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Energy Security of India: An overview in present context

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Summary

Energy has been universally recognized as one of the most important inputs for economic growth and human development. There is a strong paradoxical relationship between economic development and energy consumption. On one hand, the level of economic development has been observed to be reliant on the energy demand and on the other hand, growth of an economy, with its global competitiveness, hinges on the availability of cost-effective and environmentally benign energy sources. Energy security is nothing but the physical availability of supplies to satisfy demand at a given cost and it is thus involves supply risk as well as price risk governed by internal and external consequences. Long-term energy security demands a delicate balance between indigenous and external energy sources along with technologies in order to minimize the risks. There is a need, especially for developing country like India, for higher levels of energy supply and use to fuel economic development – at present, 'energy poverty' hinders the economic and social development for the very large numbers of people.

Introduction

India, home of approximately 1.2 billion accounting over 17% of the world's population with an expected 7 to 8% economic growth, is moving towards unquenchable thirst for energy. India today is the fifth largest consumer of energy in the world, accounting for 3.7 percent of the world's consumption. Its total primary energy demand is expected toalmost double by 2030. One harsh result of its meteoric growth is the widening the gap between energy demand and that is being produced indigenously.

A healthy rate of growth of GDP in India of around 8 to 9 percent over the next decade at least will lead to a major increase in the demand for energy. It is projected that by the year 2031, the demand for energy could increase 5 to 7 times over the year 2001. The Integrated Energy Policy Report of the Planning Commission estimated India's requirement in 2031 is expected to be in the range of 1,536 to 1,807 million tons of oil equivalents (MTOE). TERI's analysis based on extensive modeling indicates a level of around 2150 MTOE in a reference case scenario. Such an increase would pose huge challenges in respect of energy security which would be dictated by growing dependence on imports of fossil fuels, if a sincere effort is not being made to monetize the alternate resources.

India is well-endowed with both exhaustible and renewable energy resources. Coal, Oil, and Natural Gas are the three primary commercial energy sources. India's energy policy, till the end of the 1980s, was mainly based on availability of indigenous resources. Coal was by far the largest source of energy. However, India's primary energy mix has been changing over a period of time. India depends on imported oil to the extent of nearly 80% of its needs.

The energy-mix of India (Fig-1) comprises both non-renewable (coal, lignite, petroleum and natural gas) and renewable energy sources (wind, solar, small hydro, biomass, cogeneration biogas).

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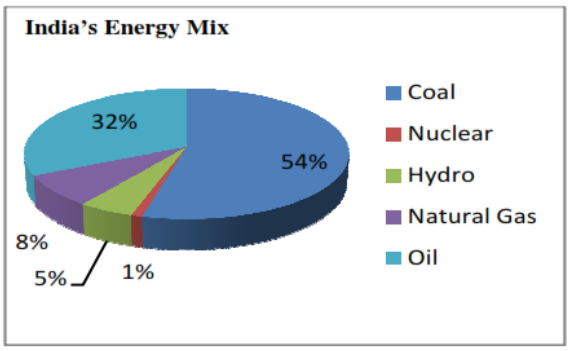

Fig.1, Energy Mix of India, (Source: Energy Stastics-2010)

Despite increasing dependency on commercial fuels, a sizeable quantum of energy requirements (40% of total energy requirement), especially in the rural household sector, is met by non-commercial energy sources, which include fuel wood, crop residue, and animal waste. However, other forms of commercial energy of a much higher quality and efficiency are steadily replacing the traditional energy resources being consumed in the rural sector.

Resource augmentation and growth in energy supply has not kept pace with increasing demand and, therefore, India continues to face serious energy shortages. This has led to increased reliance on imports to meet the energy demand. The time and situation warrant a relook into the energy security of the country.

Electricity

Access to affordable and reliable electricity is critical to a country's growth and prosperity. Per capita electricity consumption rose from 15.6 Kwh in 1950 to 704 Kwh in 2008-09 (Fig.2). However, it is a matter of concern that per capita consumption of electricity is among one of the lowest in the world. Moreover, inconsistent power supply shortages impose a heavy burden on India's fast-growing trade and industry.

The electricity consumption increased from 43,724 GWh during 1970-71 to 6,12,645 GWh during 2009-10. The country experienced energy shortage of 7.3% and peak shortage of 11.7% during the year 2003-04. Though, the growth in electricity consumption over the past decade has been slower than the GDP's growth, this increase could be due efficient use of electricity.

