

A 'dashboard' for the Indian energy sector

Ashok Sreenivas, Rakesh K. Iyer, Prayas (Energy Group)

(A version of this paper appeared in the March 14, 2015 issue of the *Economic and Political Weekly*)

1 Assessing the energy sector

Energy is among the key drivers of human development (Dixit & Nhalur, 2010, p. 5). This is particularly true for countries such as India where increases in per-capita energy consumption correlate well with improvements in human development levels as measured through HDI¹. Therefore, objective assessments of the energy sector are important to provide critical feedback to policy formulation, so that energy is harnessed effectively for human development. Given that energy production, transformation and consumption has impacts beyond the energy sector, such assessments must also consider energy's relation to the socio-environmental context it is embedded in.

Many assessment methodologies in literature focus mainly on energy *supply*, i.e. provision of affordable, reliable supplies of energy (Institute for 21st Century Energy, 2012). Methodologies such as the 'Energy Development Index' from IEA focus on energy *consumption* (International Energy Agency, 2012), while others focus on the environmental impacts of energy production and consumption, particularly in the context of climate change (Sovacool, Mukherjee, Drupady, & D'Agostino, 2011). We believe assessing the sector through any one of these lenses gives only a partial view of the sector, and thus provides potentially incomplete feedback to policy formulation. For example, focusing only on supply reliability may adversely impact environmental sustainability or providing universal energy access. Therefore, a *multi-dimensional* approach is appropriate to comprehensively understand the energy sector and its various trade-offs.

2 A multi-dimensional index to assess the energy sector

(Sreenivas & Iyer, 2014) presents such a comprehensive multi-dimensional index for the Indian energy sector consisting of five independent dimensions:

- a) Energy demand or consumption, to assess energy's contribution to well-being of citizens
- b) Energy supply, to assess how well energy supply is managed
- c) Social impacts, to assess the impacts of energy on society
- d) Environmental impacts, to assess the impacts of energy on local and global environment
- e) Economic impacts, to assess the impacts of energy on the country's economy

Each of these dimensions has a hierarchical structure culminating in a set of indicators such as import dependence or GHG emissions. Totally, there are 32 indicators across the five dimensions. Each

¹ Data shows that each percentage point increase in energy consumption correlates to an equivalent HDI increase.

indicator is scored between 1 and 100, and dimension scores are calculated from indicator scores in a bottom-up manner.

However, it may not be practically feasible to use this comprehensive index to frequently assess the energy sector because data for some indicators is not easy to obtain, and computing the index requires identifying values for 32 indicators which is time and effort-intensive. In this paper, we present a simpler 'energy dashboard' that overcomes these difficulties and enables regular and comprehensive assessments of the sector.

3 Energy dashboard for India

The objective of the proposed dashboard is to enable quick, yet comprehensive, assessments of India's energy sector. The dashboard retains the five dimensions from the energy assessment index, as energy supply and consumption are intrinsic to the energy sector and any comprehensive assessment must also include its impacts on society, environment and the economy. However, we use a smaller, but representative, set of indicators for each dimension in the dashboard. Pragmatic considerations such as representativeness, data availability and manageability, rather than analytical rigour², motivated the choice of indicators, so that the dashboard becomes a practical tool to get an overview of the country's energy sector regularly, say once a year.

3.1 Structure of the dashboard

Each dimension of the dashboard has two sub-dimensions of equal weights, and scoring each sub-dimension needs two to three indicators to capture its essence. The total number of data points required to score the dashboard is a manageable 13.

The indicators in the energy consumption dimension capture the effectiveness of energy in supporting productive lives for citizens. The first indicator examines the use of modern energy in households through two sub-indicators: percentage of households consuming above 500 kWh of electricity per year and the percentage of households primarily using clean fuels³ for cooking. 500 kWh per year is the minimum threshold for electricity consumption as defined by IEA (International Energy Agency, 2012)⁴ and should perhaps be increased in future. Data for this indicator is available from NSSO's household consumer expenditure surveys, which are conducted once in approximately five years (MoSPI, 2013; MoSPI, 2006). The second indicator assesses the role played by energy in supporting rural livelihoods by considering the percentage of rural enterprises (agricultural and non-agricultural) that use any form of

² Other non-rigorous assessments that are useful include HDI for human development levels and annual health checkups for an overview of a person's health.

