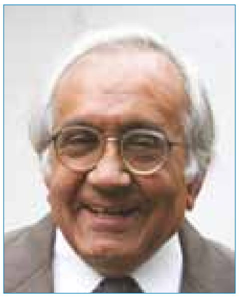
India's emerging energy needs and supply options



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India, like China, is expected to be one of the main drivers of world energy consumption as India's economy continues to grow at a rapid rate. Indeed its energy needs could be even more dynamic than those of China. In addition to a quasi-Chinese rate of economic expansion, it is also undergoing rapid population growth. Moreover, it is chasing the ever-moving target of trying to link all its people to the electricity grid. Of the 1.5bn people who according to the International Energy Agency lack access to electricity in the world, nearly 400m live in India. However, India's RGGVY (Rajiv Gandhi Grameen Vidyutikaran Yojna- Rajiv Gandhi Village Electrification Scheme) has the objective to electrify all villages and connect free of cost all estimated around 25 million households below the poverty line by March, 2012. If successful, this massive effort of electrification would have consequences for world energy producers vying to supply this modern form of energy to the Indian economy, as well as being of enormous benefit to the currently power-less poor of India.

Since 1994, the energy intensity – the ratio of energy input to economic output – of India's economy has been declining, as in most countries of the world. In figure 1 we see that it has fallen from 0.0259 kgoe/rupee in 1994 to 0.0208 kgoe/rupee by 2009. This also shows the growth in total primary commercial energy supply (TPCES); the reason for defining it as 'commercial' is to exclude the considerable use in the Indian countryside of firewood and animal dung which do not enter the regular economy. Commercial energy grew from around 210 Mtoe in 1994 to around 474 Mtoe in 2009. The twin drivers of this growth in energy use have been economic expansion and population growth. In the period of 1994 to 2009 India's GDP grew at an average growth rate of 7 per cent, whereas in the latter part of this period (2003-2009) the rate of economic expansion accelerated to an average of 8.3 per cent.

Figure 1: Energy intensity and TPCES in India since 1994

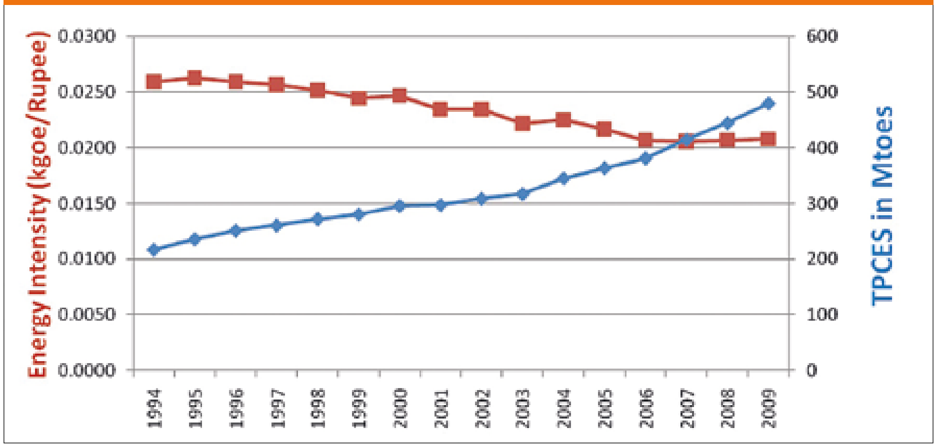


Table 1: TPCES until 2030

Year	Population (billions)	GDP (Rs billions) at 1993-94 prices		TPCES* (Mtoe) GDP growth rate	
		8%	9%	8%	9%
2009	1.169	23098	23098	474	474
2010	1.176	24946	25177	502	506
2015	1.254	36654	38738	657	684
2020	1.326	53856	59603	860	925
2025	1.389	79132	91706	1114	1236
2030	1.44	116271	141101	1445	1654

Source: http://www.censusindia.net/, and RBI (2010), Table 2
** based on falling elasticities of 0.75 for 2004 to 2010, 0.70 for 2010 to 2020 and 0.67 for 2020 to 2030.*

Table 2: projected electricity requirement until 2030

Year	Total energy requirement at GDp growht rate		Energy requirement at GDP growth rate (BKWh)		Projected peak demand GW at GDP growht rate		Installed capacity (GW) required at GDP growth rate	
	8%	9%	8%	9%	8%	9%	8%	9%
2009	906	906	834	834	125	125	188	188
2010	974	982	897	904	138	140	202	204
2015	1348	1414	1241	1302	197	206	280	293
2020	1866	2036	1718	1874	280	306	387	422
2025	2519	2850	2319	2623	378	428	522	591
2030	3403	3993	3133	3675	511	599	706	828

Source: Ministry of Finance (2011) & Planning Commission of India (2006)
• based on falling elasticites of 0.95 from 2004 to 2010, 0.85 from 2010 to 2020 and 0.78 from 2020 to 2030.
• Electricity generation and peak demand is the total of utilities and non-utilities above 1MW size.