There has been a significant progress towards the augmentation of its power infrastructure. In absolute terms, the installed power capacity has increased from only 1713 MW as on 1950 to 182,344 MW in 2011. About 65.34% of the electricity in India is generated by thermal power plants, 21.53% by hydroelectric, 2.70% by nuclear and 10.42% by Renewable Energy Sources. According to "Indian Power Sector Analysis", a RNCOS market research report indicates that India will require investments of US$ 1250 billion in energy infrastructure till 2030 to cater the growing demand at current rate.

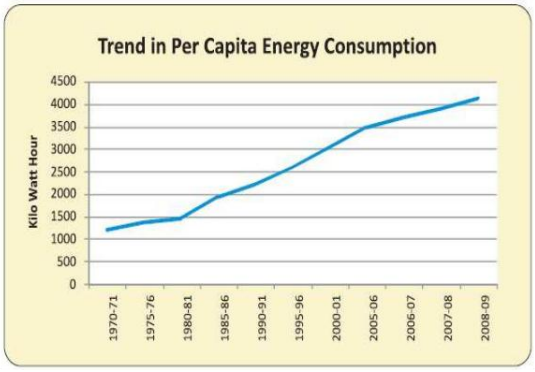

Fig.2, Energy Consumption (Source: Energy Stastics-2010)

Energy Resources: Non-renewable

Coal

Coal fueled the industrial revolution in the 18th and 19th century. It remains prime source energy till the black gold, the oil, was discovered. However, after the oil shocks during 1973 to 1979, when the price of oil increased by nine fold (from 5 to 45 USD per bbl), there was a shift in choice; coal, natural gas, and nuclear became the alternatives in place of. The concept of conservation measures became another mantra. From 1965 to 2008, the use of fossil fuels has continued to grow and their share of the energy supply has increased.

India is the 3rd largest coal producer with 557.6 million tons having share of 6.2% of world's total coal production. Being the most abundant fossil fuel in India, it continues to be one of the most important source for meeting the domestic energy needs. It accounts for 55% of the country's total energy supplies. The estimated coal reserves up to 1200m in India are 276.81 billion tons with total coal bearing area 22400 sq km. Unfortunately, the

coal in India is of inferior quality and not suitable for modern thermal power plants.

The demand of coal in India has grown rapidly with the increase in coal-fired power plants, steel, fertilizer & other coal based process industry. India's coal demand is forecast to grow by 11% a year, reaching 135 million tonnes in 2011-12 with imports set to make up about 20% of its total consumption. India currently faces coal shortage of 23.96 MT. This shortage is likely to be met through imports mainly by steel, power, and cement sector (MoC 2005). India exports insignificant quantity of coal to the neighboring countries.

Oil and Natural Gas

The latest estimates indicate that India has around 0.4% of the world's proven reserves of crude oil. India has total reserves of 1201 MMT of crude oil and 1437 BCM of natural gas as on 01.04.2010 (Fig.3&4). The production of crude oil in the country has increased from 6.82 MMT in 1970-71 to 33.69 MMT in 2003-04. The quantity of crude oil imported increased from 11.66 MMT during 1970-71 to 159.25 MMT by 2009-10. The gross production of Natural Gas in the country was 47.51 BCM during 2009-10.

