A comprehensive assessment of India's energy sector[1]

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1 Introduction

It is well-known that there is a close correlation between consumption of energy and levels of development. This is particularly true for countries at India's current level of development as can be seen from Figure 1. A small increase in per-capita energy consumption by India correlates strongly with a significant improvement in development levels, as measured by the UN's Human Development Index[2].

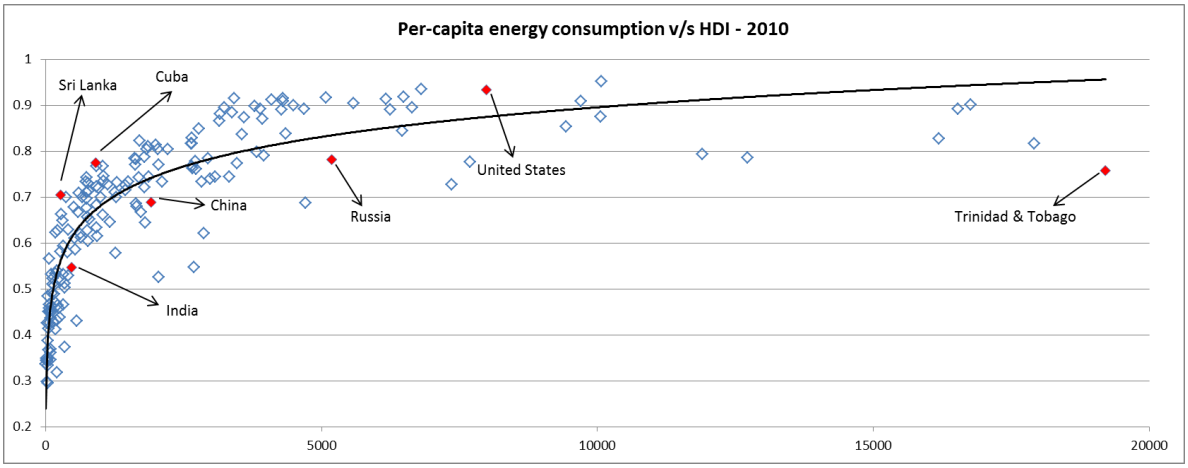

Figure 1: Correlation between per-capita energy consumption and HDI

Therefore, it is important to assess and understand the strengths and weaknesses of the country's energy sector, so that policy formulation can be better informed. Typically such assessment is done under the rubric of energy security and there is significant literature available on this. However, given the peculiarities of India, such as its high levels of energy poverty, socio-environmental stress and limited domestic fossil fuel resources, we believe it is important to adopt a more comprehensive and broader approach to assessing the country's energy sector. With this understanding, we developed a *multi-dimensional* assessment index for India's energy sector that considers the various aspects of the energy sector and its interactions with the country's social, environmental and economic structures.

Assessing the country's energy sector through this multi-dimensional index is similar to doing a comprehensive health check-up, which measures the various parameters of an individual's health, going beyond the obvious and immediate symptoms, to identify strengths and weaknesses. A further similarity to a comprehensive health check-up is that the energy sector assessment index also

[1] This article is based on a recently published report from Prayas (Energy Group) titled "A comprehensive, multi-dimensional energy index for India". The full report is accessible from prayaspune.org/peg/publications/item/270-a-comprehensive,-multi-dimensional-energy-index-for-india.html.
[2] There is a similar correlation between other development metrics (such as, say, infant mortality) and per-capita energy consumption.

becomes more useful if it is performed periodically, as this will help to not only understand the 'snap-shot' view of the energy sector but also help to identify trends that can throw further insights. As a beginning, we have applied the methodology to compute the index for 2011-12.

