
Energy Scenario in Transport Sector in India

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Prologue

The Author, who has a vast experience in consultancy and project management, had agreed to our request for reviewing the energy scenario in India with particular reference to the transport sector. His well-researched paper brings out the requirements for a sustainable and affordable energy and transport scenario. The demand/supply gap for the next

twenty-five years has also been vividly brought out.

The Author, former MD RITES, has also suggested a road map for reducing the demand-consumption gap in the coming years. A very informative and thought-provoking Article indeed.

- Editor

Introduction

In 2005, India's transport sector consumed 11% of its total primary energy demand (16.9 % of commercial energy supply). 78 % of this demand was consumed by Road Transport, 11% by Aviation, 10 % by Rail Transport and 1% by Inland Water. The Transport sector is set to grow at over 6% per annum on the back of rising economic activity and a rapid surge in the vehicle stock. By 2030, the share of transport sector is likely to double to about 20 % of the primary energy demand. Globally, the share of the Indian transport sector is likely to triple from its low of 2% in 2005 to about 6% in 2030. The growth of transport sector, primarily driven by road transport will remain heavily dependent on the availability and affordability of oil. For the energy requirements of the country as a whole, coal will, however, remain a dominant fuel with its share at 48% of total energy needs in 2030, followed by oil at 25%. The total demand of primary energy is likely to go up from 566 Mtoe in 2006 to 1280 Mtoe in 2030 with a CAGR of 3.5 %, higher than that of China at 3.0% and the World average of 1.6%. (World Economic Outlook – 2007 and 2008)

The finite nature of extractable coal (also its poor quality, long haulage) and the slow pace of crude oil production within the country will make India increasingly dependent on imports. It will be exposed to global supply risks and external price shocks casting a shadow on the long term sustainability and security of its energy requirements.

Availability of resources world-wide will not be a concern, but the huge and timely investments required to match the unprecedented demand fuelled by China and India (given their impressive growth and sheer size), with added costs for clean energy, will pose a formidable challenge for all the countries. **A collective effort and unified policy direction is the need of the hour.**

As for India, there is an urgent need to implement the recommendations of **“Integrated Energy Policy – Aug 2006”** and to go even beyond these recommendations, for new initiatives to reduce the dependence on import to the extent possible.

Note: Data is primarily based on figures published by International Energy Agency, except where indicated. Base year has been taken as 2006, unless specifically mentioned. Outlook period has been taken as 2006 to 2030. World's GDP growth has been assumed to grow at 3.3 % during the outlook period and that of India at 6.3%. Projections are based on past trends but do take into account the impact of policies already adopted world wide. This forms the basis of the **Reference Scenario (RS)**. If policies already announced are implemented and new initiatives are put in place, the demand may come down by about 16%. This forms the basis for **Alternative Policy Scenario (AP)**. Like-wise if growth remains higher than projected, energy demand will go up manifold. This forms the basis for **High Growth Scenario (HG)**. In case India is able to achieve a sustained GDP growth rate of 8%, as is being projected now, energy needs may go up by about 16% over and above those projected in the Paper.

Overview

There are two central challenges before the country : First, a sustainable and affordable energy and second, an environmentally benign system. This paper deals with the 1st challenge on the broad Indian canvas, with special focus on the transport sector. Whatever we do to tackle the first challenge, will have a very significant impact on the second one.

Some key energy indicators for the year 2006 for India in relation to China, USA, OECD countries and the World are given in Table 1:

Table 1 : Selected Energy Indicators for 2006

Country / Economy	Indicator unit	Population	GDP (PPP)	GDP per capita	Energy Production	Primary Energy TPES	Energy Supply per capita	Energy Intensity TPES/GDP (PPP)	Electricity Consumed per capita
		million	billion 2000\$	PPP	Mtoe	Mtoe	Kgoe	Toe	KWh
INDIA		1110	3671	3310	436	566	510	0.15	503
CHINA		1319	8916	6760	1749	1897	1440	0.21	2060
USA		300	11265	37675	1654	2320	7740	0.21	13515
OECD		1178	31158	26450	3842	5537	4700	0.18	8381
WORLD		6536	57564	8807	11796	11740	1800	0.2	2659

Mtoe : Million tonnes of oil equivalent Toe : Tonnes of oil equivalent
Kgoe : Kgm of oil equivalent TPES : Total Primary Energy Supply

Source : Key World Energy Statistics 2008, IEA.

