

# AN ENERGY SECURITY INDEX FOR INDIA



► September 2016

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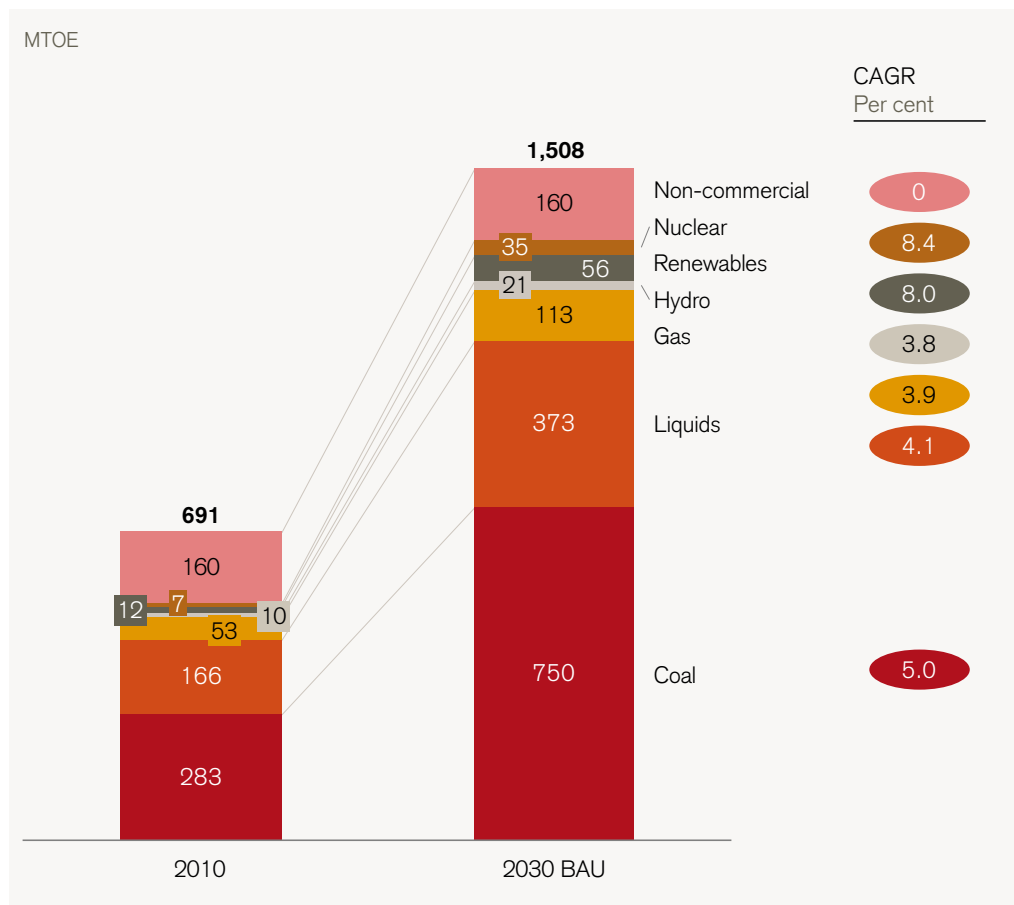
# EXECUTIVE SUMMARY

India's energy demand is being propelled by the needs and aspirations of its billion-plus residents. As domestic fuel production has lagged demand growth, India's import dependence has increased. Consequently, concerns about India's energy security have been rising. We assert that energy security for India has to be seen in the wider context of India's unique challenges. It has to also include a view on access, affordability and environmental sustainability. This paper offers a customised, broad energy security index to monitor India's energy security. The index also surfaces comprehensive measures needed to secure India's energy future.

India's energy demand is growing at 4 per cent annually, and is expected to double, from 700 million tonnes of oil equivalent (MTOE) in 2010 to 1,500 MTOE by 2030 (Exhibit 1).

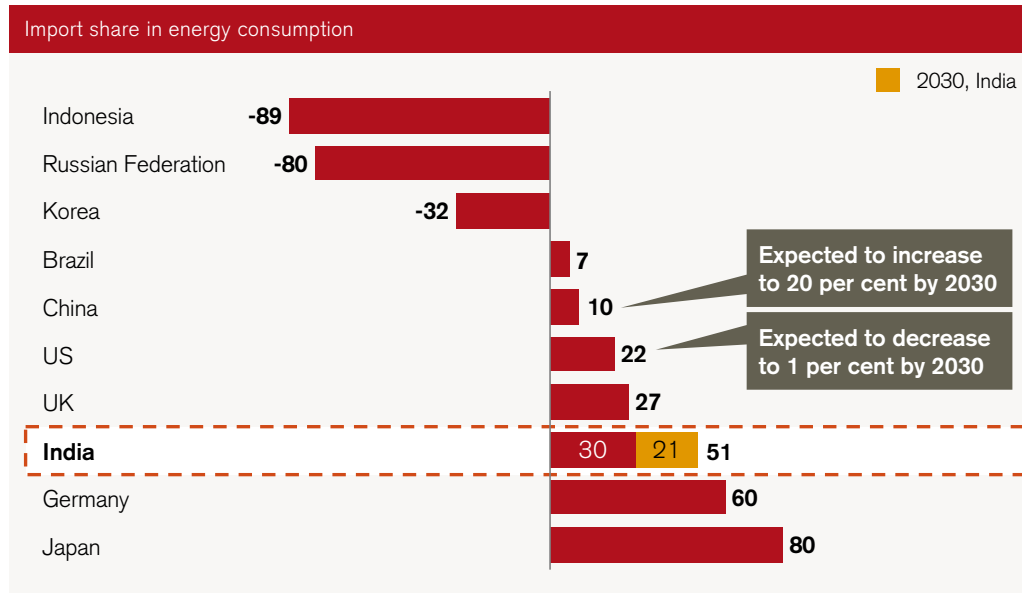
India's dependence on energy imports increased from 20 per cent to 33 per cent over the last 10 years, and could cross 50 per cent by 2030 on account of increasing demand and challenges in domestic production (Exhibit 2). This growing dependence has become a matter of rising concern in recent years.

**Exhibit 1: India's primary energy demand by fuel type**



SOURCE: IEA Energy Balances

## Exhibit 2: India could become one of the most import-dependent large economies



SOURCE: World Bank; BP Energy Outlook 2030

Energy security has to be about more than just import dependence in a country like India. Securing supply alone will not ensure true energy security. End consumers need access to affordable energy in an environmentally sustainable manner. India therefore needs a broader definition of energy security. Many institutions (e.g., ERIA<sup>1</sup>, US Chamber of Commerce<sup>2</sup>, Prayas Energy Group<sup>3</sup>) have included economic viability, access, fuel mix and sustainability as a part of energy security. Such a holistic definition will help address ground realities and aid more effective choices. This paper consolidates four critical aspects in the “India Energy Security Index”:

- Reliability and supply risks
- Economics, including cost-effectiveness and viability
- Access to modern energy for all
- Sustainability of energy intensity and emissions

Overall, 15 most relevant parameters across these four aspects have been used to define the India Energy Security Index. The parameters are quantifiable, actionable and intuitive, and can be calculated using data from public sources. For each parameter, the average of FY10–12 values has been used as the baseline indexed to 100. Sub-indices have also been outlined for each of these four aspects.



Overall, the index shows a negative evolution of India's energy security over the last 10 years, with a positive movement only in the last couple of years. The downward trend was driven by two factors. First, reduced supply reliability from higher import dependence. And second, poor economics, on account of increasing subsidies and declining energy company profitability. Since FY12, both reliability and economics have improved, but much more needs to be done in this regard.

A reasonable aspiration for the index by FY30 could be 120 (relative to about 106 today). This is ambitious and challenging, since in a business as usual scenario the index could worsen. A few steps that could help the country reach this aspiration:

- Review the regulations with the aim of improving the ease of doing business. It may attract more investments in the energy sector.
- Implement and scale up end-use efficiency improvement measures in residential, commercial, transport and industrial sectors.
- Accelerate renewables capacity additions, especially solar PV and wind.
- Strengthen electricity transmission and distribution infrastructure to enable renewables' grid integration and reduce technical and commercial losses.
- Advance the usage of both distributed solutions and grid extensions to provide affordable electricity and LPG/PNG access to 100 per cent of the households.
- Increase India's domestic exploration and production of oil, gas and coal by streamlining regulations and deploying efficient technologies.
- Secure international reserves through focused acquisitions and long-term contracts.
- Address coal supply infrastructure and increase the efficiency of coal-based electricity generation.