³ Clean fuels include LPG, biogas, PNG and electricity.

⁴ 500 kWh per year can support the usage of 1 floor fan, 2 CFL bulbs, an efficient refrigerator, 2 mobile phones and one another appliance such as a television or computer (International Energy Agency, 2012). IEA gives this as the normative requirement for urban households, but we use it for all households. The figure of 500 kWh may need to be updated in future as appliance efficiencies change.

modern energy. This information is collected by the Economic Census, though at a lower frequency than the consumption surveys (MoSPI, 2005; MoSPI, 1998).

The energy supply dimension measures the country's dependence on imports and non-renewable sources of energy. The first indicator is net energy import dependence, i.e. the share of net energy imports in total energy supply. The second indicator assesses the sustainability of energy supply by measuring the share of renewable sources⁵ in total energy supply. Total energy supply is defined to include consumption of biomass and other solid fuels (but not human or animal motive power). Data on commercial energy for these indicators is available on an annual basis from various energy ministries (CEA, 2004-2012; CCO, 2013; PPAC, 2014). Unfortunately, reliable data regarding use of biomass is not available, though it forms a significant part of India's total energy supply. Hence, this value has currently been estimated using data from few official documents (GoI, 2006; MoSPI, 2012). In future, it is hoped that availability of biomass-related data would improve and its usage would decrease, thus making this indicator score more robust.

The dashboard attempts to measure two social impacts of energy. The first assesses the effectiveness of rehabilitation and resettlement (R&R) efforts undertaken by energy projects, as they often lead to displacement of households and disruption of livelihoods. This is measured as the percentage of households which were satisfactorily resettled and rehabilitated out of the total households affected by energy projects in a year. Unfortunately, there is no systematic data collected for this indicator, though if the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement (Amendment) Ordinance, 2014 (MoRD, 2014) is implemented well, such data may become available in future. Nonetheless, this indicator is retained in the dashboard as we believe it is important to capture this oft-neglected aspect of the energy sector. The second social indicator captures the inequality in consumption of modern energy in households, measured as the average of two Gini coefficients: household electricity consumption and household LPG consumption. Data for this indicator is available from NSSO household consumption surveys (MoSPI, 2006; MoSPI, 2013).

Environmental impacts are assessed through annual average concentration levels of two pollutants: particulate (RSPM) and chemical (represented as the average of SO₂ and NO_x concentrations), at locations in the vicinity of energy projects⁶. For each location, the ratio of the pollutant concentration to its permissible limit is calculated, and the average of these ratios across locations is considered for scoring. Scoring for chemical pollution is based on the average of scores for SO₂ and NO_x. This data is available for many locations from the Central Pollution Control Board's environmental data bank and

⁵ Renewable sources include biomass whose use is assumed to be sustainable and does not include large hydro-based power generation.

⁶ Up to 26 specific locations near 11 cities were considered, though data is not available for all locations for all years. The cities considered are Kothagudem and Ramagundam (Andhra Pradesh), Bongaigaon (Assam), Korba (Chhattisgarh), Jharia (Jharkhand), Singrauli (Madhya Pradesh), Chandrapur and Tarapur (Maharashtra), Talcher and Angul (Odisha) and Anpara (Uttar Pradesh).

from the Government of India's Open Government Data Platform⁷. GHG emissions are not included in the dashboard as India's per-capita GHG emissions are very low and likely to stay below the global average for the foreseeable future, and hence may not provide any useful insights.

The economic impacts of the energy sector are captured through two indicators. The first is the energy intensity of the economy (energy required to produce one unit of economic output), and is scored based on India's rank among G-20 nations (arranged in ascending order) since there is no 'ideal value' for energy intensity. Energy intensity data is available regularly from the Energy Information Administration website⁸. The second indicator is the share of energy imports in the country's trade balance, for which data is available from the Economic Survey and energy-related ministries (GoI, Economic Survey 2013-14, 2014; CEA, 2004-2012; CCO, 2013; PPAC, 2014).