- The per capita consumption of energy in India at 510 kgoe is significantly lower than that of China at 1440 kgoe, USA at 7740 kgoe, the world being 1800 kgoe. Similarly, the per capita consumption of electricity at 503 KWh is significantly lower than that of China at 2060 KWh, USA at 8381 KWh, the World average being 2659 KWh. Both these parameters are a good indicator of the level of economic development.
- India's per capita GDP, which is a factor in determining Human Development Index (HDI) is also significantly lower than those of the developed countries. However it has crossed the threshold level of \$ 3000 .
- India's energy use efficiency for generating GDP at 0.15 toe, is happily lower than that of China, USA or the World average. There are however better performing countries such as Hong Kong /China at 0.08 toe, Japan at 0.10 toe and Denmark at 0.12 toe. There is some incongruence in the derived figure of energy intensity for India. According to Indian official data 2000-2005, the demand for diesel which makes up for 70 % of the oil used in road transport fell at the rate of 0.7%. Energy consumption in the transport sector grew only by 1.9%, in spite of a 14% increase in vehicle ownership during this period. Increase in the prices of petrol and diesel and introduction of more efficient vehicles could partially explain this surprising trend, but perhaps there is more than what meets the eye. Whatever be the actual figure for energy intensity, it is a good indication that with the available technologies, it is possible to achieve the energy intensity levels of around 0.10 toe and there is considerable scope of improvement even from the current, though controversial, figure of 0.15 toe.
- If India has to maintain its projected growth rate of 6.3 % over the outlook period (RS) , it must face up to providing clean, convenient, and reliable energy at affordable price to its vast population, industry and other sectors. The primary energy demand to cater for this over the outlook period is reflected in Table 2.

Table 2 : Energy Demand through Outlook Period (RS)

Country/ Economy	Primary Energy Demand (Mtoe)					Share (%)		Growth (% p.a.)
	2006	2015	2020	2025	2030	2006	2030	
India	566	771	905	1075	1280	4.83	7.52	3.5
China	1898	2906	3282	3629	3885	16.18	22.83	3.0
USA	2319	2420	2460	2533	2566	19.77	15.08	0.4
OECD	5536	5878	5994	6122	6180	47.20	36.32	0.5
WORLD	11730	14121	15123	16149	17014	100.00	100.00	1.6

Mtoe: Million tonnes of oil equivalent

Source: *World Energy Outlook 2008*

In absolute terms, India's primary energy supply must grow from 566 Mtoe in 2006 to 1280 in 2030 at an annualized growth rate of 3.5 %, taking its share of world's primary energy from 4.83 % to 7.52%. This will still be well below China's share at 22.83 %. It is interesting to note that more than half (57%) of the additional demand during the outlook period comes from China (46%) and India (11%).

The demand on the electricity generation over the outlook period is shown in Table 3.

Table 3 : Electricity Generation over Outlook Period (RS)

Country/ Economy	Electricity Generation (Twh)					Share (%)		Growth (% p.a.)
	2006	2015	2020	2025	2030	2006	2030	
INDIA	744	1286	1654	2108	2645	3.93	7.95	5.4
CHINA	2903	5559	6606	7495	8241	15.34	24.77	4.4
U.S.A	4272	4616	4848	5090	5332	22.58	16.03	0.9
OECD	5536	5878	5994	6122	6180	29.26	18.58	0.5
WORLD	18921	24975	27708	30512	33265	100.00	100.00	2.4

Twh: Terawatt-hour = 10^{12} Watt

Source: *World Energy Outlook 2008*

- To keep pace with the energy needs, electricity generation will have to grow at an annualized rate of 5.4 % (Table 3) compared to 4.36% from 2002 to 2007. In spite of the growth of 4.36% in the past, availability of power has been continually falling short of demand due to significantly high transmission and distribution losses (current shortage is at 8% with peak shortage at 11.6%).