An effective mechanism for creating a strong technology ecosystem, improving private-sector participation in the energy sector and regular interactions with the stakeholders for implementing these will be necessary to reach our initiatives. The pace and quality of implementation will determine the overall energy security outcome.

A first step could be the adoption of this holistic energy security index, with reasonable targets followed up by a concerted set of actions, and supported by a few key enablers. Such a path could make a big difference to India's energy security.

Given India's participation in the recent Paris climate agreement, the country is likely to meet its development aspirations while adhering to its commitments on the growth of non-fossil fuel sources and the reduction of carbon intensity.<sup>4</sup> This process will require trade-offs and choosing between competing options in the face of finite resources. The index, given its coverage of sustainability, access, economics and security of supply, can serve as a tool to highlight and make these trade-offs.



# 1. THE NEED FOR AN “INDIA ENERGY SECURITY INDEX”

Import dependence has traditionally been used as the sole determinant of energy security for India. This does not do justice to the myriad challenges of India’s energy landscape—such as access, affordability and sustainability. Also, it does not allow for appropriate trade-offs between various objectives (e.g., greater renewables usage improves sustainability but could compromise affordability or lead to lower reliability if grid integration is poor).

Several agencies (e.g., IEA, World Energy Council, US Chambers of Commerce, World Bank, ERIA) have broadened the definition of energy security to include fuel mix, sustainability and economic viability. Should India adopt one of these indices to measure its energy security?

We believe that India needs its own tailored index that takes into account India’s challenges. Such an index should also measure whether India is meeting the energy needs of all its citizens in an affordable and environmentally sustainable manner.

## ENERGY SECURITY: A GROWING CONCERN

India’s primary energy demand is growing at a relatively rapid 4 per cent per annum compared to the global growth rate of 2 per cent. Domestic production has lagged demand growth, thus increasing India’s import dependence. Energy imports rose from 20 to 33 per cent over the last 10 years.<sup>5</sup> The level of dependence is rather stark in the case of crude oil, where India has an import dependence of about 80 per cent.<sup>6</sup> Despite having the world’s fifth largest coal reserves, India imported 30 per cent of its coal requirement in FY14.<sup>7</sup> Coal imports reduced last year due to increased domestic production and lower demand; however, these low levels need to be maintained even when coal demand subsequently picks up. The country is still far from adequately utilising its plentiful solar and wind resources.

Greater import dependence has driven up India’s import bill and exposure to volatile energy prices. In FY12, India spent 55 per cent of its goods export revenue on financing energy imports alone. The figure has declined in recent years with a dip in global oil prices, but increasing imports and fluctuating prices continue to pose risks. Another concern is the potential geopolitical volatility of the Middle East, a region from which India sources almost one-third of its energy imports.<sup>8</sup>

## EXPANDING THE DEFINITION OF ENERGY SECURITY

Several agencies, including the erstwhile Planning Commission<sup>A,9</sup>, consider parameters other than import dependence in determining energy security. The belief is that a nation is energy secure only when it can meet the energy needs of its citizens in an affordable and sustainable manner. Such an objective entails much more than merely securing energy supply and reducing import dependence. It means providing every household at least a “lifeline” level of energy<sup>B</sup>—which is affordable or economically viable for all stakeholders—and doing so in a way that does not harm the environment.

A The integrated energy policy of the Planning Commission shared a similar view

B The Planning Commission of India defines essential or lifeline energy for a household as 30 kWh of electricity and 6 kg of LPG per month



India has to address several challenges to attain such energy security:

- **Fuel imports:** Flat domestic Oil & Gas (O&G) production and rapidly increasing demand have led to increased hydrocarbon imports. Hydrocarbon potential (including that of unconventional) in many basins is yet to be mapped.
- **Capacity and investments:** The energy sector needs capacity additions, but investments have slowed. Performance of energy companies has been worsening.
- **Load factors:** Coal power plants have been operating at historically low load factors due to low uptake by distribution utilities. Gas power plants have been struggling due to low availability of domestic gas. These plants would most likely be needed even if there is a strong growth in renewables capacity building.
- **Renewables:** Despite an increasing trend of using renewables, the share of commercial renewables, excluding non-commercial energy sources like firewood and cow dung, and nuclear energy in the primary energy mix is still insignificant. Given their intermittent nature, challenges around their grid integration also need to be addressed.
- **Financial condition of distribution utilities:** The poor financial condition of the distribution utilities and historical lack of investment in strengthening/modernising the Transmission and Distribution (T&D) infrastructure has led to increased load shedding. This can also affect power generators and their lenders.
- **CO<sub>2</sub> emissions:** India is already the world's third-highest carbon dioxide (CO<sub>2</sub>) emitter, with emissions expected to rise as the per capita energy demand increases. The new push to India's manufacturing sector could also increase CO<sub>2</sub> emissions. Backup generators running on diesel, due to intermittent power supply, are inefficient, high cost and emit more CO<sub>2</sub>.
- **Access:** Access to modern energy sources, especially for cooking, remains a real challenge for India—over two-thirds of households still rely on firewood and cow dung.<sup>10</sup>
- **Energy intensity:** India's energy intensity is high due to demand-side inefficiencies. Inefficient appliances and the prevalence of old vehicles have contributed to this scenario. Energy use has become more efficient through various residential and commercial demand-side management programs (DSM), e.g., replacement of incandescent bulbs with CFL/LEDs.

Efficiency needs to go much further as India's energy demand for transportation, household energy and manufacturing increases.

- **Subsidies:** Energy subsidies have been weighing down government finances. The recent deregulation of diesel prices, government's push for direct subsidy transfer and a slump in global oil prices eased the burden somewhat in the past two years.

### **A CUSTOMISED INDIA ENERGY SECURITY INDEX**

Several energy security indices exist globally and countries and organisations use them to obtain a more holistic perspective on energy security. Besides offering a credible way to quantitatively measure energy security, these indices also help to set aspirations, assess policy options, track progress, measure the impact of actions, and understand potential trade-offs.

While these indices provide useful learnings, they do not capture the unique challenges specific to India's energy sector, such as low levels of access and affordability. For example, most of these indices interpret increasing per capita consumption of energy as detrimental to energy security, which need not hold true for India. A customised India Energy Security Index, then, is necessary. The next section discusses a relevant articulation of energy security for India and tries to develop the index based on that definition.



## 2. DEFINING THE INDIA ENERGY SECURITY INDEX

What is the right index for India that looks beyond import dependence and addresses accessibility, affordability and sustainability of energy?

This chapter defines an India-specific, customised energy security index that consolidates four aspects or sub-indices: reliability, economics, access and sustainability. This comprehensive list covers all aspects of India's energy challenges. The index includes 15 parameters that are quantifiable, actionable and intuitive. These parameters can be estimated using data from public sources.

The parameters can be tracked as absolute values but have been converted into a comparable scale in order to consolidate into the index. The four sub-indices and the overall index have been normalised by taking the average of FY10–12 values as the base-year value of 100.

### DEFINING ENERGY SECURITY FOR INDIA

We have defined energy security in the Indian context as “reliably providing energy access to all citizens in an economically viable and environmentally sustainable manner.” Based on this definition, energy security has four aspects:

- **Reliability and supply security:** The ability to ensure adequate energy supply while reducing supply risks.
- **Economics:** The ability to provide cost-effective energy that is economically viable for all stakeholders—consumers, suppliers/industry and the government.
- **Access:** The ability to deliver affordable modern energy to all citizens.
- **Sustainability:** The ability to have a sustainable energy mix and control emission levels in the long-term.

### DESIGN PRINCIPLES USED TO CONSTRUCT THE INDEX

For ease of adoption, the index needs to be transparent in calculation and easily computable on a regular basis, at least annually. The following four design principles were used to select the final list of index parameters suited to the above definition:

- **Quantifiable:** The parameters should be quantifiable, which is why subjective parameters (e.g., strength of institutions, policies) were not considered.
- **Actionable:** The parameters should link to certain tangible action steps.
- **Intuitive:** Both the parameter and metric (for quantifying the parameter) should be commonly understood and relatable to energy security.
- **Availability of credible data from public sources:** Parameters for which data is available from well-recognised public sources free of charge on an annual basis were considered. NSSO data (published at five-year intervals) was used for parameters such as electricity and cooking fuel access, which are highly relevant to energy security, and for which no other suitable annual data source was available.

## METHODOLOGY USED FOR INDEX CREATION

Based on the four design principles described above, 15 parameters have been selected, that could represent the most relevant energy security issues in the Indian context. These parameters have been distributed across four sub-indices—four each for reliability, economics and access, and three for sustainability (Exhibits 3 and 4).