These proposed indicators in the dashboard capture both positive and negative facets of energy, and hence provide a good overview of various aspects of the energy sector. Data for most indicators is available at reasonable frequencies from public sources, and hence the dashboard can be scored regularly with relatively little effort, making it a practical tool to assess the health of the energy sector. Table 1 summarizes the dashboard structure.

Table 1: Structure of the proposed dashboard for India's energy sector

Dimension	Indicator	Valuation	1-100 Score
Energy consumption	Use of modern energy in households	Average of (% of households consuming at least 500 kWh per year) and (% of households primarily using clean fuels for cooking)	Same as indicator value
	Use of modern energy in rural enterprises	% of rural enterprises using electricity or other fuels	Same as indicator value
Energy supply	Net energy import exposure	% of net imports in total primary energy supply	(100 - indicator value)
	Sustainability of energy supply	% of renewables in total primary energy supply	Same as indicator value
Social Impacts	Quality of R&R	% of households with satisfactory R&R among those affected by energy projects	Same as indicator value
	Inequality in modern energy consumption in households	Average of Gini coefficients of household electricity consumption and LPG consumption	100 * (1 - indicator value)
Environmental	Particulate pollution	Average of ratios of annual	100 * (1- indicator value)

⁷ These are available at <http://cpcbodb.nic.in> and <http://data.gov.in> respectively. In future, one may also consider using the Cumulative Environment Pollution Index or the recently launched National Air Quality Index.

⁸ www.eia.gov

Impacts		average RSPM concentration at locations near energy projects to permitted norms ⁹	
	Chemical pollution	Average of the values for SO ₂ and NO _x using a method similar to RSPM	100 * (1- indicator value)
Economic Impacts	Primary energy intensity	BTU of primary energy per \$ (PPP) of GDP	India's rank among G-20 nations' energy intensities, scaled to 100
	Impact on trade balance	Energy import value as % of trade balance	(100 - indicator value)

3.2 India's energy dashboard scores

We computed India's energy dashboard scores for three years, namely 2004-05, 2008-09 and 2012-13, to illustrate its usefulness. As no reliable data is available for the R&R indicator in the social dimension, we only considered the two Gini coefficients for the social indicator in this evaluation. We only considered LPG consumption for clean cooking fuel in this evaluation, since there is negligible use of other clean fuels in India currently. Some indicator values had to be interpolated or extrapolated as they were not available for the specific year in question, while the nearest available year's data was used for some¹⁰. The scores are presented in Figures 3 and 4, and reveal some interesting insights:

1. The scores are below (or close to) 50 for all dimensions across all years, which is of some concern. Perhaps of greater concern is the fact that scores for two dimensions – supply and environment – steadily deteriorate over this period.
2. The consumption dimension scores improved from a poor 25 in 2004-05 to 33 in 2012-13. The percentage of households consuming electricity above the threshold reached 54% in 2012-13, and the percentage of households using clean cooking fuels increased to 33% in 2012-13, with both increasing at about 5% annually. However, growth in usage of modern energy in rural enterprises has been very slow. It has marginally increased from 21% in 2004-05 to 23% in 2012-13, and it will take more than 100 years for all rural enterprises to use modern energy at current rates of progress.
3. The supply dimension scores fell from 54 to 46 between 2004-05 and 2012-13. The import exposure score in particular decreased alarmingly, as India's import dependence went up to 33% of all energy and 43% of commercial energy in 2012-13. The decreasing score for the share of renewables in total energy supply may actually be a welcome sign. The share of renewables in India's energy mix was about 24% in 2012-13, which is quite healthy. But this high figure is because of the large share of biomass usage, which has many negative health and social impacts. The share of this indicator

⁹ For example, if the ratios of observed concentrations to permitted norms are 0.9, 0.7 and 0.6 at three locations, the score for this indicator would be 27, as the concentration is 0.73 of the norm on average. If the average ratio is above 1 (i.e. above permitted norms), the score is 0.

