A low-carbon, technology-driven strategy for India's energy security*

U. Aswathanarayana

Preamble

It is the energy use that has made modern life (automobiles and airplanes, communication, food, health, entertainment) possible. Energy security has to go hand in hand with economic development and environmental protection. India has to customize its own energy portfolio, consistent with its endowment of energy resources, and employing technologies which are economically viable, socially equitable, ecologically sustainable and have minimal carbon emissions. Any energy security strategy for India has to be comparable to that of China because of two critical commonalities, namely large populations (~1 billion) and high dependence on coal (~60%; Table 1).

Statement of India's energy problem

The consumption of electricity per capita (639 kWh) in India is among the lowest in the world – comparable to that of Vietnam and Mozambique. About 412 million Indians have no access to electricity. At the rate of USD 41 per connection, it would cost USD 17 billion (Rs 680,000 crores) to provide electricity to all from the grid. Where a habitation is too far from the grid, recourse has to be taken to decentralized biodiesel, mini-hydel, wind, biomass gasifiers, and photovoltaic units as sources of electricity. About 668 million people continue to use animal dung, agricultural waste and fuelwood as fuel for cooking. Because of the low fuel efficiency of the cook stoves (~8%), particulate matter in the Indian households burning biomass is 2000 μg/cubic m (as against the allowable 150 μg/cubic m), leading to 400,000 premature deaths. Though agriculture contributes 19% of India's GDP, it employs 60% of the workforce. It is critically important that those presently engaged in agriculture should be enabled to move to the industry and services sectors, through the instrumentality of widespread access to electricity. Power-generating capacity is projected to grow from its present level of 146–255 GW in 2015, and 522 GW in 2030. The International Energy Agency (2007) estimates that during the period 2006–15, India would need to make an investment of USD 1.25 trillion (Rs 50 lakh crores), including the infrastructure of USD 1 trillion (Rs 40 lakh crores) in the energy sector. Reduction in energy demand is to be achieved through low-energy adaptations (e.g. fluorescent tubes in place of filament lamps, frost-free refrigerators) and adopting energy-efficient technologies in buildings, farming, and economy in general. India has sites for the geological sequestration of 500–1000 Gt of CO_2, but the techno-economic viability of this technology is not yet well established.

Sectoral contribution of energy resources

The two thrust areas of energy security, namely improvement in energy efficiency and reduction in carbon emissions are explained sector-wise:

Coal

Coal has been and continues to be the backbone of the energy industry in India. Indian coal tends to have high ash content (30–50%) and low fuel value (4500 kcal/kg, as against the standard with 6000 kcal/kg). About 12% of the coal used in India is imported (36 mt of coal equivalent) for use in the steel industry. During 2006–15, India plans to build coal-fired power stations of 113 GW capacity. China has achieved the extraordinary feat of building 105 GW of mostly coal-fired power plants in 2006 alone – this works out to building two 1000 MW power plants every week, for which there is no precedent anywhere in the world. The coal-fired power plants in India are not only responsible for high CO_2 emissions (948 g of CO_2/kWh), thereby contributing 60% of CO_2 emissions in India, but are among the least efficient in the world. Apart from increasing the production of coal and washing it, it is important to raise the efficiency of future coal-fired power stations using supercritical technologies which cost USD 600–900/kW, and can attain efficiencies of ~40%. Coal is used in steel, cement and fertilizer industries, and there is much scope for improving the efficiency of coal use in these applications. For instance, the cement industry presently uses 3.5 GJ (of coal energy)/tonne of clinker. Coal use can be reduced by 17% by modifying the raw-material mix and process flowsheet.

Oil and natural gas

India's oil reserves are estimated at 6 billion barrels (bb). India produced 0.8 mb/d, and imported 1.8 mb/d (i.e. 70%) of oil in 2005. In 15 years, it is estimated that 90% of our oil requirements may need to be imported. Since most of the oil is used to run motor vehicles, efforts should be directed towards producing low carbon-emitting, fuel-efficient cars (e.g. 40 mpg), incentives in the form of efficient, safe and affordable public transportation systems, and disincentives in the form of higher cost of cars and permission to

Table 1. Energy comparisons between China and India

Parameter	China	India
Population (× billion)	1.31	1.1
Per capita energy use (GJ/capita)	52	22
Per capita CO_2 emissions (t CO_2 per capita)	3.8	1.2
Total country emissions (× mt CO_2)	5007	1342
GDP per capita (USD PPP) in 2006	7630	3736
Rate of GDP growth in 2006	11	9.7
Proven reserves of hard coal (× bt)	115	98
Production of coal in 2006 (mt)	~2400	~400
Contribution of coal energy to primary energy (%)	~60	~70

*Source of statistical data: *World Energy Outlook 2007*, International Energy Agency, Paris.

own cars (as is being effectively practised in Singapore). Other possibilities are 5% ethanol blend, and the use of CNG in vehicles. India has proven reserves of 1100 bcm (billion cubic metre) of natural gas. In 2005, India produced 29 bcm, and imported 6 bcm of natural gas. Kerosene and cooking gas are heavily subsidized (40%), but the benefits hardly reach the poor.

Nuclear power

India has now 17 operational reactors, which generate 3% of the country's electricity. The current target is to raise the nuclear power capacity to 20 GW by 2020, and 40 GW by 2030, assuming hopefully that India would be able to achieve full access to the global nuclear market. The single most important benefit of nuclear power is that hardly any carbon dioxide (a greenhouse gas) is emitted. While coal-fired thermal power stations have to be established at pitheads in order to save on transportation costs, and hydroelectric power stations have to be set up at dam sites, a nuclear power station is not subject to such constraints (a 1000 MWe power station would need annually about 3.1 mt of hard coal, but only about 24 t of enriched uranium). In the context of agitations for using land for non-agricultural purposes, this is an important consideration as the atomic power plants can be established in rocky, barren land away from habitation. Presently, the cost of nuclear fuel in India is roughly twice the global price. The price will go down when we are able to access the international uranium market through the Nuclear Suppliers Group. In the Indian context, nuclear power is likely to become competitive with thermal power at places 500 km away from coal deposits. In the case of coal-fired power stations, fuel cost accounts for about 60% of the electricity cost, as against 15% in the case of light water reactors. Consequently, nuclear power costs will increase at a lower rate than for coal power, as a consequence of inflation.

Renewable energy resources

India is well-endowed with hydropower. The installed capacity of hydroelectricity is 34 GW, while the potential is 150 GW. India is ranked fourth in the world in wind energy – the current installed capacity is about 6 GW, and the potential is 65 GW. India, which produces 1900 million litres of ethanol, is the fourth largest producer of ethanol in the world (after Brazil, USA and China). Oil seeds of *Jatropha curcas* constitute the feedstock of biodiesel. The productivity of jatropha works out to 3.75 t of oil seeds/ha. Since India has 17.5 mha of wasteland in which jatropha could be grown, there is immense scope for the sector, not only to contribute to energy security, but also to provide considerable rural employment. Solar water heaters (1.9 million sq. m) currently used in buildings and in the industry are a small fraction of the potential estimated at 140 million sq. m.

U. Aswathanarayana is in the Mahadevan International Centre for Water Resources Management, Hyderabad 500 082, India.
e-mail: uaswathanarayana@yahoo.com