran-Iraq war.

However unlike the first race which was induced by major oil supply disruption, the current one is because of combination of several smaller events. During the first run up in crude oil price it went up from about $11/bbl in 1972 to $80/bbl (in terms of 2004 $) in 1980. Then it fell to an average band of $25/bbl by 1986 lasting till 2002. As prices were coming down, the race of alternate energy sources also slowed down. Oil lost its share and others gained. But AES did not succeed in securing any significant market share. How will the current of AES race develop? How will it be influenced by the oil prices in the future? The following chart shows two pricing scenarios.

Chart 1. World Oil Price Forecast



For a number of reasons, this time the race of AES and NET will gain speed rather than slow down as happened during the first race. Besides the possibility of high oil prices there is

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some urgency to look for alternate energy because of environmental concern of greenhouse gases produced by burning increasing amount of fossil fuels. There is a greater likelihood of the oil prices remaining high and even going above $100/bbl rather than falling to lower levels of $30 or $40/bbl as forecast by many energy analysts.

What are renewable energy sources?

Before we start discussing the role of AES in meeting the future energy demand, it may be useful to take a look at its classification. At present we have commercial energy sources consisting of oil, gas, coal, hydro and nuclear and non commercial sources of energy like fire wood (though in many places, this is not free), agricultural wastes etc. Fossil fuels are non renewable and biomass can be considered as renewable. The International Energy Agency (IEA) defines modern renewables as bio fuels, wind, solar, small hydro power, marine and geothermal energy. The following table based on the IEA classification shows different kinds of modern renewables and their uses.

Technology	*Energy Product*
Biomass Energy	
Combustion (Domestic scale)	Heat (cooking, space heating)
Combustion (Industrial scale)	Process heat, steam, electricity
Gasification/power production	Electricity/heat
Gasification/fuel production	Hydrocarbons, methanol, H2
Hydrolysis and fermentation	Ethanol
Pyrolysis/production of liquids	Bio-oils
Pyrolysis/production of solids	Charcoal
Extraction	Biodiesel
Digestion	Biogas
Wind Energy	
Water pumping and battery charging	Movement and power
Onshore wind turbines	Electricity
Offshore wind turbines	Electricity
Solar Energy	
Photovoltaic solar energy conversion	Electricity
Solar thermal electricity	Heat, steam, electricity
Low temperature solar energy use	Heat (water and space heating, cooking and drying), and cold
Passive solar energy use	Heat, cold, light and ventilation
Artificial photosynthesis	H2 or hydrogen rich fuels
Hydro power	Electricity
Geo thermal energy	Electricity
Ocean Energy Systems	
Tidal barrage, wave energy, tidal currents, OTEC (ocean thermal energy conversion)	Electricity
Hydrogen	Electricity and power

Because of high oil prices and the possible impact on the environment due to increasing use of fossil fuels, there is an increasing need to replace fossil fuels. Also for many countries energy security is a big problem because of uncertainty in securing the required amount of oil and gas at reasonable prices. Thus there is not only a need to find new renewable energy sources but also to use fossil fuels in the most efficient way by developing new and improved technologies like hybrid cars, improved technology to produce oil shale and tar sands among others

Participants in the energy market share race

Of the several renewable energy sources, wind power shows the greatest potential today. Its cost to generate electricity is comparable to fossil alternatives, particularly when environmental costs are also taken into consideration. Photovoltaic panels have dropped in price to 30 to 20% of their cost in 1980 but they remain uneconomical. Modern renewables like small wind turbines, photovoltaic cells, small scale or micro hydroelectric facilities are economical for distant villages where grid power will be very expensive.

Solar thermal technologies have been providing heat and hot water for residential and industrial end uses for several years They are competitive even without any subsidies. Marine energy sources are tidal forces, ocean currents, wave power, and thermal gradients have yet to be developed. Fuel cells technology using hydrogen is developed and found to be economical for some specific conditions. However the basic problem in the extensive use of hydrogen cells is its cost and also the source for generating hydrogen. If fossil fuels are used to generate hydrogen, we have not solved the fundamental problem of reducing fossil fuel dependency besides its high cost.