¹⁰ Inter- and/or extrapolation was used for some years for the two consumption indicators, the biomass component of the supply indicators and the Gini coefficients for the social indicators. 2010 data was used to approximate air pollution values for 2012-13, and 2011 data was used for 2012-13 energy intensity. Data was available for all other indicators and years.

reduced from 31 to 24 over this period, because of the welcome fact that the share of biomass use reduced from about 32% to 23%¹¹, even as the share of modern renewables increased.

4. The scores for the social indicators, which only consist of inequality measures for consumption of electricity and LPG in this evaluation, improved over the years though the scores are still not good. The Gini coefficient for electricity reduced from 0.64 to 0.53, while the Gini coefficient for LPG consumption reduced from 0.82 to 0.72 which is quite high.
5. The environmental dimension scores show a very disturbing trend. Over the years, they reduced from 36 to a poor 29. RSPM concentrations in the vicinity of energy projects have consistently been above permissible limits, resulting in a score of 0 for all three years. The average RSPM concentration at the chosen locations was 1.9 times the permissible limit in 2010, with three locations (near Jharia in Jharkhand and Chandrapur in Maharashtra) recording average concentrations over 3.5 times the permissible limit. Chemical pollution also worsened over time with SO₂ concentrations going up from 20% of norms to 30%, and NO_x concentrations going up from 38% of norms to 56%. This alarming trend, with potentially severe health impacts, should be addressed at the earliest.
6. India's scores on the economic dimension improved from 35 to 46 between 2004-05 and 2012-13, as the contribution of India's energy imports to its trade balance reduced from 74% to 64%, and India's energy intensity rank improved from 11th to 9th among G-20 nations¹².