The **reliability** aspect of the energy security index looks at whether India is able to reliably obtain sufficient energy to meet its needs. “Reliably” also implies assessing the associated short- and long-term risks and mitigation measures put in place. The longer term risks include supply and market risks arising from over-dependence on imports, little diversification of import countries/routes and over-reliance on certain fuel sources. Adequate safety stock or strategic reserves are also essential to safeguard the economy against the short-term risks associated with supply shocks and price fluctuations.

Obtaining adequate energy is not enough. This energy should be acquired in a way that is economically viable for all stakeholders—the government, consumers and suppliers/industry. The **economics** aspect of the energy security index examines this economic viability, which means different things for different stakeholders. For consumers, affordability of the energy mix is important. Suppliers/industry must find it economically viable to provide energy to citizens, which can be assessed by measuring the industry’s returns on investments. For the government, economic viability implies a sustainable level for subsidy and import bills.

All citizens must have access to sufficient and economically viable energy. The **access** aspect of the energy security index captures India’s ability to provide adequate modern energy to its citizens. Such sources of energy should be affordable even to the poorest.

Finally, India can be truly energy secure if it does all of the above in a sustainable manner—both with respect to the environment and longevity of the energy mix. Meeting the recently committed INDC targets of reducing emissions intensity by 33 to 35 per cent will improve sustainability.<sup>11</sup> The **sustainability** aspect of the energy security index covers the share of renewables in the overall energy mix, the efficiency of energy use and emission levels.

The index has been created using both top-down and bottom-up approaches. The customised definition of energy security and its four aspects have been derived in a top-down way based on understanding the challenges that India’s energy sector faces. The 15 parameters underlying the four aspects have been selected in a bottom-up manner. More than 10 global energy security indices were analysed to create a comprehensive list of 140 parameters used to quantify energy security globally. Based on the design principles and stakeholder inputs, these parameters were filtered to identify 15 relevant parameters across the four aspects of energy security (Exhibit 3).

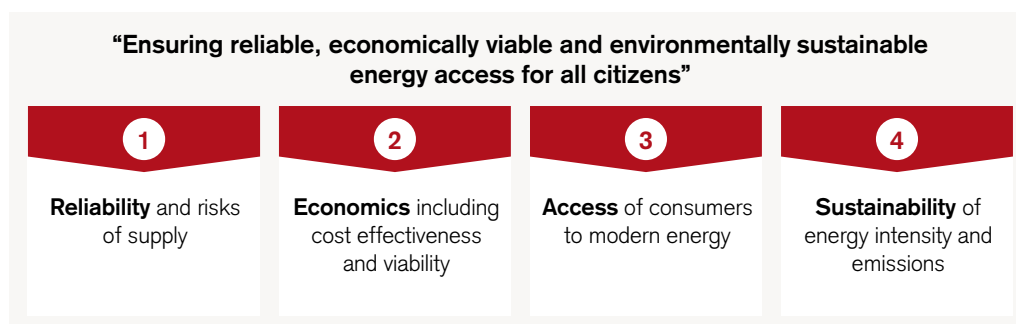
Values of all 15 parameters have been calculated annually from publicly available data. To create a single index value, the parameters have been aggregated into four sub-indices with equal weightage applied to each parameter within a sub-index. The sub-indices are further aggregated with equal weightage into the overall index. The weightages could change in case of major disruptions or discontinuities in the sector.

The index and sub-index values have been expressed relative to the base-year value, which has been normalised to 100. The base-year values of the parameters have been calculated as an



average of the FY10, FY11 and FY12 values to remove the impact of any abnormal parameter values in FY11. The value of the index in a particular year shows the relative improvement/decline compared to the base year. A higher index (or sub-index value) means higher energy security than the base year.

### Exhibit 3: Index definition and components



Some parameters, which could be considered relevant were excluded due to absence of credible data on them. These include the pollution caused by the energy sector (across land, water and air) and end-use efficiency of the energy sector (expressed more directly in terms of passenger-kilometres per MTOE of fuel used and the efficiency of appliances).

The 15 parameters and the metrics used to quantify them are shown in Exhibit 4.

### DEFINING REASONABLE RANGES FOR INDEX PARAMETERS

The index will serve as a practical tool only if it has a “reasonable” target value (including for its constituent parameters) that ensure that concerted efforts are made to make India more energy secure.

The year FY30 has been taken as a reference year for discussing a reasonable value for various parameters. This value for individual parameters is based on a mix of government targets/aspirations and the performance of other countries to see if it is practically achievable with a stretch in the given timeframe if concerted efforts are made. Identifying reasonable levels/ranges for some parameters was not feasible—such as for energy imports as a percentage of exports, energy subsidy as a percentage of government budget, the cost-effectiveness of India’s primary energy mix and affordability of energy for lower-income segments. This was due to the influence of multiple exogenous variables.

These ranges might need to change in the future in case of major disruptions in the energy sector. The table below summarises the reasonable ranges identified for each parameter and the rationale behind the selection. Just achieving the reasonable level on the overall index does not mean that India has attained a comfortable level of energy security—India must achieve a reasonable level on all the four sub-indices and 15 parameters to be energy secure. Reasonable ranges for all the parameters were aggregated to obtain the acceptable range for the four sub-indices, which were further aggregated to obtain the acceptable range for the overall index—which is 120. Achieving this will require significant effort across all the four aspects of energy security. Even maintaining the current level on energy security may not be easy, considering the challenges India faces and the ever-increasing demand.

## Exhibit 4: Index parameters

Methodology	
<ul style="list-style-type: none"> <li>The index consists of 15 parameters, which reflect the most relevant energy security issues for India's context</li> <li>All parameters can be calculated annually from publicly available data</li> <li>To create a single number, the parameters have been aggregated into four sub-indices, which are further aggregated with equal weightage into an overall index, expressed relative to the average FY10–12 value = 100</li> </ul>	
Parameters	Metric
<b>1</b> <b>Reliability sub-index</b> (Reliability and risks of supply)	<b>1A</b> Years of secure fossil fuel supply remaining R/P for domestic and Indian-owned international sources + years of fossil fuel supply through long-term and infra-linked contracts <hr/> <b>1B</b> Dependence on imports for meeting energy needs Net energy imports as share (percentage) of primary energy supply <hr/> <b>1C</b> Diversification of import countries and fuel mix Average of HHI <sup>1</sup> of India's energy imports (percentage by country) weighted for its political risk and India's energy sources (percentage by sources) <hr/> <b>1D</b> Availability of safety stocks Average of coal stock in power plants and strategic, commercial oil stocks (in days of consumption)
<b>2</b> <b>Economics sub-index</b> (Economics including cost effectiveness and viability)	<b>2A</b> Energy imports as a proportion of India's exports Energy imports as percentage of total exports <hr/> <b>2B</b> Energy subsidy as a proportion of government budget Petroleum and electricity subsidy (including assistance towards under-recoveries) as a percentage of budgetary spending <hr/> <b>2C</b> Cost-effectiveness of India's primary energy mix Weighted average of real cost of energy in INR/TOE for India's fuel mix <hr/> <b>2D</b> Attractiveness of the energy sector for investments Return on invested capital for 20 leading energy companies
<b>3</b> <b>Access sub-index</b> (Access of consumers to modern energy)	<b>3A</b> Household access to electricity Percentage of households electrified through grid or distributed generation (Solar PV, etc.) <hr/> <b>3B</b> Household access to modern cooking fuels (LPG, PNG, kerosene and biogas) Percentage of households using LPG/PNG/kerosene/biogas (for cooking) <hr/> <b>3C</b> Extent of electricity outages SAIDI/(8,760), where SAIDI is the system average interruption duration index in hours/year <hr/> <b>3D</b> Affordability of energy for lower-income segments Per capita spend on essential energy/per capita income (for lowest income decile)
<b>4</b> <b>Sustainability sub-index</b> (Sustainability of energy intensity and emissions)	<b>4A</b> Contribution of renewable resources to primary energy supply Share (percentage) of renewables (solar, wind, hydro and clean biofuel) in total primary energy supply <hr/> <b>4B</b> Energy intensity of the Indian economy Energy consumption per unit real GDP (TOE/'000 USD GDP) <hr/> <b>4C</b> CO <sub>2</sub> emission intensity of primary energy use Amount of CO <sub>2</sub> emitted per unit of primary energy consumption (tCO <sub>2</sub> /TOE)

<sup>1</sup> HHI Index (Herfindahl–Hirschman Index) is the sum of squares of per cent share of all constituents (import by country, production by source) which varies between 0 (most diversified) and 1 (least diversified).