2 The energy sector assessment index for India

2.1 The various dimensions of the index

Energy supply, distribution and consumption are not only correlated to human development, but also have social, environmental and economic impacts. To accommodate these various important, but somewhat different aspects, the proposed energy sector assessment index is multi-dimensional in nature and consists of the following five dimensions:

- **Demand dimension**: This dimension assesses the extent to which energy is enabling citizens to lead productive lives through its use in households, enterprises and communities.
- **Supply dimension**: This dimension measures the country's efforts at securing reliable supply of energy, and most closely matches a lot of work done in the energy security area.
- **Social dimension**: Energy projects often require significant amounts of land, leading to displacement of citizens. Hence it is important to understand how well the country is rehabilitating those displaced by energy projects, and also the kind of development levels seen around energy projects. This dimension assesses these aspects.
- **Environmental dimension**: Production, distribution and consumption of energy results in local environmental pollution in the form of air and water pollution, and contributes to climate change. This dimension assesses the environmental management status of India's energy projects from this point of view.
- **Economic dimension**: Given rising energy costs and imports, it is important to use energy efficiently to power the economy and India's development. This dimension measures this aspect of the country's energy-economic system and also measures the impact of the energy price subsidies provided by India.

2.2 Assessment methodology

For each dimension of the energy sector assessment index listed above, a hierarchy of elements is built ending with *indicators*, which have specific values. For example, indicators could represent India's energy access levels, import exposure, or subsidy levels. Figure 2 gives the complete hierarchy for the demand dimension, along with weights and indicators mentioned in bold. The energy sector assessment index has more than 30 indicators across the five dimensions.

Indicators are given values based on information available from official data sources, other published information or information sourced from responses to applications under the Right to Information Act. However, it should be noted that data is not easily available for all indicators. Therefore, some indicators had to be slightly modified based on data availability and values for some indicators had to be estimated or approximated using other proxies or based on values for other years. For example, data about usage of modern energy in rural non-farm enterprises (an indicator in the demand dimension) is only available for 1998-99 and 2004-05 and the value for 2011-12 was

extrapolated from these values. Similarly, lack of official data about the resettlement and rehabilitation (R&R) of those displaced by energy projects forced us to rely on some research papers for data about a few energy projects. The full report gives details of all such approximations along with justifications.