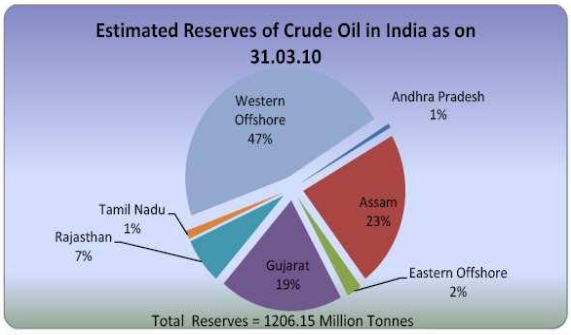

Fig.3, Reserves of Crude Oil in India as on 31.03.2010

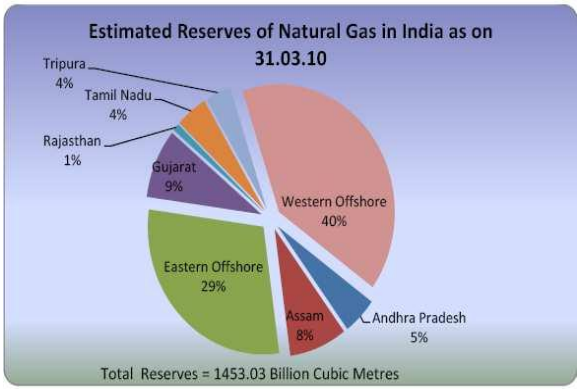

Fig.4. Reserves of Natural Gas in India as on 31.03.2010

The International Energy Outlook 2005 (EIA 2005b) projects India's gas consumption to grow at an average annual rate of 5.1%, thereby reaching 2.8 TCF by 2025 with the share of electric power sector being of 71%. India's consumption of natural gas has risen faster than any other fuel in the recent years. Natural gas demand has been growing at the rate of about 6.5% during the last 10 years.

Industries such as power generation, fertilizer, and petrochemical production are shifting towards natural gas. Apart from encouraging domestic production, the import of LNG (liquefied natural gas) is being considered as one of the possible solutions for India's expected gas shortages. Several LNG terminals have been planned and two LNG terminals have already been commissioned: (1) Petronet LNG Terminal of 5 MTPA (million tonnes per annum) at Dahej, and (2) LNG import terminal at Hazira. Sector wise consumption of Oil & Gas during the year 2009-10 were, Transport -50%, Industry- 13%, Plantation-18%, Power generation-7%, Misc Services-13% and Private sales were 1%.

Nuclear

Nuclear power is the fourth-largest source of electricity in India after thermal, hydroelectric and renewable sources. As of 2010, India has 20 nuclear reactors in operation generating 4,780 MW. 5 plants are under construction and are expected to generate an additional 2,720 MW. India's nuclear power industry is undergoing rapid expansion with plans to increase nuclear power output to 64,000 MW by 2032. The country is involved in the development of nuclear fusion reactors through its participation in the ITER

project and is a global leader in the development of thorium-based fast breeder reactors.

The 2006 Planning Commission appointed Dr. Kirit Parikh expert body on Integrated Energy Policy (IEP) estimated India to produce 63,000 MW of nuclear power by 2032 from the current level of 4,780 MW or about 3% of total power capacity.

Even if India were quadruple its nuclear power output to 20 GW by 2020, nuclear power generation would only consume 2000 metric tonnes of uranium per annum. Based on India's known commercially viable reserves of 80,000 to 112,000 tons of uranium, this represents a 40 to 50 years uranium supply for India's nuclear power. Therefore, India has sufficient uranium resources to meet its strategic and power requirements for the foreseeable future.

Large deposits of natural uranium, which promises to be one of the top 20 of the world's reserves, have been found in the Tummalapalle belt in the southern part of the Kadappa basin in Andhra Pradesh in March 2011.

Energy Resources: Renewable

Hydro Energy

India is blessed with immense amount of hydro-electric potential and ranks 5th in terms of exploitable hydro-potential on global scenario. The present installed capacity as on 30-06- 2011 is approximately 37,367.4 MW which is 21.53% of total electricity generation in India. Hydropower now accounts for about 25% of India's generation capacity, down from 40% in 1980. The favorable economics of developing thermal generation coupled with difficulty in securing long-term financing presents a substantial roadblock for large-scale hydro development. In addition, 56 number of pumped storage projects have also been identified with probable installed capacity of 94,000 MW. In addition to this, hydro-potential from small, mini & micro schemes has been estimated as 6,782 MW from 1512 sites. Thus, in totality India is endowed with hydro-potential of about 250,000 MW. The power plants at Darjeeling and Shimsha (Shivanasamudra) were established in 1898 and 1902 respectively and are among the first in Asia.

Solar

India has a great potential to generate electricity from solar energy which by and large neglected, however recently the country is in the course of emerging as a major user of solar energy. Most parts of India have 300 - 330 sunny days in a year, which is equivalent to over 5000 trillion kWh per year - more than India's total energy consumption per year.

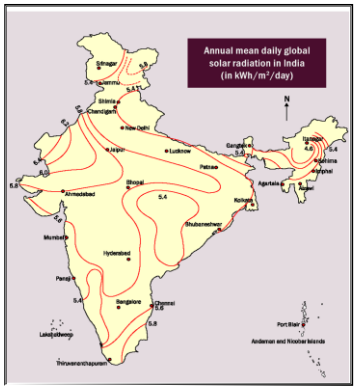

Fig. 5: Annual mean daily global solar radiation in India.