Economics of biofuels

We have made much progress in developing and in the use of biofuels like ethanol, and biodiesel. But their economics is still questionable. In the US, variable cost for biodiesel is $2.85 per gallon from soybean oil and $1.55 from yellow grease (while wholesale diesel costs about $2.00 per gallon as of late 2006). Even then their maximum potential is about 0.03 million barrels a day (MMBD). In the case of ethanol, economics is slightly better. Variable cost to produce ethanol from corn is about $1.20 per gallon and $1.00 per gallon from cellulose. Total maximum potential is about 1.8 MMBD which is not insignificant in relation to 9 MMBD of gasoline demand in the US. Brazil has been the leader in the use of ethanol to replace gasoline for powering their transportation. At high oil prices, ethanol appears to be a viable alternative to fossil fuels even in the absence of subsidies.

In the case of India, where demand for sugar is finely balanced, land is limited, food production needs to be increased and water is always scarce, economics of ethanol is unlikely to be attractive. According to Nimbkar Agricultural Research Institute (NARI) there is a need to develop technology to convert residues left after harvest (consisting of cellulose and hemi cellulose) into ethanol. This will help in producing food and fuel from the same piece of land. NARI claims the cost of producing ethanol from sweet stalk sorghum to be just Rs 10 to 14 per liter ($0.90 to $1.26/gallon).

Unlike the US and Brazil, which have the luxury of diverting resources to produce ethanol instead of feeding the people, India may not have that choice. However it is not the case in the case of biodiesel. In his speech on alternate fuels on April 18, 2006, President Abdul Kalam recently stated that India has about 60 million hectares of waste land and 30 millions of that can be used to grow Jatropha or such energy plantation to produce biodiesel. Each hectare can produce about 2 tons of biodiesel at a cost of Rs 20 per liter ($1.80 per gallon). At current high oil price this is certainly economical.

There are other differing estimates which are less economically attractive. Some experts estimate that each hectare can produce 3 tons of seeds which will yield just one ton of diesel and cost to produce diesel after taking into consideration a subsidy of Rs 6,000 per hectare of investment will be Rs 30 per liter ($2.70 per gallon). Potential of 60 to 30 million tons of biodiesel in comparison to the current diesel demand of about 42 million tons is

quite huge. This will also create huge employment and put to use enormous amount of waste land. This is an alternative which should be followed by India in a mission mode as suggested by the President.

In addition to the above AES, in case of a developing country like India, alternate technology like smokeless chulas, modern wood stoves and the like can increase the efficiency of using fire wood. Despite the high potential of this "low tech" technology, and enormous budget allocation over the years, penetration of this technology has been slow.

India has been a leader in developing and refining biogas technology using cow dung, human and animal waste and vegetable waste. This renewable technology is also economical even without subsidy. However the adoption of this technology is hindered despite the enormous efforts by the government. This is because of the populist pricing policy adopted by the government in selling petroleum products like kerosene and liquid petroleum gas (LPG) as well as electricity. When electricity is sold practically free, which villager will invest in biogas plants to produce methane? When kerosene is sold below market price, what incentive will there be to use biogas for cooking or lighting purpose?

Role of Ministry of Non-conventional Energy Sources

Annual budget allocation of Ministry of Non-conventional Energy Sources (MNES) for 2006-07 is Rs 580 crores which is a fraction of ONGC's budget of Rs 14,400 crores. MNES estimates total potential power from renewables by 2032 to be around 172,000 MW. This consists of 52,000 MW from biomass, 45,000 from wind power, 15,000 small hydro, 5,000 from bagasse and 5,000 from municipal solid waste (MSW). As of the end of 2005, there was 7,160 MW of AES (wind turbine 4,434 MW, cogeneration 867 MW, small hydro 1,748 MW, 3.8 million biogas plants and 35.2 millions improved chulhas) contributing to India's energy needs.