Fuel-wise Energy Demand

Fuel wise primary energy demand, during the outlook period for the Reference Scenario is given in Table 4:

Table 4 : Fuel-wise Primary Energy Demand in Mtoe (RS)

	Energy Demand (Mtoe)		Share (%)		Growth (%p.a.)
	2005	2030	2005	2030	2005-2030
Total Primary Energy Demand	539	1299	100	100	3.6
Coal	208	620	39	48	4.5
Oil	129	328	24	25	3.8
Gas	29	93	5	7	4.8
Nuclear	5	33	1	3	8.3
Hydro	9	22	2	2	3.9
Biomass and waste	158	194	29	15	0.8
Other renewables	1	9	0	1	11.7

Mtoe: Million tonnes of oil equivalent

Source : *World Energy Outlook 2007*, IEA

Note: There is minor variation in these figures from those in Table 2 which are based on WEO 2008, which has factored in the impact of recent global slow down.

Integrated Energy Policy

In order to meet with these challenges, the Planning Commission has drawn up an “**Integrated Energy Policy, Aug 2006**” on the advice of the Expert Committee, chaired by Dr. Kirit. S. Parikh, Member (Energy), Planning Commission. Some of the interesting observations for the outlook period are:

- **Primary energy** supply must grow at a CAGR of 4.3 % to 5.1 %.
- **Commercial energy** supply must grow at a CAGR of 5.2 % to 6.1 %.
- **Coal** will remain India's most important source accounting for not less than 41% of energy mix under any scenario and potentially reaching 54% of the energy mix under certain scenarios. Even at 41% level India will need about 1.6 billion tonnes of coal (4 times the current production). Known extractable coal can last for 40 years and perhaps 80 years if properly surveyed and efficiently extracted. Imported coal for coastal plants will however be economical over domestic coal as well as imported gas and should be encouraged. Coal imports in any case will be required upwards of 11% (minimum demand, maximum production scenario) and could go up to as high as 45% (maximum demand, minimum production scenario). About 75% of domestic coal production will continue to be used for power generation. (WEA forecast for Coal in the energy mix is 48% in 2030).
- **Oil** - Production of crude oil will be a major concern. Reserves are low, about 5 to 6 years of the present consumption. New finds may help to some extent. India will remain heavily import dependent (over 90 %). Runs a major risk of supply dislocations and external price shocks. Refining capacity is, however, in excess of demand.
- **Gas** - Reserves and production are low. Availability will remain a concern. Attempts should be made to access cheap imported natural gas on long term basis and set up captive fertilizer /gas liquefaction plants in the gas rich countries. (*Reliance's recent find in block D-3 and D-9 in KG basin of about 20 trillion cft and similar claims by ONGC, when confirmed, will make India almost self sufficient on current demand. - Author*).
- **Hydro** - Even if full hydro potential of 1,50,000 MW is realized (current utilization is at 17 %), its contribution to energy mix will remain at 1.9 % to 2.2 %.
- **Nuclear** - Even if there is a twenty-fold increase, its contribution to energy mix will be 4% to 6.4 %. There is a big potential for developing thorium cycle, given the large reserves of Thorium. Nuclear deal will make a major impact and will be the most potent measure for long term energy security.
- **Renewables** - Even with a forty-fold increase, contribution to energy mix will be about 5% to 6% . Solar power holds promise. (*use of solar thermal power could make a sizeable impact reaching the contribution level of 5 to 6 % much earlier. - Author*).

India will find it increasingly hard to import the required fossil fuels with its share at a low of 13 % of the incremental world supply in the case of most energy efficient scenario to a high of 21% in the coal dominant scenario.

Some of the important recommendations of the Integrated Policy are as under:

- Improve energy efficiency and energy conservation.
- Maximise domestic coal production.
- Create coastal infrastructure for import of coal.
- Ramp up nuclear and hydro options.
- Develop in-situ coal gasification technology.
- Redouble exploration efforts for coal, oil and gas.
- Access hydrocarbon reserves overseas and gas pipelines to India
- Create technology mission for carbon sequestration.
- Create technology mission for use of solar power.
- Undertake pilot projects for use of biomass and bio-fuels.
- Undertake R&D for exploiting gas hydrates.
- Access off-shore wind power potential.
- Undertake R&D for fusion technology.