The daily average solar energy incident over India varies from 4 to 7 kWh/m2/day (Fig.5) with about 1500–2000 sunshine hours per year (depending upon location), which is far more than current total energy consumption.

The amount of solar energy produced in India is less than 1% of the total energy demand. The grid-interactive solar power as of December 2010 was merely 10 MW. Government-funded solar energy in India only accounted for approximately 6.4 MW-yr of power as of 2005. However, as of October 2009, India is currently ranked number one along with the United States in terms of solar energy production per watt installed.

Wind

India is endowed with a large, viable and economically exploitable wind power potential. Over the last 10 years wind capacity has grown at a CAGR of 22%. India is placed at the third position in the world in terms of new additions in 2008 and this corresponds to an overall increase of over 40% in new wind power stations. The Government of India has set up the Centre for Wind Energy technology (C-Wet) to map wind energy potentials. The C-WET has set

up more than 1,000 wind monitoring and wind mapping centers across 25 states.

As of 31 March 2011 the installed capacity of wind power in India was 14550MW, mainly spread across Tamil Nadu (6007 MW), Maharashtra (2310.70 MW), Gujarat (2175.60 MW), Karnataka (1730.10 MW), Rajasthan (1524.70 MW), Madhya Pradesh (275.50 MW) & Andhra Pradesh (200.20 MW. It is estimated that 6,000 MW of additional wind power capacity will be installed in India by 2012. Wind power accounts for 6% of India's total installed power capacity, and it generates 1.6% of the country's power.

Geothermal Energy

The geothermal gradient, which is the difference in temperature between the core of the planet and its surface, drives a continuous conduction of thermal energy in the form of heat from the core to the surface. Geothermal power is cost effective, reliable, sustainable, and environmentally friendly, but has historically been limited to areas near tectonic plate boundaries.

Fig.6: Geothermal provinces of India,

Recent technological advances have dramatically expanded the range and size of viable resources, especially for applications such as home heating, opening a potential for widespread exploitation. India has to depend on clean, rural based, cheap energy sources and cannot ignore its 10,600 MW geothermal potential. In India the most promising geothermal fields are Puga, Manikaran, Tattapani, Cambay, and the West coast (Fig.6).

Biomass

Biomass is an important energy source contributing to more than 14% of the global energy supply. About 38% of such energy is consumed in developing countries, primarily in the rural and traditional sectors of the economy. Among various options available for bioenergy-biodiesel, bioethanol, burnt vegetable oil waste and biomass gasification are three major options, which have huge potential in. Indian climatic conditions offer an ideal environment for biomass production. Bio-energy has remained critical to India's energy mix. The current potential of surplus agro and forest residues to energy is estimated at 16,881 MW along with an additional "waste-to- energy" potential of 2,700 MW. With the setting up of new sugar mills and the modernization of existing ones, the potential of Bagasse cogeneration is estimated at 5,000 MW. The cumulative installed capacity, of grid-interactive biomass and Bagasse cogeneration power was 1,870.83 MW only, as on 30.6.2009. In addition, about 5,000 MW of power can be produced from sugar mills residues. Thus the estimated biomass power potential is about 21,000 MW.

Other Resources

Tidal & Wave Energy

The potential along the 6000 Km of coast of India is about 40,000 MW. This energy is however less intensive than what is available in more northern and southern latitudes. In India the research and development activity for exploring wave energy started at the Ocean Engineering Centre, Indian Institute of Technology, Madras in 1982.

Fig.7, Renewable Energy from Ocean Seas

Primary estimates indicate that the annual wave energy potential along the Indian coast is between 5 MW to

15 MW per meter, thus a theoretical potential for a coast line of nearly 6000 KW works out to 40000-60000 MW approximately. However, the realistic and economical potential is likely to be considerably less.

Shale Gas

Shale gas has become an increasingly important source of natural gas in the United States over the past decade, and interest has spread to in Canada, Europe, Asia, and Australia. One analyst expects shale gas to supply as much as half the natural gas production in North America by 2020. In India, several basins - Cambay, Assam-Arakan, Damodar Basin and Gondwana are expected to hold shale gas resources. As per the initial studies, many shale sequences in well explored basins are found to be promising like Damodar, Cambay, Krishna Godavari and Cauvery basins (Fig.8). The potentiality of these basins was also vetted by international experts.