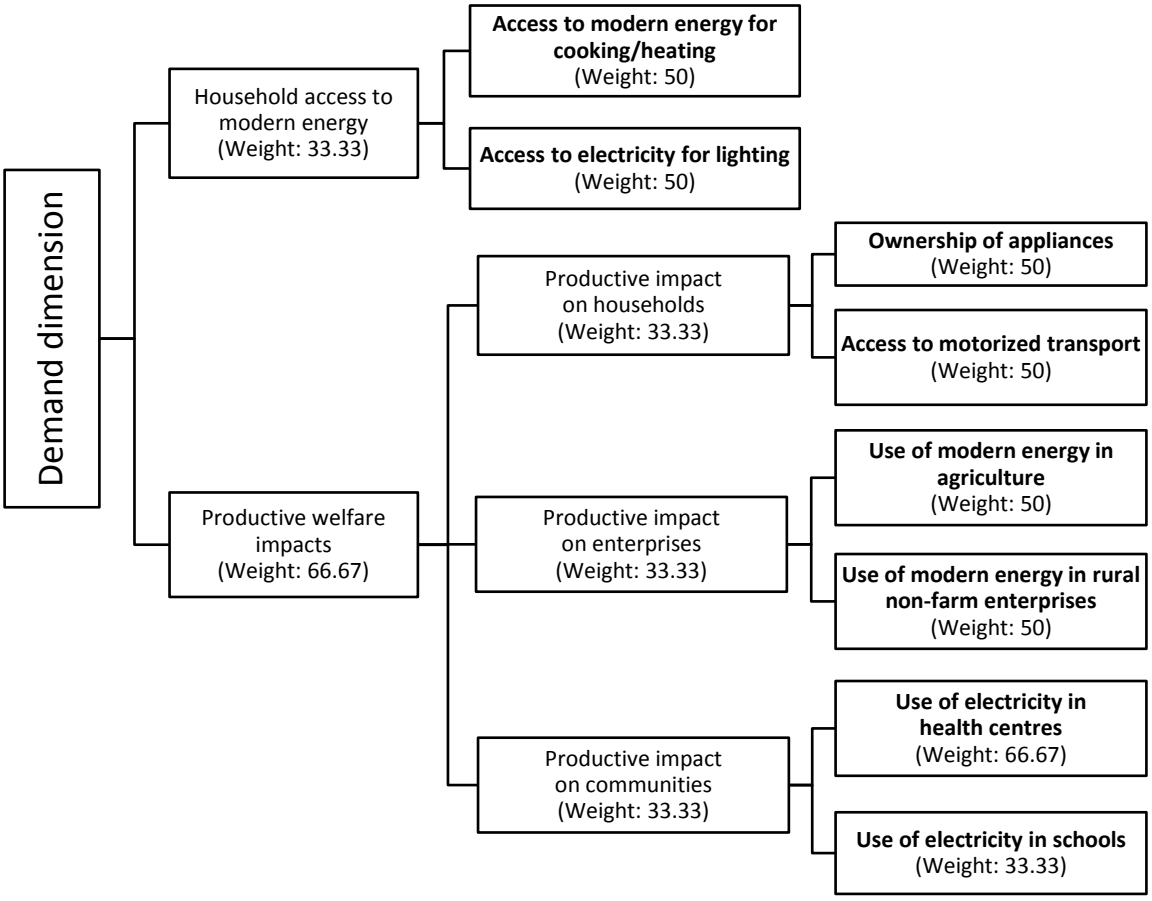

Figure 2: Hierarchy for the demand dimension

Indicator values are then converted into scores in the range of 0 to 100 through a process of normalization, where global normative benchmarks for the scores of 0 and 100 are used to the extent possible. This makes most of the normalization straightforward – for example, percentage values are easily scaled up to the 0-100 range. For some indicators, such as energy intensity of the economy, there are no global normative benchmarks to represent 0 and 100. In such cases, an international comparison with the group of G-20 nations[3] is used, and India is scored based on its rank among the G-20 nations.

Scores for each level in the hierarchy are obtained through weighted sums of scores of its immediate descendants. Thus, the score for "Productive welfare impacts" in the demand dimension is a weighted sum of scores of "Productive impact on households", "Productive impact on enterprises"

[3] We consider 19 of the G-20 nations, i.e. Australia, Canada, Saudi Arabia, United States, India, Russia, South Africa, Turkey, Argentina, Brazil, Mexico, France, Germany, Italy, United Kingdom, China, Indonesia, Japan and South Korea, which together account for around 62% of the world's population, 76% of its annual primary energy consumption and 73% of its GDP. The 'country' we do not consider is the European Union.

and “Productive impact on communities”, while “Productive impact on enterprises” itself is scored as the weighted sum of scores for “Use of modern energy in rural agriculture” and “Use of modern energy in rural non-agricultural enterprises”. In most cases, all the elements at a level in the hierarchy were weighted equally, except where literature suggested that some elements were more important than others. Moreover, we confirmed that our framework was robust and not heavily dependent on the choice of weights, by performing a sensitivity analysis on the results of the assessment. The sensitivity analysis showed that dimension level scores changed by less than 5% even if individual weights were changed by up to 50%.

3 Results of the assessment

We computed the energy sector assessment index for India for 2011-12 based on officially available data to the extent possible. However, data was either difficult to obtain or simply not available for some categories, typically related to socio-environmental impacts. In such cases, we relied upon responses to queries filed under the Right to Information Act for some energy projects and data available from some published literature. International data was taken from sources such as the World Bank and IMF. All indicator values were estimated using such data and based on the proposed methodology. These values were then converted to scores on a 0-100 scale and scores for all elements in the hierarchy were computed in a bottom-up fashion. Figure 3 presents the scores for all the five dimensions while Table 1 presents all the indicator values and scores for the demand dimension.