Transport Sector

Transport sector is the life line, and the economic growth of any country is vitally linked to the health of its transport sector. India is likely to become the most populous country in the world by 2031, overtaking China's population (U.N report 2006). The urban population is likely to reach 40% from 30% presently. India's per capita income has risen to Rs 33,283 in 2007-08 (up 60 % in last 5 years) and has reached a tipping point in personal ambitions of western life style, and ownership of personal transport. The explosive growth of two wheelers and cars will lead to a massive demand for road infrastructure, urban planning and availability of fuel. Air travel will also see a big spurt. Whatever be the advantage of rail transport in terms of fuel efficiency and emissions (debate has been going on for years), its share will go down further. Some quick and positive steps by the Government in having Mass Rapid Transit Systems and High Speed Trains may help reduce the gap to some extent. Similarly, rail share of Freight is likely to decline in favour of road. Here again, the development of Freight Corridors is likely to tip the balance somewhat. A likely mode-wise mix is given in Table 5.

Table 5 : Likely mix of the Transport Sector over the outlook period

FREIGHT

Mode	2006-07		2029-30	
	Mill. Tonnes	% Share	Mill. Tonnes	% Share
Rail	728	34.60	5300	30.24
Road	1300	62.00	12000	68.20
Coastal Shipping	70	3.30	270	1.50
Air	2	0.10	10	0.06
Total	2100	100.00	17580	100.00

PASSENGER

Mode	2006-07		2029-30	
	Nos. (Bill)	% Share	Nos. (Bill)	% Share
Rail	6.20	15.70	19.20	13.00
Road	33.00	84.05	125.20	84.00
Coastal Shipping	0.001	0.05	0.009	0.10
Air	0.090	0.20	2.30	2.90
Total	39.291	100	146.709	100

Note : All the figures would be subject to change in view of the financial crisis.

Road sector will remain the most dominant player in the transport sector carrying 84% of passengers and 68% of freight. Of the total energy consumed in the transport sector 98.5 % is met through petroleum products and the rest by electric power. Transport sector consumed 27% of total oil and oil products in India during 2006-07. This is likely to go up to 45% by 2030; 97% of its fuel requirement will be met by the liquid fuels (petroleum products), where India is already import dependent for crude oil. (WEO-2008)

As per the official figures, India's energy demand for transport grew by 1.9 % per annum in 2000-2005. As already stated, these figures do not match up the actual physical growth of transport during this period. According to IEA's estimate, the transport demand will grow at a brisk pace of 6.1 % per annum. The demand almost doubles by 2015 and more than quadruples by 2030, reaching 162 Mtoe. The share in the primary energy increases from 10 % in 2005 to 20 % in 2030. Further, the share of global transport energy is likely to triple from 2% in 2005 to about 6 % in 2030. (WEO 2007)

Transport sector currently consumes 27% of the total primary oil demand (2005). This is likely to increase to 47 % in 2030, with road transport consuming a hefty 40 % of this. The likely mode-wise projection for share of energy is given in Table 6.

Table 6 : Mode Wise Share of Energy in Transport Sector

Mode	2006-07	2029-30
Road	78 %	86%
Aviation	11%	9%
Railways / IWT	11%	5%

Source: WEO 2007, IEA

Road Transport

The number of vehicles on road in India increased from 19 million in 1990 to 67 million in 2003. This went up to 72.7 million in 2004, an increase of 8.5% (TERI). According to a conservative estimate of IEA, the population of vehicles on road is likely to reach 295 million by 2030 (a growth of of 5.7 % per annum). Two wheelers will

account for 50 % of total vehicle stock in 2030. (Small cars such as Nano may have an impact which is yet to be assessed). The fleet of Light duty vehicles (LDVs) will increase faster than any other category at about 10 % annually, growing from 11 million in 2005 to 115 million in 2030.

High Growth Scenario

Experience around the world shows that vehicle ownership takes-off when per-capita GDP expressed in PPP terms reaches a level of between \$3000 and \$10,000 (ADB, 2006). India's per capita GDP crossed the tipping point in 2006 at per-capita GDP of \$ 3310 and has seen a corresponding increase in vehicle ownership rate. If India is able to achieve a GDP growth of 8 %, the ownership of vehicles and the fuel consumption will see a very significant increase, 27 % more than projected in the Reference Scenario. *(It is doubtful if the required investment and requisite infrastructure will be in place to keep pace with such a staggering demand)*

Oil Supply

Table 7 gives the existing consumption and future demand of crude oil in India. Table 8 gives India's crude oil production in 2006.