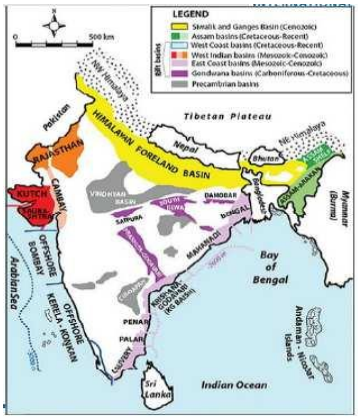

Fig.8, Prospective Shale Gas Basins in India.

ONGC-Schlumberger pilot project in the Damodar Basin at an expenditure of Rs. 128 crore has made an initial gas-in-place estimate of 300-2100 TCF. The gas reserve spread over 12,000 square km in the Durgapur-Raniganj area - is the world's third shale gas find.

CBM

Having the 3rd largest proven coal reserves and being the 4th largest coal producer in the world, India holds significant prospects for commercial recovery of CBM. Prognosticated CBM resource has been estimated to be around 4.6 TCM.

Way Forward

Due to rapid economic expansion, India has one of the world's fastest growing energy consumers and is expected to be the second-largest contributor to the increase in global energy demand by 2035, accounting for 18% of the rise in global energy consumption.

As on date about 70% of India's energy generation capacity is from fossil fuels, with coal accounting for 40% of India's total energy consumption followed by crude oil and natural gas at 24% and 6% respectively. India's dependence on energy imports is expected to exceed 53% of the country's total energy consumption. In 2009-10, the country imported 159.26 million tonnes of crude oil which amount to 80% of its domestic crude oil consumption and 31% of the country's total imports are oil imports. The growth of electricity generation in India has been hindered by domestic coal shortages and quality; consequent upon India's coal imports for electricity generation increased by 18% in 2010.

Why Energy Security ?

- Essential to achieve the economic growth rates of over 8-10% p.a. to which the nation is committed.
- High global demand and attendant supply constraints, also geopolitical developments, resulting higher oil & gas prices.
- International competition in hydrocarbon resources.

The country has to pursue major programs for diversifying energy supply towards greater independence using indigenous sources of energy while at the same time to secure sustainable resources from overseas and also improving the efficiency of energy use.

- Reform & restructuring the energy sector to develop globally competitive, efficient and environmentally compatible operations.
- Require building a National Energy Map from the viewpoint of national resource endowment
- Enhancement of strategic oil reserve through accelerated domestic exploration and acquiring global acreages.
- Achieving 90 percent self-sufficiency with appropriate mix from national companies, private players and IOC's.

- Substitution from oil to gas, CBM, Gas Hydrates, Ocean Energy, Shale oil, Oil Shale. Biodiesel & other fuels.
- Improving energy in energy intensive industries like fertilizers, aluminum, textiles, cement, Iron & steel and paper, consume around 65 per cent of total industrial energy.
- Adequate port & shipping facilities for oil and gas import.
- Boosting Energy related R&D work.
- Enhancement of the national knowledge-base and acquisition of technologies in respect of conservation, non-conventional fuel.

As projected in coal vision 2025 document the demand at 8% GDP will be 1.25 BT by 2025. The use of coal for electricity generation in India is expected to increase by 2.2% per annum during 2002 - 25, thus requiring an additional 59,000 MW of coal-fired capacity. CIL Board approved formation of a subsidiary 'Coal India Videsh Ltd' with objective to acquire overseas reserve, produce and import Coking and high grade Non-Coking coal to India. To contribute 10 MT of coal by 2011-12 and 50 MT by 2020, which is presently under consideration of Government.

Diversification of oil import in addition to the Middle East region should be considered as an important strategy. A snapshot of country-wise oil and gas resources in this region is presented in Table 1. The oil industry in the region has witnessed a flurry of foreign investment to initiate/expand exploration and production activities. The other regions which can be focused into is Africa, especially Nigeria, Angola & Libya; however these regions to be dealt with different approach considering the inherent socio-political environment.

Country	Oil (Billion bbl.)	Gas (TCM)
Azerbaijan	31-38	1.3
Kazakhstan	95-101	4-4.9
Turkmenistan	34	7.3-8.9
Uzbekistan	1	3.1-3.5
Total	178-191	16-18.9

Table, 1: Proven oil and gas reserves in the Caspian region

To deal with higher gas requirements the neighboring countries like Bangladesh and Myanmar can be explored as alternate sources of gas supply. Ample opportunities exist to import gas from Iran and the Caspian region as well.