Figure 3: Energy dashboard across the years

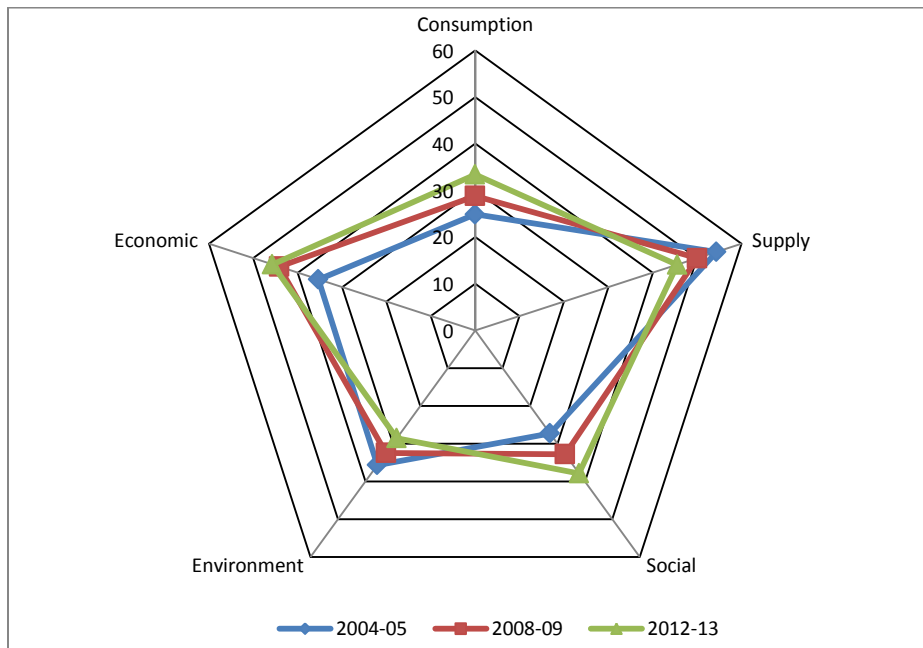
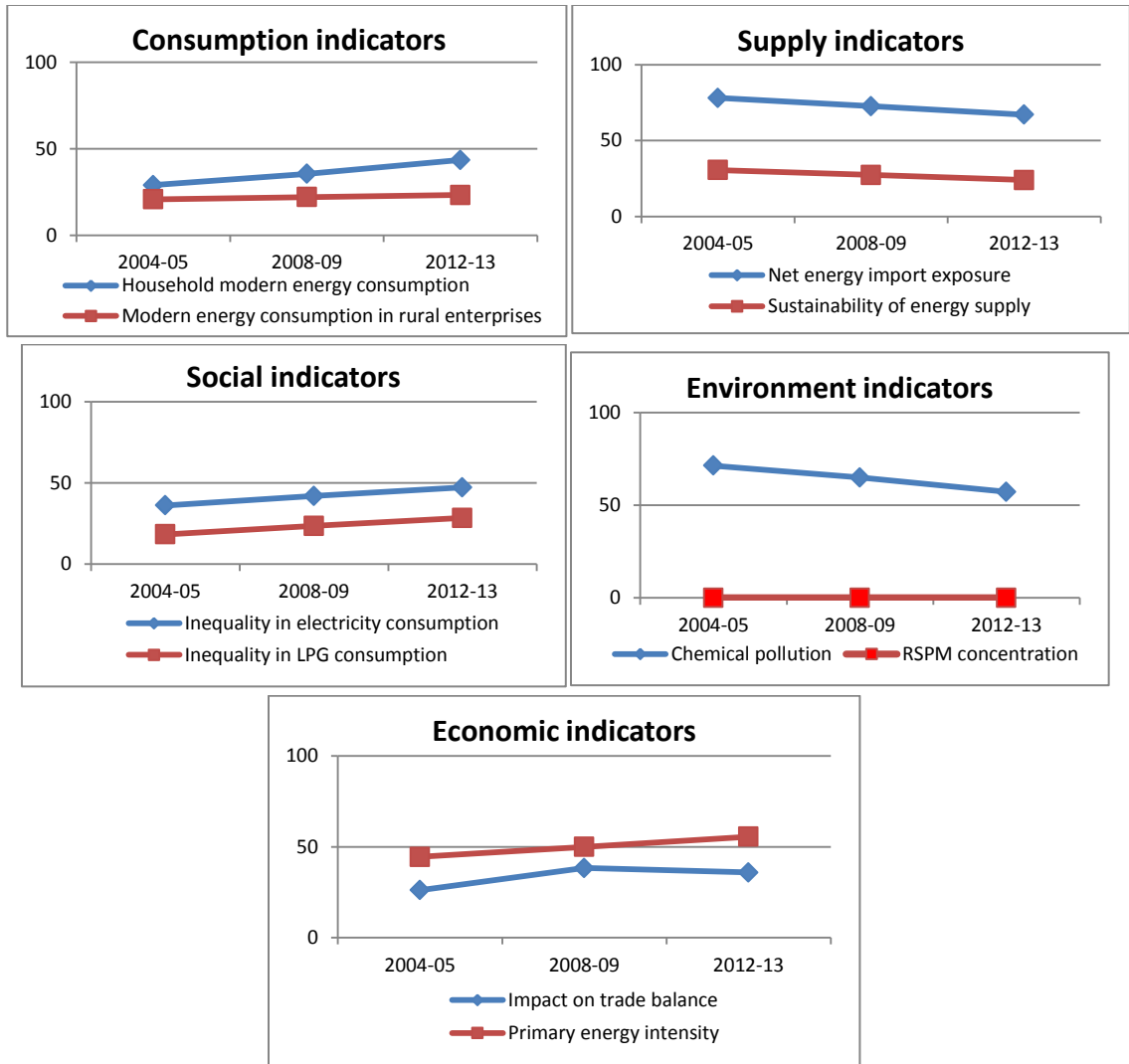


Figure 4: Energy dashboard indicator trends

¹¹ However, the absolute amount of biomass consumed has increased.

¹² The share of energy imports in trade balance reduced because other imports increased faster than energy imports, which went up six times in this period. Over this period, India's energy intensity improved by about 12.6%.



4 Concluding remarks

Given the close relationship between energy and human development, the energy sector should be regularly assessed to understand all its positive and negative impacts, so that it can inform policy formulation accordingly. In this paper, we propose a practical, yet comprehensive, dashboard to easily assess the energy sector periodically, and illustrate its usefulness by scoring the dashboard for three years and analysing the results. The key findings of the analysis are as follows.