Table 7: Primary Energy Demand – Oil (Mtoe)

PERIOD	1990	2000	2005	2015	2030	2005-2030
OIL	63	114	129#	188	328*	3.8% / annum

equivalent to 2.7 mb/day

* equivalent to 6.85 mb/day

Table 8 : India's Crude Oil Production 2006

	Onshore	Offshore	On/offshore	Unidentified*	Total
No of fields	85	9	1	41	136
Beyond peak	56	9	1	-	66
Production(kb/day)	157	414	35	80	687
Share (%)	23	60	5	12	100

*fields for which production is not reported

Source: IHS data base : IEA estimates

All 9 offshore fields, which contributed 60 % of crude have peaked; 66 % of onshore fields, which contributed 23% of crude have also peaked. Crude production is estimated to peak at around 750 kb/day in 2010 and decline to about 400 kb/day in 2030. New finds may just about to offset the decline in the matured fields. The time taken between discovery and production of a new field is about 8 to 10 years. This, when viewed in the face of a projected demand of 6.85 mb/day in 2030 at GDP growth

of 6.3 % (CR), indicates an import dependency of over 94 %. In 2024, India is likely to be 3rd largest oil importer after USA and China.(WEO-2007)

India spent \$68 billion on import of crude in 2007-08.

India imported 2.56 million barrels/day of crude oil in 08-09 (View this in the context of crude oil demand of 6.85 mbd/day in 2030 in Reference Scenario and 27 % more in case of the High Growth scenario).

India has decided to create an emergency oil stock, to mitigate short term supply disruption, Phase I (started in 2007), is likely to be completed in 2012 at a cost of \$2.7 billion with a capacity of 5 Mt (14 days of domestic consumption). The oil reserves will be held in rock caverns with inter connected galleries. 2nd and 3rd phase will cater to another 10 Mt. These are yet to be taken up.

The demand on oil could decrease by about 17% in case of Alternate Policy Scenario, but could also go up by about 27% in case of high growth scenario if GDP of 8 % per annum is achieved.

India has to up its investments in E&P, particularly in off shore exploration where potential is high. Indian service industry and R&D will have to be supported in a big way. Acquisition of overseas oil assets through joint ventures, and bilateral agreements will continue to dominate the agenda before the Government.

Options

The following options exist before us to substitute oil:

- Industrial use of Naptha, Fuel Oil, High Speed Diesel Oil and domestic use of LPG and Kerosene should be replaced by natural gas. Gas should be used for Power Generation only after meeting the above demand (gas availability is expected to be much better than oil).
- Increase use of Bio Fuels.
- Encourage blending of Ethanol with petrol.
- Extend electrification of Railways.
- Improve Railway's freight service for a larger share in transport.
- Promote urban mass transport.
- Improve fuel efficiency of motorized vehicles.
- Encourage use of hybrid vehicles.

Under former President Kalam's vision for energy independence, India could eliminate its oil dependence over the next 40 to 50 years by

- Developing solar power using photovoltaic cells. Surplus solar power during day time can be used to split water to produce hydrogen that can

provide electricity at night and can also be used to run motor vehicles using fuel cells.

- Developing cheap batteries with high storage density for the hybrid/ electric vehicles.
- Developing nuclear power based on Thorium.

Conclusion

Coal will be the dominant fuel for India for the next 20 to 30 years or even beyond. Oil will remain the predominant source for the growth of transport sector. Road transport will prevail over other modes. Both coal and oil are finite commodities. Import dependence will be very high. Global supply risks and price shocks are a matter of great concern. Creation of reserve stock is vital to sustained growth. There is an urgent need to follow the recommendations of the Integrated Policy, 2006 (Planning Commission). Energy conservation measures must be highlighted and implemented without delay. Having single Ministries for Energy as well as for Transport, as recommended by the Administrative Reforms Commission are highly desirable but in the current political set up difficult to implement.

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