The Indian nuclear power industry is likely to undergo a significant expansion in the coming years. India is expected to generate an additional 25,000 MW of nuclear power by 2020, bringing total estimated nuclear power generation to 45,000 MW. India has also done a great amount of work in the development of a thorium centered fuel cycle.

Due to dwindling domestic uranium reserves, electricity generation from nuclear power in India declined by 12.83% from 2006 to 2008. Following a waiver from the Nuclear Suppliers Group in September 2008 which allowed it to commence international nuclear trade, India has signed bilateral deals on civilian nuclear energy technology cooperation with several other countries, including France, the United States, the United Kingdom,, Canada. And South Korea.. India has also uranium supply agreements with Russia, Mongolia, Kazakhstan, Argentina and Namibia.

India is among top 5 destinations worldwide for solar energy development as per Ernst & Young's renewable energy attractiveness index. India presents substantial potential for investments in the solar energy segment, particularly in the manufacture of solar photovoltaics. The recent Special Incentive Package Scheme (SIPS) for semi-conductors has attracted the interest of several players.

The Government of India has launched the National Solar Mission. The main features of the Mission are:

- The mission envisages an installed solar generation capacity of 20,000 MW by 2022, 1,00,000 MW by 2030 and of 2,00,000 MW by 2050.
- The total expected investment required for the 30-year period will run is from USD 19 to 23 billion.
- Between 2017 and 2020, the target is to achieve tariff parity with conventional grid power and achieve an installed capacity of 20 GW by 2020.
- 4-5 GW of installed solar manufacturing capacity by 2017.

IEP Parikh committee report in August 2006 said that even if India somehow succeeded in raising the contribution of renewable energy by over 40 times by 2031-32 inclusive of a renewable power capacity of 1,00,000, contribution of renewable to India's energy mix would not go beyond 5.6% of total energy required in 2031-32.

Greater reliance on renewable energy sources offers enormous economic, social, and environmental benefits. The potential for power production from captive and field-based biomass resources, using technologies for distributed power generation, is currently assessed at 19,500 MW including 3500 MW of exportable surplus power from bagasse-based cogeneration in sugar mills (MNES 2005).

The renewable purchase obligation (RPO) is being implemented throughout the country for compulsory use of a minimum quantity of renewable energy in the power supply system. Under the Electricity Act 2003, the National Electricity Policy 2005, and the Tariff Policy 2006 it is obligatory for the state electricity regulatory commissions to purchase a certain percentage of power from renewable energy sources.

India's Strategic Energy Partners are Russia, Central Asia-Kazakhstan & Turkmenistan, China, Japan, Korea, Saudi-Arabia, Iran, Turkey, Norway, Nigeria, Angola, Sudan, Venezuela, Brazil, Ecuador and Cuba, USA, UK & Canada and it is needed to accelerate the strategic move with these countries.

Conclusion

Energy Security in India is the major challenge for the nation. The increase in current as well as future import dependence has repercussions on it. With globalization taking place, supply disruptions from one region would affect the other regions as well. Thus safeguarding energy security with right strategy and consolidated short and long term measures is required to achieve sustainable development.

For India it is not a question of choosing among alternate domestic energy resources but to exploit all available domestic energy resources to the maximum as long as they are competitive. The options are:

- Increasing the nuclear power capacity to 20 fold by 2031-32, so that the contribution to India's energy mix is up to 6.4%.
- Increasing the uses of renewable energy by 40 fold, it may account more than 6% of India's energy mix by 2031-32.
- In all scenarios, fossil fuels needs to be around 75% to
- 85% of the energy mix, as against 96% at present.
- Other sources like gas hydrates, tidal, shale gas, CBM etc should be given sufficient R&D to exploit them economically.

References

India energy handbook, 2010, PSI Media Inc, USA.

Energy statistics-2010, Ministry of stastics & programme implication, GOI, Eighteenth issue, 2011,

Overview of coal mining Industry in India, CIL book, 2007.

Basic statistics on Indian Petroleum & Natural Gas-2009-10

IEA Database & World Energy Outlook

Integrated Energy Policy Report-2006, Planning Comm.

Pachauri Dr. P K , 2011, Keynote Lecture of at ONGC, Dehradun

Report, Ministry of Power, GOI, 2011

Ahemad Talmiz Global Energy Security and India's Energy diplomacy, 2010, IEE, Riyadh.

Wikipedia.org

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