Table 1: Reasonable range for index parameters

Sub-index	Parameters	Metric	Reasonable range <sup>1</sup>	Rationale
1 Reliability sub-index	▪ Years of secure fossil fuel supply remaining	R/P for domestic and Indian-owned international sources + years of fossil fuel supply through long-term and infra-linked contracts	>40 years	Average of peer countries which are net importers—China, Brazil, Thailand, Malaysia, Indonesia
	▪ Dependence on imports for meeting energy needs	Net energy imports as share (percentage) of primary energy supply	<25 to 30 per cent	Attainable level of imports by FY30 if concerted efforts are taken
	▪ Diversification of import countries and fuel mix	Average of HHI of India's energy imports (percentage by country) weighted for its political risk and India's energy sources (percentage by sources)	<0.20	Attainable level by putting concerted efforts on renewables, which will reduce coal share
	▪ Availability of safety stocks	Average of coal stock in power plants and strategic, commercial oil stocks (in days of consumption)	>25 days	Achievable level of coal and oil stocks by FY30
2 Economics sub-index	▪ Energy imports as a proportion of India's exports	Energy imports as percentage of total exports	NA	Highly dependent on exogenous variables—exports, other imports
	▪ Energy subsidy as a proportion of government budget	Petroleum and electricity subsidy (including assistance towards under-recoveries) as a percentage of budgetary spending	NA	Highly dependent on uncontrollables—global prices
	▪ Cost-effectiveness of India's primary energy mix	Weighted average of real cost of energy in INR/TOE for India's fuel mix	Lower than peer countries—China	Global prices drive cost; not possible to give absolute target
	▪ Attractiveness of the energy sector for investments	Return on invested capital for 20 leading energy companies	>15 per cent	Greater than cost of capital
3 Access sub-index	▪ Household access to electricity	Percentage of households electrified through grid or distributed generation (Solar PV, etc.)	100 per cent	–
	▪ Household access to modern cooking fuels (LPG, PNG, kerosene and biogas)	Percentage households using LPG/PNG/kerosene/biogas (for cooking)	>80 per cent	Attainable level on electricity access by FY30 if concerted efforts are taken
	▪ Extent of electricity outages	SAIDI/(8,760), where SAIDI is system average interruption duration index in hours/year	<3 per cent	Values of European countries with buffer
	▪ Affordability of energy for lower-income segments	Per capita spend on essential energy/per capita income (for lowest-income decile)	Less than current levels	Depends on uncontrollables—cost of energy and income level
4 Sustainability sub-index	▪ Contribution of renewable resources to primary energy supply	Share (percentage) of renewables (solar, wind, hydro and clean biofuel) in total primary energy supply	>7 per cent	50 per cent of Govt's renewable capacity ambition (extrapolated till FY30)
	▪ Energy intensity of the Indian economy	Energy consumption per unit real GDP (TOE/'000 USD GDP)	<0.4	Attainable level by putting high efforts on energy efficiency
	▪ CO <sub>2</sub> emission intensity of primary energy use	Amount of CO <sub>2</sub> emitted per unit of primary energy consumption (tCO <sub>2</sub> /TOE)	<2.5	Based on Govt. target of reducing emissions intensity of GDP by 20 to 25 per cent of FY05 levels by FY20

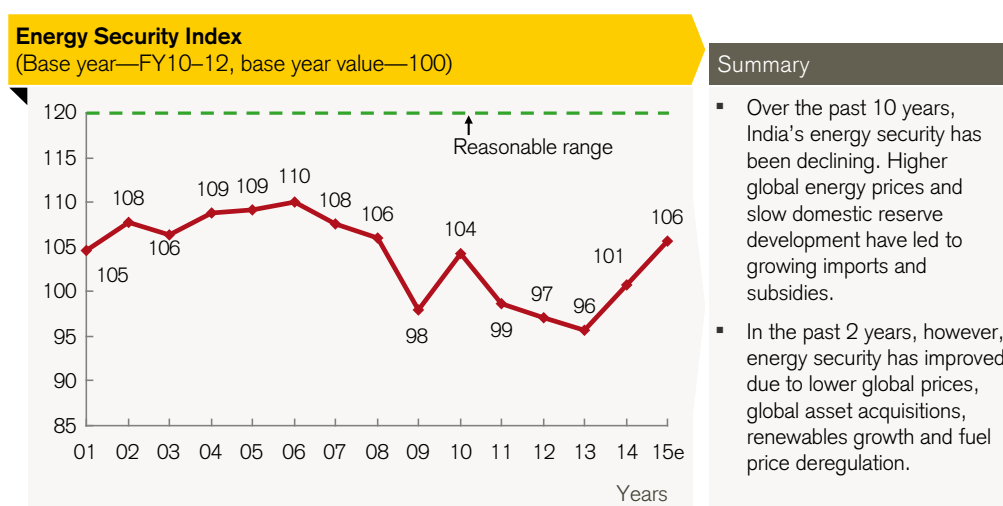
<sup>1</sup> Reasonable range has been defined such that it is achievable by FY30



## 3. INDIA'S PERFORMANCE ON THE INDEX

India's energy security has been declining over the last decade (Exhibit 5) despite efforts on many fronts to secure energy supply and increase access. Higher global energy costs, slow development of domestic reserves, poor energy company returns and high subsidies have been major challenges. The last couple of years have seen a significant positive movement driven largely by lower crude prices, more secure access to supply due to global asset acquisitions by Indian companies, renewables growth and steps taken to reduce subsidy burden like fuel price deregulation and direct benefits transfers.

**Exhibit 5: India energy security index**



Bridging the gap from 2015 value (around 106) to the reasonable range of around 120 is a significant challenge. Sub-indices for access and sustainability are significantly below reasonable levels. Access to modern fuels and electricity is currently far short of benchmarks. Renewables share is insignificant and carbon intensity of energy is increasing due to the rising share of coal based power. The sub-indices of reliability and economics, although within the reasonable range right now, have seen the highest decline in the past few years. These are susceptible to further declines driven by increasing imports, inadequate expansion and development of domestic reserves and poor economics of energy companies (particularly power).

The rest of this chapter assesses India's performance on each sub-index in the energy security index.

### RELIABILITY OF INDIA'S ENERGY SUPPLY

Of the four sub-indices, the reliability sub-index has declined the most over the past decade (Exhibit 6). India is still above the acceptable range on reliability due to abundant coal reserves,

but growing imports and inadequate expansion of O&G reserves might lead to a further decline in the sub-index.

- **Secure fossil fuel reserves have been declining**

Secure fossil fuel reserves have been assumed to consist of domestic reserves, international reserves owned by Indian public companies and infrastructure-linked or long-term gas contracts. Inadequate exploration combined with increasing demand has led to a steady decline in fossil fuel reserves. India has domestic oil, gas and coal reserves for 18, 45 and 94<sup>C</sup> years respectively, at the current level of production.<sup>12</sup> To enhance energy security, Indian companies have acquired stakes in international assets (primarily O&G), but have not grown domestic reserves at a commensurate pace.

- **India is increasingly dependent on imports to meet primary energy needs**

The slow development of domestic reserves while energy demand expanded rapidly has driven up imports. India imported 70 per cent of its oil demand in FY01, and 80 per cent in FY13. Gas imports started in FY04, and India now imports one-third of its gas requirements. India imports thermal coal in addition to its import needs for coking coal, leading to 30 per cent of India's coal demand being imported in FY13.<sup>13</sup> This has reduced in the past year because of increased domestic production and low demand from the power sector.

The bulk of India's O&G imports come from the Middle East. This proportion has not reduced since FY08 despite the emergence of several new sources of global supply.<sup>14</sup> The turmoil in recent years in the Middle East compromises India's resilience against supply risks.

- **ISPRL's storage capacity has the potential to lower the risk of short-term supply shocks to some extent**

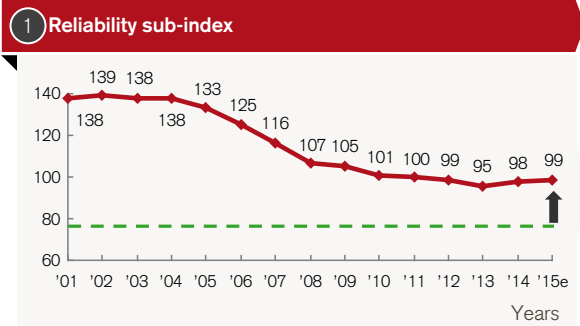
Indian Strategic Petroleum Reserves Limited (ISPRL), which has been commissioned to build strategic reserves, has constructed 5.33 MMT of storage space in Visakhapatnam, Mangalore and Padur in the first phase. These strategic reserves are expected to be completely filled in 2016. Once filled, these stores could decrease risks of short-term disruption in supply. In the second phase, ISPRL is planning to further create 12.5 MMT of storage space across Padur, Chandikhol, Bikaner and Rajkot.<sup>15</sup>

Various government initiatives, currently underway, should improve the reliability of India's energy supply. Continued production improvements by public sector players, coal-block auctions and the entry of private players in coal mining, together with the revival of the slump in coal demand by the power sector should help reduce import dependence for coal.