Table 1 shows how population, economy and energy use are likely to rise in absolute numbers over the next 20 years to 2030 and how these trends translate into India's future electricity needs is illustrated in table 2.

What would be the impact on electricity requirements if all households were connected to electricity?

To estimate this, first of all we need to establish a baseline by projecting from the last household energy consumption survey of 1999-2000 what household energy use would be in 2030. This takes account of the fact that as households' income rises so does their overall energy consumption, but it assumes that within their overall energy consumption, their pattern of fuel use (as between electricity, firewood, dung etc) would remain unchanged. Table 3 shows the result.

It should be noted that the requirement of electricity, kerosene and gas for household consumption are included in the projection given in Table 3. The impact of the RGGVY scheme, which targets provision of electricity to all by March 2012, will alter the demand for electricity. To account for this impact, household demands are projected from 2010 onwards using the energy use pattern of only those households, which had electricity in the 1999-2000 household consumption survey. These projections are given in Table 4.

The differences between the two tables give us the impact of electrification of households on their energy consumption. This is summarised in table 5. The differences are substantial only in 2015, as even without the acceleration in rural electrification planned under RGGVY, most of the households will have been electrified by 2020. It is worth noting that for the year 2015 electrification does not reduce kerosene consumption significantly. This is rational. As long as kerosene is available, especially subsidised kerosene, what is saved from lighting is used as fuel and the consumption of dung goes down. This substitution is more convenient and the dung saved has greater value as fertiliser.

Electricity demand grows by 5 mtoe which is around 16 bkwhr in 2030, for which we have projected a requirement of 3100 to 3600 bkwhr. Even after adding T&D losses and auxiliary consumption, additional demand for households comes to be around 0.5 per cent of the total projected electricity requirement.

Electrification of all the villages would not only increase household demand but also increase consumption for productive industrial activities.

Since many rural households use dirty bio-fuels such as wood and dung, they suffer from indoor air pollution with significant adverse impact on health particularly of women and children. It is estimated in 2001 that 25m adults had symptoms of respiratory diseases with 17m having serious symptoms.

Also 30bn person hours are spent in gathering bio-fuels often by girls who are kept out of school. Due to these externalities on health and education, India's integrated energy policy plans to provide entitlements of liquid petroleum gas (LPG) to all households appropriately subsidized for the poor households. The additional requirement of subsidized LPG in 2015, if the programme is fully implemented by then, is estimated to be around 15 →

Table 3: Projected energy consumption by households in India 2030 (Mtoe)

Year	Fire wood		Electricity		Dung		Kerosene		LPG	
	8%	9%	8%	9%	8%	9%	8%	9%	8%	9%
2005	87	87	16	17	36	36	12	12	14	14
2010	93	93	25	27	40	40	14	14	22	24
2015	98	98	36	39	42	41	15	15	31	34
2020	101	102	48	52	42	41	15	15	40	42
2025	104	105	59	63	41	40	15	15	47	48
2030	106	106	68	70	41	40	15	15	51	52

Table 4: Impact of electrification on household energy demand (Mtoe)

Year	Fire wood		Electricity		Dung		Kerosene		LPG	
	8%	9%	8%	9%	8%	9%	8%	9%	8%	9%
2010	88	88	28	30	32	32	13	13	23	25
2015	92	92	40	44	32	31	14	14	32	35
2020	96	97	52	57	32	31	14	14	41	43
2025	99	100	64	68	30	29	14	14	47	49
2030	102	102	73	75	29	29	14	14	52	52

Table 5: Changes in energy consumption by households in 2030 with electrification (Mtoe)

	Fire wood		Electricity		Dung		Kerosene		LPG	
	8%	9%	8%	9%	8%	9%	8%	9%	8%	9%
Difference	-4	-4	5	5	-11	-11	-1	-1	0.3	0.2

→ mtoe which would reduce over time as incomes increase and fewer households qualify for subsidy. Thus, the implications of energy access to all are really modest and benefits significant.