Table 1: Capital Costs and the Typical Cost of Generated Electricity from the Renewable Options

Source	Capital cost (crores of Rs/MW)	Estimated cost of generation (Rs/kwh)
Small Hydro Power	5.00 – 6.00	1.50-2.50
Wind power	4.00 - 5.00	2.00 – 3.00
Bio-mass power	4.00	2.50-3.50
Bagasse Cogeneration	3.5	2.50 3.00
Biomass gasifier	1.94	2.50-3.50
Solar Photovoltaic	26.5	15.00-20.00
Energy from waste	2.50-10.0	2.50 – 7.50

Source: Ministry of Non-conventional Energy Sources (MNES)

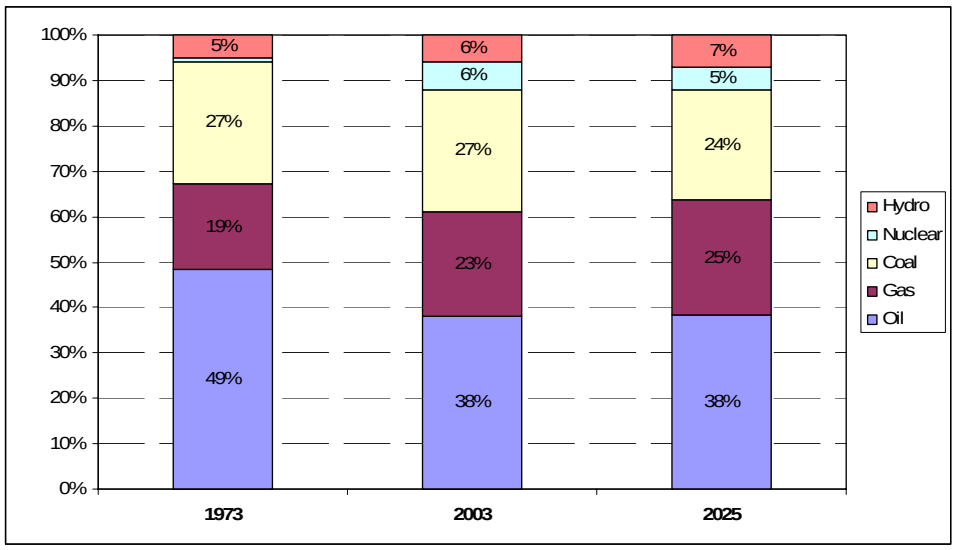
As planning commission has pointed out in its report, development of modern renewables have been driven more by subsidy considerations and achieving paper targets rather than real economics or real objective of reducing fossil fuel substitutions. Table 1 shows the reasonable attractiveness for some of the renewables in India.

Changing market shares of world energy sources

Chart 2 shows the changes in the market shares of traditional commercial energy sources. Between 1973 and 2003, the oil share of the world energy market declined from 49% to 38% and is forecast by the EIA to remain at that level by 2025. While gas, coal and nuclear shares have increased their share between 1973 and 2003, those changes are marginal but for nuclear, which has gone up from 1% to 6%. The latest report by ExxonMobil titled "The Outlook for Energy" in April 2006 is also forecasting similar market shares for traditional energy sources. Renewables like wind and solar are forecast to contribute not more than 3

MMBD oil equivalent energy in 2030. In comparison to the oil consumption of 115 MMBD, this is very small.

Chart 2 World Energy Sources for 1973, 2003 and 2025



Source: BP Statistical Review of World Energy and International Energy Outlook by the Energy Information Administration (EIA).