C There is variability across different sources on the amount of "recoverable coal resources". We have taken the data from the publicly available BPStats data

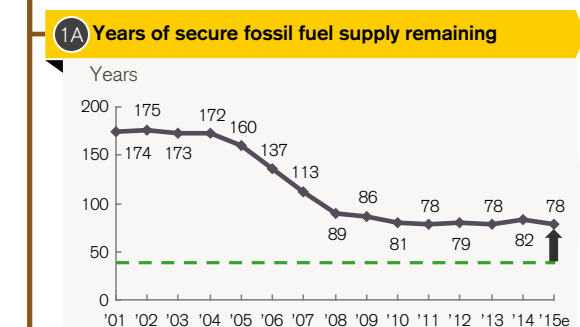
**Exhibit 6: Reliability sub-index**

Reasonable range  
Arrow indicates whether reasonable range is above or below the green line  
Improving  
Stable  
Worsening

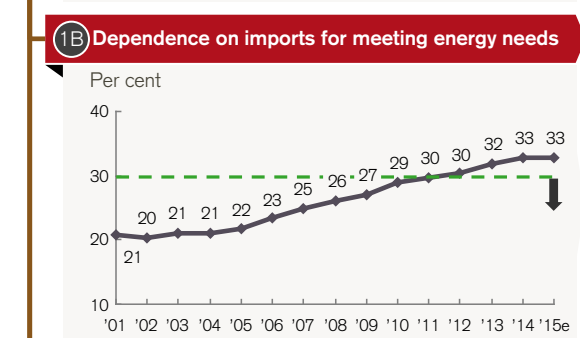


**Summary**

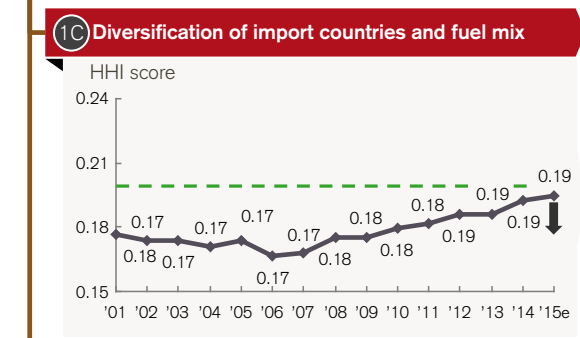
- India's performance on the Reliability sub-index has declined over the past 10 years due to low domestic production, increasing import dependence and increasing dependence on coal.
- The performance stabilised in past two years driven by the acquisition of international fossil fuel assets and addition of strategic oil reserves.



- India's R/P ratio has been declining due to poor domestic exploration and slow international asset acquisition.
- As of FY14, domestic R/P was 18 years for oil, 45 years for gas and 94 years for coal.
- International asset acquisitions have stabilised the R/P ratio in recent years.



- Import dependence has been steadily increasing due to high demand growth and slow development of domestic reserves. In FY13, India imported 25 per cent of its coal, 81 per cent of its oil and 32 per cent of its gas requirement.
- Increased domestic coal production in the past year has reduced imports.



- India has not significantly diversified its energy imports, with the majority coming from the Middle East in FY13, just marginally down from its share in FY07.
- The HHI score for fuel mix diversification has worsened due to a steady increase in the share of coal in supply from 35 per cent in FY01 to 45 per cent in FY13.

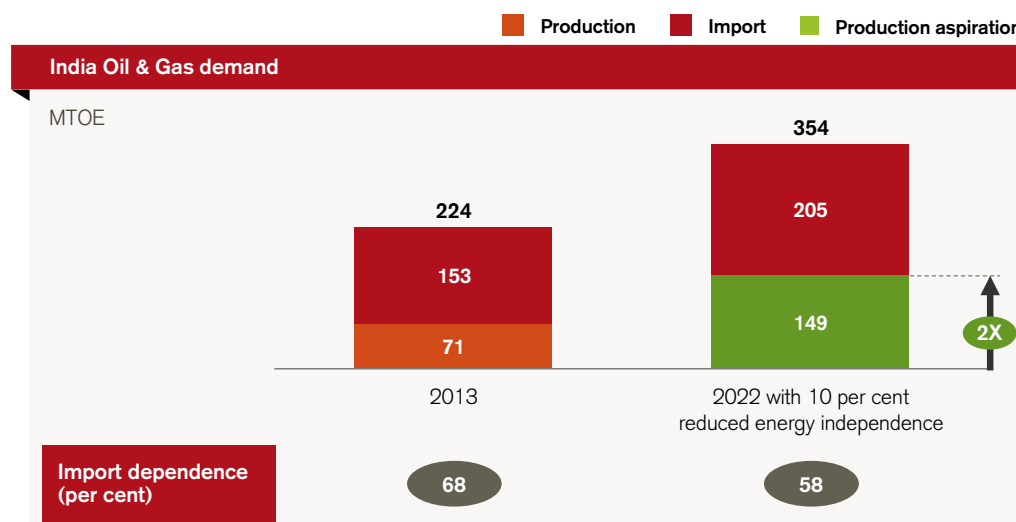


- Commercial oil stocks increased from 14 MMT in FY04 to 25 MMT in FY14.
- 5.33 MT of recently commissioned strategic oil reserves as a part of ISPRL Phase-I are expected to be completely filled by 2016.
- Coal stock at power plants in September FY14 were the lowest in 25 years due to drop in domestic supply. However, record growth in domestic coal production in the past year has resulted in all plants having adequate stocks.

1 Data for coal stock in power plants not available pre-2008

Steps to achieve the Prime Minister's vision of reducing import dependence for O&G by 10 per cent by FY22<sup>16</sup> will also help to improve reliability. Recent regulatory initiatives, like the Hydrocarbon Exploration and Licensing Policy and gas pricing policy for domestic production from challenging fields have the potential to boost investments in this sector. But, it could be a challenge to meet the target by solely relying on domestic reserves and production, as domestic production will need to more than double (Exhibit 7) to meet this aspiration. Since India's proven domestic 2P reserves<sup>D</sup> are only 800 MTOE for oil and 1,300 MTOE for gas, meeting the production target will mean reducing the oil reserves to production (R/P) ratio from 18 currently to 8 and the gas R/P ratio from 45 currently to 24. International acquisitions of O&G assets and the planned infrastructure-linked contracts can help, improving supply security through greater control over the import supply chain.

### Exhibit 7: Production must double to meet PM's aspiration of 10 per cent reduced import dependence by 2022



SOURCE: IEA Energy Balances

### ECONOMIC VIABILITY OF ENERGY FOR ALL STAKEHOLDERS

India's performance on the economics sub-index has been mixed over the past decade (Exhibit 8). While performance has overall declined in the past 10 years, economic performance improved over the last two years, driven by the reduced crude import bill and product price deregulation.

- **Falling global crude prices cut down the import bill despite increasing energy imports**

India's energy import bill increased from USD 16 billion in FY01 to USD 177 billion in FY14 due to greater fuel imports and rising global oil prices. Energy imports in FY14 were 55 per cent of India's total goods exports. The slump in oil prices in 2014, however, reduced the energy import bill from USD 185 billion in FY13 to USD 177 billion in FY15, despite the rising import quantity.<sup>17</sup>

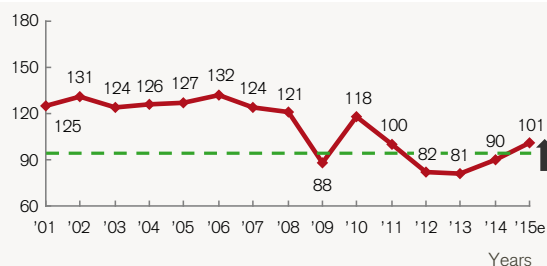
D 2P reserves stand for "Proved + Probable" reserves



## Exhibit 8: Economics sub-index

- Reasonable range
- ↑ Arrow indicates whether reasonable range is above or below the green line
- Improving
- Stable
- Worsening

### 2 Economics sub-index



### Summary

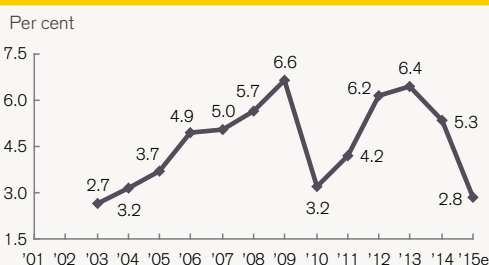
- India's performance on the Economics sub-index has declined over the past 10 years due to increasing dependence on oil imports, increasing crude prices and high levels of petroleum and electricity subsidies.
- The performance improved in past two years driven by deregulation of petrol and diesel prices and falling global crude prices.