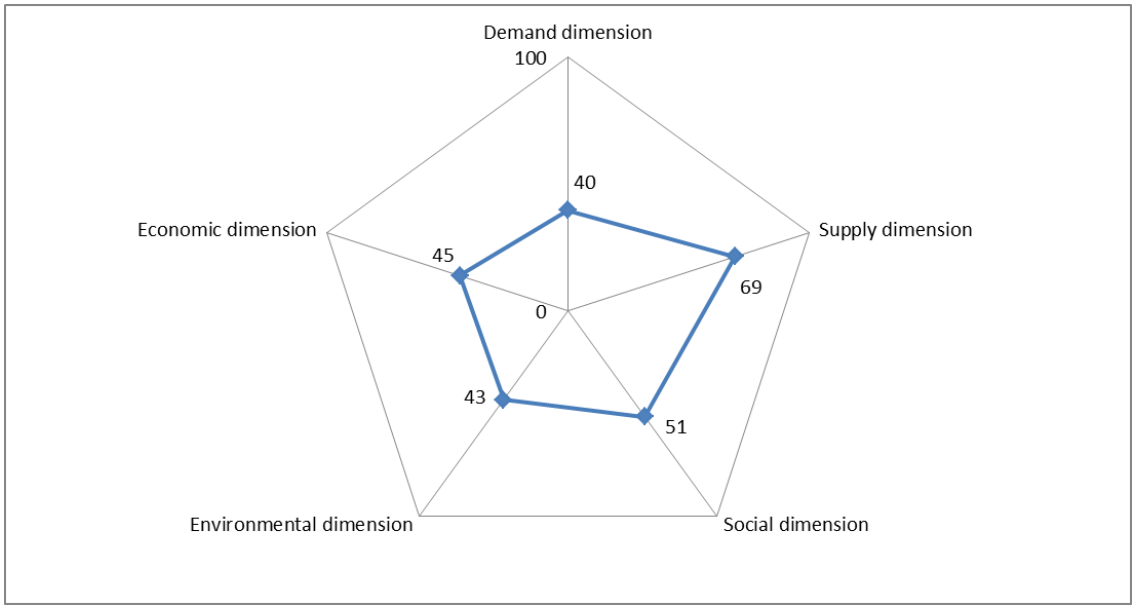

Figure 3: India’s energy assessment index scores for 2011-12

Indicator	Value	Unit	Worst value	Best value	India’s score
Access to modern energy for cooking/ heating	29.06	%	0%	100%	29.06
Access to electricity for lighting	67.25	%	0%	100%	67.25
Household access to modern energy	Sub-dimension score				48.15
Ownership of appliances	59.20	%	0%	100%	59.20

Access to motorized transport	25.73	%	0%	100%	25.73
Productive impact on households	Sub-sub-dimension score				42.46
Use of modern energy in agriculture	0.2032	Pumps per farm holding	0	1	20.32
Use of modern energy in rural non-farm enterprises	27.38	%	0%	100%	27.38
Productive impact on enterprises	Sub-sub-dimension score				23.85
Use of electricity in health centres	35.70	%	0%	100%	35.70
Use of electricity in schools	47.11	%	0%	100%	47.11
Productive impact on communities	Sub-sub-dimension score				39.50
Productive welfare impacts	Sub-dimension score				35.27
Demand dimension	Dimension score				39.57

Table 1: Indicator values for the demand dimension

3.1 Key findings of the assessment

The assessment throws up some interesting insights about the state of the Indian energy sector.

Firstly, it is interesting to see that the dimension with the best score is the supply dimension (69) while the dimension that scores the worst is demand (40), with the environmental (43), economic (45) and social (51) dimensions not much further behind.

This is interesting because much of the popular discourse about the challenges facing the Indian energy sector tend to focus on supply-side issues such as pricing of energy discouraging investments in the sector, the tardy environmental clearance regime slowing down project development and India's growing energy imports and its implications. While some of these may indeed be genuine concerns, the scores suggest that the other dimensions deserve as much or more attention.