Supply Options

India's options for energy supply are limited. It has very small reserves of crude oil and currently nearly 80 per cent of consumption of petroleum products is based on imports. While some more reserves of natural gas have been located in the Krishna-Godavari basin, these deep sea reserves pose formidable challenges to exploit. Domestic gas is not expected to constitute more than 20 percent of India's primary energy supply. The most important resource is coal. India will continue to depend on it for the next few decades. Even for coal, the presently estimated extractable reserves would be exhausted in 40 to 45 years if coal consumption keeps growing at the current rate of growth of 5 per cent per year.

Among the renewables hydro-power is important. However, assuming full development of India's potential, it can generate no more than 450 bkwhr of electricity. Compared to the projected requirement for 2030 of 3400 to 4000 bkwhr, this is less than 15 per cent. Wind power potential is much smaller and with the current technology the estimated potential of 45 GW can generate about 90 bkwhr which will be less than 3 per cent of the needed generation in 2030.

Other renewables such as ethanol, bio-diesel and wood plantation have limited scope as India is short of land and these would compete with food production. Cellulosic ethanol, when the technology is developed can make a substantial contribution if ethanol can be produced from agricultural wastes such as wheat straw or rice straw.

The sources that have sizable potential are solar energy and nuclear power. India's strategy is to use its limited uranium reserves to run first generation plants that also produce plutonium along with power, using the plutonium in fast breeders reactor that produce more plutonium than what is put in, and then using in the third stage its abundant resource of thorium can provide 4 to 5 million MW of power for more than 100 years. The catch here, however, is the time required to realise this. By 2030 one can expect no more than 100 GW of nuclear capacity.

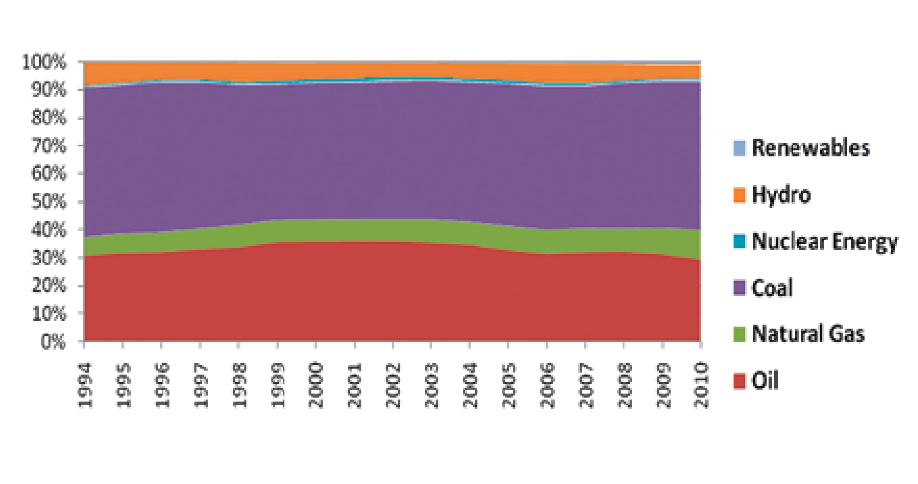
Solar is abundant and the land requirement does not have to compete with agricultural land. The problem is its high cost. Today solar power costs 5 times as much as coal power in India. Yet there is lot of hope that solar power can be made cost-competitive with coal power by 2020. India's long-term hope for energy security rests critically on realising that goal. Energy efficiency is a major resource and should be pursued with the highest priority. Nonetheless there are limits to what it can deliver. Our projections based on falling elasticities do embody gains from energy efficiency to a large extent. ■

Table 6: Percentage of energy use met by domestic production

	1980-81	1990-91	2000-01	2011-12*
Coal	99.7	97.8	96.1	93.02
Lignite	100	100	100	100
Oil	32.6	42.8	30.3	27.59
Natural gas	100	100	100	69.30
Hydro	100	99.93	99.96	95.94

Source: Planning Commission, 2008
** Projected; Note: Excludes nuclear and wind power; does not take into account increases in domestic gas production from 2009*

Figure 2: Structure of Commercial Energy Supply



Source: BP (2011)