### 2A Energy imports as a proportion of India's exports



- Oil imports make up most of India's energy imports.
- Increasing dependence on oil imports and rising crude prices have increased the import bill since past 10 years.
- In FY14 and FY15, however, low oil prices brought down the import bill.

### 2B Energy subsidy as a proportion of government budget



- The government provides petroleum subsidies on kerosene and LPG to OMCs and electricity subsidies to utilities.
- The sharp fall in subsidies post FY12 was driven by falling global oil prices and deregulation of petrol and diesel prices.

### 2C Cost effectiveness of India's primary energy mix



- The cost of India's primary energy mix is largely driven by coal, oil and gas prices, which have steadily increased on a real basis in the past 15 years.
- Falling global crude prices in FY14 and FY15 led to decrease in weighted average cost of energy.

### 2D Attractiveness of the energy sector for investments



- The returns that leading energy companies in India have obtained as a proportion of the capital invested have declined in the past 10 years.
- This could be attributed to the increasing stranded assets arising out of poor infrastructure development, low fuel supply and increased cost of fuel.

- **Petrol and diesel price deregulation has reduced subsidies**

India provided subsidies on petroleum products (LPG, kerosene, and until recently, petrol and diesel) and electricity amounting to INR 1.6 lakh crore in FY13.<sup>18</sup>

The slump in oil prices in 2009 and 2014 helped cut the subsidy bill, as did the deregulation of petrol and diesel prices (in 2012 and 2014 respectively). At the same time, the power distribution sector's tariff gap is leading to losses to state electricity boards (SEBs) and distorting consumption behaviour.

- **Increasing imports and fuel prices have driven up the cost of India's primary energy mix**

The cost of India's primary energy mix was about INR 11,600 per tonnes of oil equivalent (TOE) in FY14 (up from INR 6,000 in FY01). The inflation-adjusted prices of coal, oil and gas have risen steadily over the past 15 years, driving the cost increase. A growing share of costlier imported fuel has also pushed up the overall cost of energy.<sup>19</sup> Low global crude prices in the past two years have reduced this overall cost. The power generation cost from renewable sources has reduced significantly though and is expected to drop further. However, the overall impact of renewables cost on the index is low given they constitute a very small proportion of the current energy mix. The impact on the index will be much more substantial in the future given the increasing proportion of renewables in the energy mix and the significant expected reduction in renewables cost, especially solar.

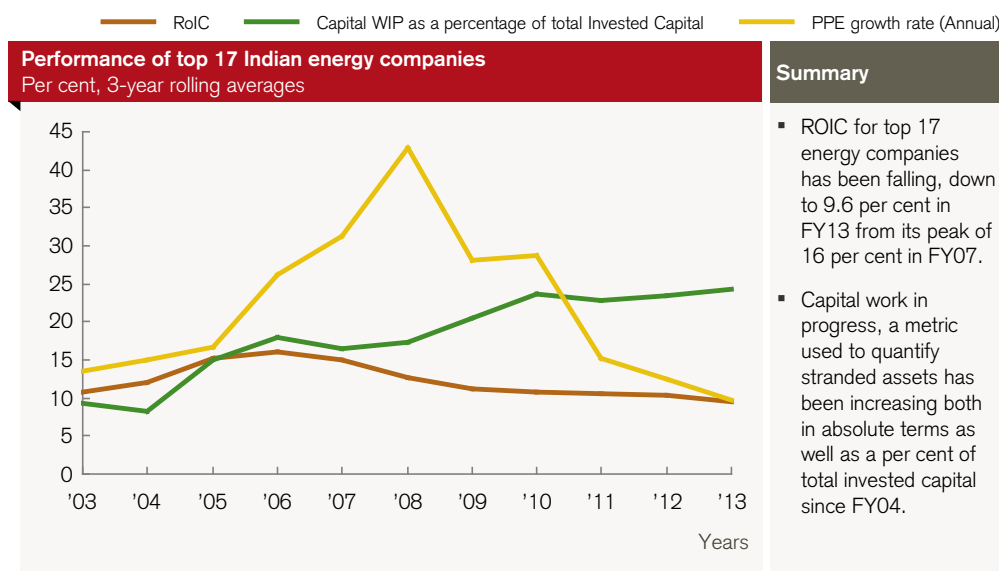
- **Stranded assets have reduced the returns of energy companies**

The returns on invested capital (RoIC) of 20 leading Indian energy companies selected across sectors of O&G, conventional power and renewables have dropped to 10 per cent. The returns of power companies have dipped to 6 per cent owing to stranded assets, low utilisation and poor financial conditions of DISCOMs.

India's political and administrative machinery has had to make constant efforts to "push" investments—often forcing public enterprises into non-viable investments, or exposing private investors and banks to the "winner's curse" (when companies/auction winners tend to overpay compared to the intrinsic asset value). Both paths have led to stranded assets and poor returns, resulting in the increasing share of work-in-progress (WIP) capital (Exhibit 9). The declining returns and increasing level of stranded assets have led to a decline in investments by energy companies. This is evident from the slowdown in growth of the total fixed asset base of these companies.

Economics will improve with successful implementation of the direct LPG subsidy transfer scheme. Initiatives to make business processes transparent should draw more private investment. The government's plan to increase coal production to 1,500 MTPA and expand installed renewable capacity to 175 GW by FY22 is likely to reduce the dependence on imports for coal. The increased coal production, reforms in the ailing distribution sector and proposed investment in T&D are likely to improve the balance sheet of DISCOMs, Plant Load Factors (PLFs) of generators, and to some extent, the financial attractiveness of the power sector.

### Exhibit 9: Performance of top 17 Indian energy companies<sup>E</sup>



### ACCESS TO AFFORDABLE MODERN ENERGY

India's performance on the energy access sub-index has steadily improved over the past 15 years on the back of increasing rural electrification through the grid and distributed renewables, and a shift from biomass to modern cooking fuels (Exhibit 10). However, rural access to electricity and modern cooking fuel is still far from acceptable.

- **Household electricity access is low, but increasing steadily**

As per NSSO estimates, over twenty per cent of Indian households do not have access to electricity. This highlights the absence of last-mile distribution infrastructure. Even though 98 per cent of India's villages have been electrified, just 68 per cent of rural households have access to electricity. Distributed renewable energy (DRE) has been used to electrify about 8,000 villages in 2013 and can be a good mechanism in the future as well.

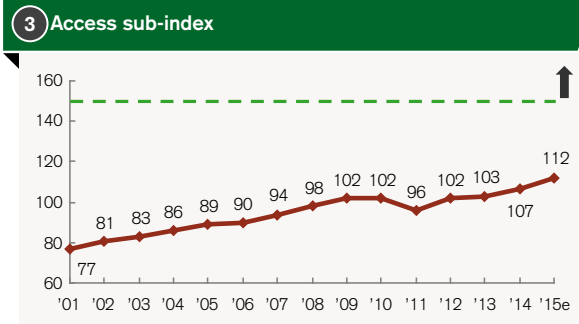
- **Although households are shifting to modern cooking fuels, a large proportion still use traditional forms of biomass**

Around 65 per cent of Indian households, mostly in villages, still use firewood, chips and cow dung as cooking fuel. LPG has replaced kerosene as the primary cooking fuel in urban areas, where the share of kerosene dropped from 30 per cent in FY01 to less than 5 per cent in FY13. LPG penetration is still very low in rural areas, with just 12 per cent of households currently using it.<sup>20</sup> The recent push to increase rural LPG penetration is an effort in the right direction.

<sup>E</sup> This list contains the top 17 Indian energy companies by revenues. This is the same list as the one used in parameter 2C, excluding the renewables' companies as they were new entrants and did not have significant revenues compared to the top 17 companies. RoIC stands for Returns on Invested Capital, Capital WIP stands for the Work-In-Progress capital, PPE is a measure of fixed assets and stands for Property, Plant and Equipment.