The scores on the demand dimension are low due to two factors:

1. About 40 crore Indians (well above population of US) lack access to electricity and about 80 crore Indians lack access to clean cooking fuels. This is the case even though it is 65 years since India achieved independence, about 30 years since India began its first 'clean cook stoves' program and 2 years beyond the deadline of 2012 for universal electricity access promised by the Ministry of Power in 2005. These low levels of access result in low scores not just for the access indicators but also for indicators such as inequality in consumption of modern energy.
2. Indian rural enterprises (both agricultural and non-agricultural) use too little of modern energy in the form of electricity, petroleum products etc. As a result, energy has not contributed sufficiently to improving productivity in these crucial sectors. This is probably because modern energy is either too costly or too unreliable or both.

While the demand dimension scores suggest that energy has not enabled people to lead productive lives, the scores on the social and environmental dimensions indicate that energy-related projects have played a disabling role in people's lives as the ill-effects of energy generation, transmission and consumption have not been suitably mitigated. This is illustrated by the following:

1. The scores for air and water pollution are a poor 30 and 0 respectively, with the score for RSPM concentration also being just 0. These indicate abysmal enforcement of existing pollution norms and poor environmental management of the energy sector.
2. India's score on providing compensatory R&R for those affected by energy projects is a modest 40, with the score for providing alternative livelihoods to those displaced being a poor 26, and the score for providing resettled households with access to health centres being an extremely poor 0.

The above points perhaps explain why energy projects, particularly large ones, frequently face grass-roots resistance. These scores indicate that those most affected by such projects seem to enjoy very few of the benefits arising from such projects but typically suffer significantly in the bargain.

India also scores poorly (28) on managing the financial impacts of the energy sector due to its energy imports forming a significant part of its trade deficit, and its energy subsidies as a share of GDP being quite high on an international comparison. The former in particular requires attention because the trend has been that India's energy imports have been rising faster than its overall GDP over the past decade, and many studies indicate that this is likely to grow significantly in the future. Addressing this requires India to improve its energy efficiency and exploit its domestic resources (both renewable and non-renewable) more efficiently, while also paying heed to the socio-environmental issues mentioned above. Its poor score on subsidies also indicates the need for a better targeted and implemented subsidy mechanism.

Interestingly, many indicators on which India scores well also hide some concerns. For example, the indicator for per-capita GHG emissions from energy is the only one where India scores a perfect 100. However, the reason for this good score is that India's per-capita primary commercial energy consumption is so low – a mere 470 kg-oil-equivalent (kgoe) compared to more than 2300 kgoe for the G-20 nations. Such a low consumption is consistent with India's low development levels and does not indicate high carbon efficiency. Similarly, the high scores for target achievement for electricity generation and fossil fuel production (around 84 each) are deceptive, because a shortfall of more than 15% is much more problematic than a score of 84 suggests.

Finally, it should be mentioned that obtaining data for this assessment, particularly related to the socio-environmental aspects of energy, was very difficult. An objective assessment of the energy sector is not possible without the availability of such data. Hence there is a need for more robust, regular and comprehensive data collection mechanisms.

To summarize, an objective assessment of India's energy sector for 2011-12 shows that some of the major challenges facing the sector, such as very low levels of energy access and consumption, and very poor socio-environmental management, do not seem to get the attention they should.

4 Conclusions

Energy being one of the key inputs to socio-environmental development, it is important to objectively and comprehensively assess the sector. Towards this objective, we developed a comprehensive, multi-dimensional energy sector assessment index for India. This index should be computed periodically to assess the energy sector's strengths and weaknesses and to identify trends early so that policy interventions can be proposed to address the weaknesses and negative trends, if

any. The index has been applied to India for 2011-12 to get an understanding of the strengths and weaknesses of the Indian energy sector.

While some commonly discussed weaknesses of the sector such as increasing imports and the fiscal impact of subsidies get highlighted by the assessment, it also throws up some challenges – arguably more important challenges – that are less known or understood. These typically pertain to the low levels of energy access and consumption, and the poor socio-environmental management regime in the country. These challenges need to be addressed expeditiously if the energy sector has to meaningfully contribute to the country's development.

While the index has been developed specifically with India in mind, it is likely that it can be adapted and used for other developing countries, which perhaps face similar challenges.