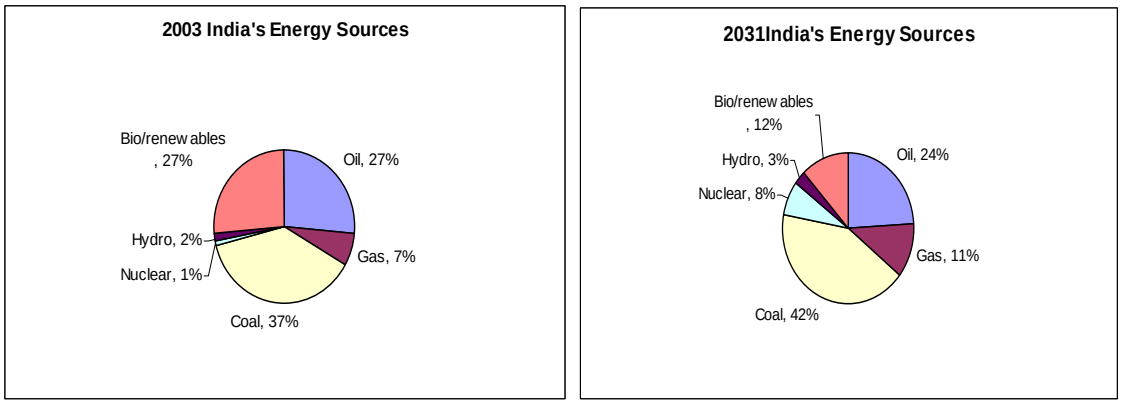
Two significant assumptions affecting these two forecasts by the EIA and ExxonMobil are sufficient oil reserves (proven and yet to be discovered) and oil prices around $30/bbl. ExxonMobil forecast is not explicit about the underlying crude oil assumption. Both these forecasts assume that the world oil will not peak any time soon. They refute the argument of some of the experts who have forecast that world oil will peak soon based on Hubbert's principle. It is true that Hubbert's prediction was accurate with respect to the US. But there are several experts who do not think Hubbert's principle will hold for the rest of the world. They also disagree with the argument advanced by Houston oil economist Matthew Simmons in his often quoted book "Twilight in the desert" where he has challenged the huge proven reserves of Saudi Arabia and also their capability to increase substantially above the current production of 10 to 12 MMBD.

Changing market shares of India's energy sources

While the developed world uses mostly commercial energy sources, India's dependence on non-commercial resources (mostly biomass) like fire wood and agricultural wastes may be as much as 35% amounting to about 114 million tons of oil equivalent (MTOE) in 2003. Based on the data of Ministry of Non-conventional Energy Sources, modern renewables might have contributed about 4 MTOE. It is assumed that contribution from non-commercial sources at best will remain at the same level of 114 million tons and contribution of modern renewables will be about 60 million tons.

If India's energy market develops along the scenario given by the planning commission in their draft Integrated Energy Plan, then oil share will decline marginally from 27% to 24% in 2031 (See Chart 3 below). Gas share will increase from 7% to 11%, coal from 37% to 42%, nuclear from 1% to 8% while share of biomass will go down from 26% to 7% and share of renewables will go up from 1% to 5%. As standard of living goes up in villages, it is to be expected that their use of non-commercial fuels will go down and commercial energy whether from renewables or non-renewables will be bound to go up.

Chart 3 India's Energy Sources



Source: Planning commission for traditional sources.

In one sense this is a heroic forecast. During the last 60 years, India's achievement to improve the living standards of rural population has not been all that impressive. Continuing dependence of rural people on non-commercial sources of energy which in one aspect is not really renewable (destruction of forests for fire wood) has been unconscionably high.

Conclusion

To promote renewables, there should be a greater appreciation of India's energy security needs and also grave energy crisis the country is facing. This is not on the national agenda of the country or any of the political parties. In India, subsidies are misused especially in the energy sector. The government needs to streamline energy pricing policy both in electricity and petroleum sector if it wants to promote the use of renewable energy sources. Mere sloganeering or setting mission statements is not likely to make much difference.

Just like the country's petroleum navarathnas are able to supply petroleum products with reasonable level of professional expertise despite the usual bureaucratic problems of public sector problems, the government needs to promote preferably private sector companies in renewables. This needs to be supported by appropriate legal and regulatory framework with the fiscal and government supports. Only then India will be able to achieve the full benefit of the expertise India has in modern renewables. Even if the rest of the world is not planning for the beginning of the end of oil era, India, with its limited oil and gas reserves, should do so to take advantage of its technical expertise and to manage geopolitical risks.