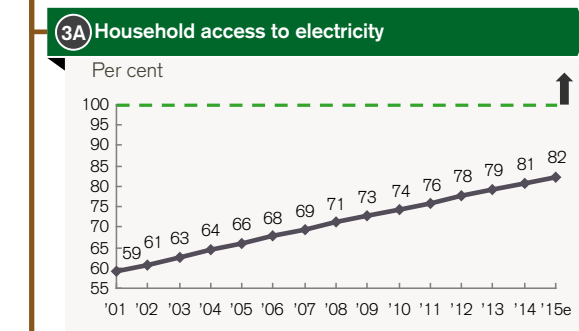
**Exhibit 10: Access sub-index**

--- Reasonable range  
 ↑ Arrow indicates whether reasonable range is above or below the green line  
 Improving  
 Stable  
 Worsening

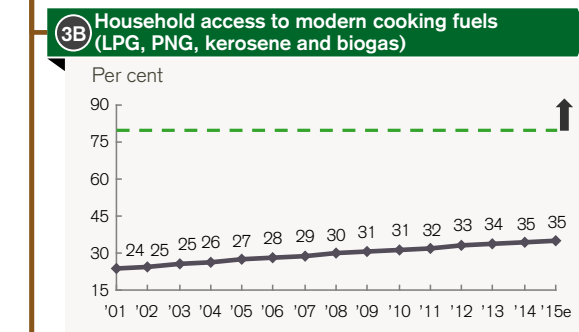


**Summary**

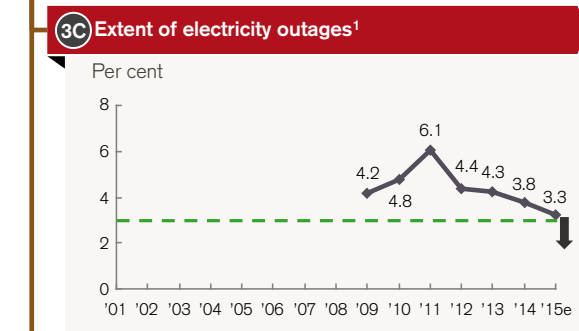
- India's performance on the Energy access sub-index has steadily improved over the past 15 years due to increasing rural electrification through grid and distributed renewables and a shift from biomass to modern cooking fuels.
- However, load shedding has been high.



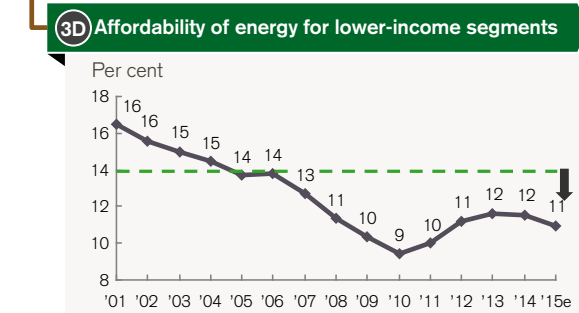
- Household access to electricity has been steadily increasing, primarily driven by increased rural grid electrification; however, it needs to be further improved.
- India is on track to achieve 100 per cent village electrification by May 2018 as only ~9,000 villages remain to be electrified.



- Household access to modern cooking fuels increased from 23 per cent in FY01 to over 35 per cent in FY15.
- The increase has been driven by replacement of biomass by LPG and kerosene in rural areas, and by LPG and PNG in urban areas.



- In spite of excess power generation capacity, poor financial condition of DISCOMs has led to high electricity outages.
- Some of the variation to SAIDI could also be attributed to inadequate metering at the feeder levels and low reporting of data.



- Amount spent by the bottom-most income decile on lifeline energy (30 kWh electricity and 6 kg LPG per month per household) as a percentage of their monthly income has been steadily decreasing.
- The decrease could be attributed to monthly income for this segment growing faster than the subsidised fuel prices.

<sup>1</sup> Data for SAIDI not available pre-2008

- **The increasing demand-supply gap is causing higher electricity outages**

Based on the System Average Interruption Duration Index (SAIDI) data reported by the Central Electricity Authority (CEA), electrified households experienced about an hour of load shedding every day in FY13.<sup>F</sup> Despite adequate power generation capacity, high T&D losses and poor financial condition of DISCOMs have led to increasing outages. Distribution utilities today have accumulated losses of over INR 3 lakh crore, and are making annual losses to the tune of INR 70,000 crore.<sup>21</sup> This is leading to load shedding instead of meeting demand.

- **Subsidies provided for LPG and electricity have made essential energy more affordable for the lower income families**

The central government provides subsidised LPG cylinders and the state governments provide subsidised power to households with low consumption. A household in the lowest income decile currently spends INR 282, or 11 per cent of its monthly expenditure, on lifeline energy—which is 30 kWh of electricity and 6 kg of LPG (as defined by the erstwhile Planning Commission). This has come down from 16 per cent of its monthly expenditure in FY01.<sup>22</sup>

## ENVIRONMENTAL SUSTAINABILITY OF INDIA'S FUEL MIX

India's performance on the sustainability sub-index has improved steadily over the past 15 years, driven by increasing generation from renewables and a higher share of service industry in the economy (Exhibit 11). However, the CO<sub>2</sub> emissions intensity of primary energy has been growing due to the rising share of coal in the primary energy mix and extensive use of diesel generators for backup power.

- **The share of commercial renewable energy is very low but has been steadily increasing**

Commercial renewables (including solar PV, CSP, wind, small and large hydro and clean biomass)<sup>G</sup> contributed to 4 per cent of India's primary energy generation in FY15. This is more than double the value of 1.5 per cent in FY01. Although solar PV and wind capacity saw the highest growth, their contribution to overall renewable energy production is currently insignificant.<sup>23</sup> There are no commercial RE-based options to replace oil consumption currently at scale.

- **The shift to a service-dominated economy has reduced the energy intensity of India's GDP**

The energy intensity of India's GDP reduced from 0.77 TOE/'000 USD in FY01 to 0.51 TOE/'000 USD in FY15.<sup>24</sup> An increasing share of services in India's GDP—up from 56 per cent in FY01 to 67 per cent in FY15—helped with this reduction. This parameter has been taken as a proxy for the energy efficiency of the economy, as reliable data was not available to quantify efficiency across all the end-use sectors of residential, commercial, industry and transport. Improvement in end-use energy efficiency could also have reduced the energy intensity; however, lack of data makes it difficult to quantify it.

F We believe these numbers underestimate load shedding, as the available data covers just a third of all distribution utilities in the country

G Clean biomass means usage of biomass as either a fuel for electricity generation, or bio gas/biofuels

- **India's CO<sub>2</sub> emission intensity has increased on account of a growing share of coal in the primary energy mix**

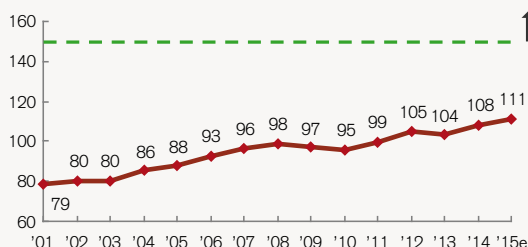
CO<sub>2</sub> emissions are a cause for concern in the context of climate change. As per IEA data, India's CO<sub>2</sub> emissions stood at 1,900 million tonnes in FY14, up from 970 million tonnes in FY01. Over this period, the share of both renewables and coal in the energy mix has grown at the expense of constantly declining share of non-commercial energy sources (e.g., biomass, firewood, cow dung). However, with coal's share in the primary energy mix growing much more significantly (up from 35 per cent in 2000 to 45 per cent in 2012) which could be due to lack of growth in nuclear and hydro, the intensity of CO<sub>2</sub> emissions has increased from 2.1 tonnes/TOE to 2.4 tonnes/TOE. Extensive use of diesel gensets as backup power in small industries, farms and residences, during load shedding, is another cause of rising emissions.

The sustainability of India's energy sector could get a boost through achieving the renewables target of 175 GW by FY22 and the implementation of end-use efficiency measures such as the large scale implementation of schemes promoting the use of efficient appliances like LEDs. T&D losses can be reduced by upgrading existing T&D infrastructure and through adequate metering at feeder and households level. Setting up more efficient Ultra-Supercritical power plants may also improve power generation efficiency. All these steps will be important to meet the INDC target of reducing emissions' intensity by 33 to 35 per cent.

### Exhibit 11: Sustainability sub-index

Reasonable range  
 Improving  
 Arrow indicates whether reasonable range is above or below the green line  
 Stable  
 Worsening

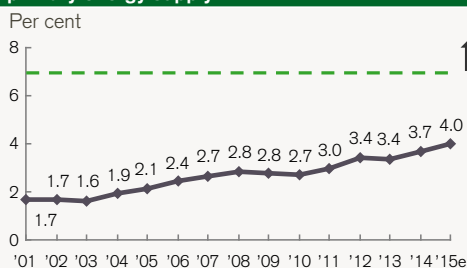
#### 4 Sustainability sub-index



#### Summary

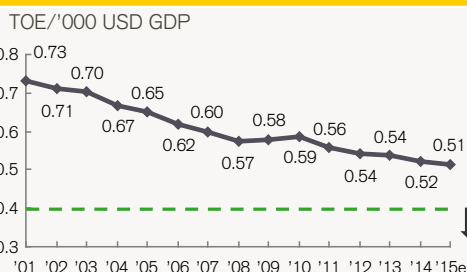
- India's performance on the Sustainability sub-index has steadily improved over the past 15 years driven by increasing generation from renewables and a shift to a service-dominated economy.
- The increasing intensity of CO<sub>2</sub> emissions is a cause of concern.