- Energy is not contributing sufficiently to peoples' lives as indicated by the low consumption scores. In particular, there needs to be greater attention to provision of modern cooking fuels to households and modern energy to rural enterprises. One hopes that recent Government pronouncements on providing reliable power supply to all by 2019 will help to address some of these concerns (MoP, 2014).

- Rapidly growing energy imports are a serious concern for energy security, and need to be addressed through measures such as improved efficiency, responsible harnessing of domestic resources and better diplomatic initiatives.
- Data regarding key social indicators related to R&R after displacement is not collected systematically. This gap should be addressed.
- The impact of energy projects on the local environment is bad and worsening, with particulate matter concentrations consistently above prescribed limits. This needs to get more attention than it currently does, and addressed on a priority basis.

These findings demonstrate that it is important to regularly assess the energy sector using a mechanism such as the proposed dashboard to get a birds' eye-view of the sector and identify important trends.

5 References

- CCO. (2013). *Coal Directory of India (2012-13)*. Ministry of Coal, Ministry of Coal. Kolkata: Coal Controller Organization.
- CEA. (2004-2012). *All India Electricity Statistics: General Review*. Ministry of Power, Ministry of Power. New Delhi: Central Electricity Authority.
- Dixit, S., & Nhalur, S. (2010). *Electricity for All: Ten Ideas towards Turning Rhetoric into Reality*. Prayas Energy Group. Pune: Prayas Energy Group.
- Gol. (2006). *Integrated Energy Policy*. Planning Commission, Government of India. New Delhi: Planning Commission.
- Gol. (2014). *Economic Survey 2013-14*. Government of India, Ministry of Finance. New Delhi: Ministry of Finance.
- Institute for 21st Century Energy. (2012). *International Index of Energy Security Risk: Assessing Risk in a Global Energy Market*. U.S. Chamber of Commerce. Washington DC: U.S. Chamber of Commerce.
- International Energy Agency. (2012). *World Energy Outlook - Methodology for Energy Access Analysis*. International Energy Agency. Paris: International Energy Agency.
- MoP. (2014, December 28). *Landmark Initiatives Towards Achieving 24x7 Power for All*. Retrieved January 9, 2015, from <http://pib.nic.in/newsite/PrintRelease.aspx?relid=114146>
- MoRD. (2013, September 27). *The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act*. New Delhi, Delhi, India: Ministry of Law & Justice .
- MoSPI. (1998). *4th Economic Census*. Ministry of Statistics & Programme Implementation. New Delhi: Ministry of Statistics & Programme Implementation.

- MoSPI. (2005). *5th Economic Census*. Ministry of Statistics & Programme Implementation. New Delhi: Ministry of Statistics & Programme Implementation.
- MoSPI. (2006, May). Household Consumer Expenditure Survey - 61st round (2004-05). (National Sample Survey Organization, Ed.) New Delhi, Delhi, India: Ministry of Statistics & Programme Implementation.
- MoSPI. (2012). *Energy Statistics 2012*. Ministry of Statistics & Programme Implementation. New Delhi: Ministry of Statistics & Programme Implementation.
- MoSPI. (2013, May). Household Consumer Expenditure Survey - 68th round (2011-12). (National Sample Survey Organization, Ed.) New Delhi, Delhi, India: Ministry of Statistics & Programme Implementation.
- PPAC. (2014). *Indian Petroleum & Natural Gas Statistics (2013-14)*. Ministry of Petroleum & Natural Gas , Ministry of Petroleum & Natural Gas . New Delhi: Petroleum Planning and Analysis Cell .
- Sovacool, B. K., Mukherjee, I., Drupady, I. M., & D'Agostino, A. L. (2011). Evaluating energy security performance from 1990 to 2010 for eighteen countries. *Energy*, 36(10), 5846-5853.
- Sreenivas, A., & Iyer, R. K. (2014). *A comprehensive, multi-dimensional energy index for India*. Prayas Energy Group. Pune: Prayas Energy Group.