#### 4A Contribution of renewable resources to primary energy supply



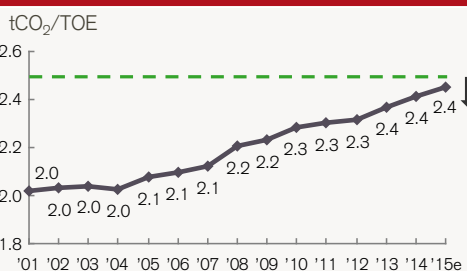
- The share of renewables (solar PV and CSP, wind, small and large hydro and clean biomass) in the primary energy mix has been increasing steadily from 1.6 per cent in FY01 to 3.7 per cent in FY15.
- In FY13, renewable energy consisted of 40 per cent hydro and 40 per cent clean biomass.

#### 4B Energy intensity of the Indian economy



- India's energy intensity has held constant around 0.5–0.6 TOE/'000 USD GDP over the past few years.
- The decrease of energy intensity in the initial years was driven by an increasing share of services in GDP.

#### 4C CO<sub>2</sub> emission intensity of primary energy use



- CO<sub>2</sub> emitted per unit energy consumed has been steadily increasing from 2.1 tons/TOE in FY01 to 2.4 tons/TOE in FY15.
- The increase could be attributed to an increasing share of coal in the primary energy mix (from 35 per cent in FY01 to 45 per cent in FY15).





## 4. RECOMMENDATIONS TO IMPROVE INDIA'S ENERGY SECURITY

India needs to focus its efforts across all the aspects of energy security—reliability, economics, access and sustainability. Only then will overall energy security improve. Efforts in only a few areas could lead to spot improvements without gains in the overall energy security. For example, increased use of modern fuels without a parallel effort toward domestic exploration and production trades off access for reliability.

All the steps of the energy value chain—fuel production, conversion capacity, efficiency and access—need attention. Effective institutional mechanisms for continuous inter-ministerial coordination, a stronger technology ecosystem and greater involvement and investment from the industry will be required to improve the energy index.

Perhaps, the first important step would be to adopt this comprehensive energy security index.

### ACTIONS THAT MAY HELP INDIA IMPROVE ENERGY SECURITY

Some representative actions that India could consider on various fronts to improve energy security are as follows:

- **Review and set up transparent regulations to attract more private and public investment in the energy sector**
  - Maintain taxation/subsidy parity between liquids, gas and renewables (with adjustments for emissions where necessary) to ensure the most economical fuel mix.
  - Revise the tariff mechanism for power distribution companies to allow the cost of purchased power to be passed on to consumers, enable time-of-day pricing and encourage investment in network reliability.
  - Regulate a transparent bidding and pricing mechanism for coal miners to explore and develop reserves in known mineralised areas.
  - Direct energy subsidies to only the low-income groups and scale up initiatives like direct subsidy transfers.
  - Revisit the current system of distance-based pipeline tariffs, which is restricting investment for gas penetration in far-flung areas.
  - Expedite efforts to improve the financial condition of distribution utilities. In addition to operational and financial improvement, focus on building capacity and improving technical quality of the T&D network.
  - Undertake initiatives for transformation of PSUs—clarifying their mandate, appointing longer-tenured leadership with strong performance monitoring systems, shifting focus to growth, performance and competitiveness, establishing performance-oriented and innovation culture, building capacity of the workforce.

- **Implement efficiency improvement measures in end-use sectors and generation even more aggressively**

- Reduce residential and commercial energy intensity through demand-side management. This would involve increasing the penetration of labelled appliances, and stringent implementation of (Energy Conservation Building Code) ECBC norms for commercial buildings, while introducing ECBC norms for residential buildings as well.
- Introduce time-of-day tariffs for the industrial segment along with demand-response management programs to drive year-on-year reduction targets.
- Incentivise use of star-labelled electrical pumps over diesel pumps in the industrial and agriculture sector.
- Increase efficiency of coal-based electricity generation by shifting most of the additional capacity to ultra-supercritical technology and shutting down older inefficient plants.

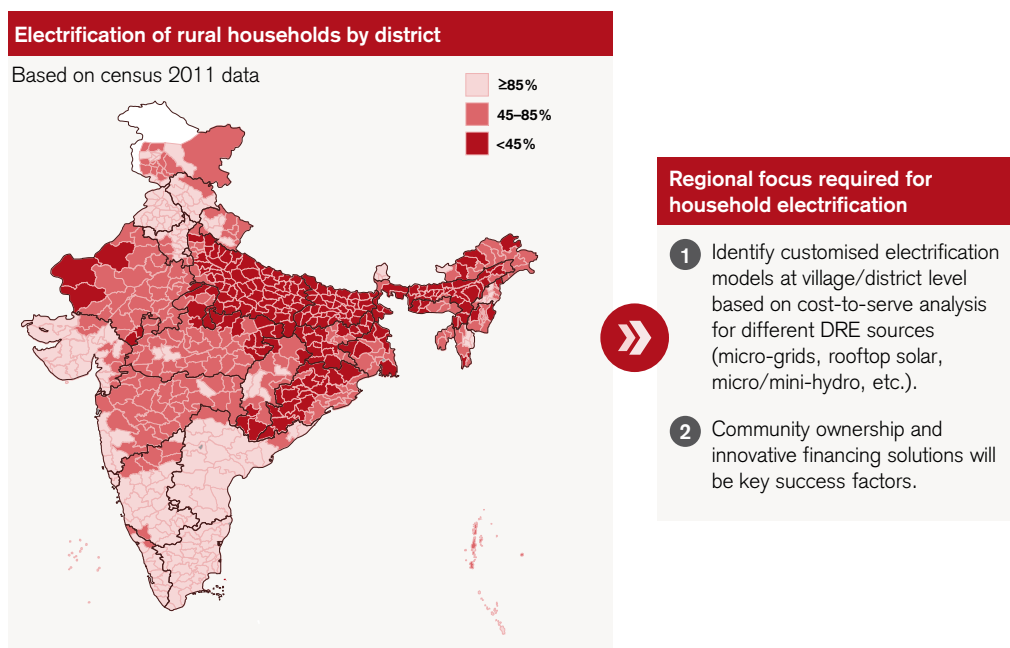
- **Accelerate the capacity addition of grid connected and distributed renewables**

- Continue to incentivise till grid parity is achieved and devise interventions for rural micro-enterprises and other anchor loads to shift to renewable solutions rather than using diesel power.
- Enforce renewable purchase obligations (RPOs) unilaterally and encourage states to meet RPO targets.
- Invest in relevant technologies (e.g., low wind speed technology, solar energy storage at lower cost) with focus on building local R&D and manufacturing capabilities to achieve the government's renewables target.
- Introduce peaking power policy to allow developers to invest in storage to make solar viable for evening peaks.
- Roll out successfully piloted models for off-grid solar while introducing new elements, such as competitive bidding and viability gap funding, to ensure competition and transparency.
- Channelise and attract funds for off-grid renewables (e.g., budgetary allocations, CSR budgets) and create economically viable models for sourcing private investment.
- Address the challenges of grid integration, which will involve investments for grid extensions and reinforcement, battery cost, or additional reserve capacity and infrastructure for balancing fluctuations.

- **Increase access to electricity and modern fuels through a mix of grid extensions, last-mile connectivity and other innovative electrification measures**

- Focus on household connectivity in already electrified villages, considering that though 98 per cent of villages are electrified, only 68 per cent of rural households have access to electricity (Exhibit 12).
- Accelerate shift to a gas-based economy through expansion of the pipeline network, some of which might need viability gap funding support.
- Take steps to reduce load shedding by distribution utilities through setting up of IT-based and third-party data measurement systems and launching incentive/penalty mechanisms. Doing this will also reduce the use of diesel gensets for backup power.

**Exhibit 12: Regional focus for electrification of rural households<sup>25</sup>**



SOURCE: Census 2011

- **Ramp up India's domestic production of oil, gas and coal, and secure international reserves**

- Continue streamlining regulations like the Open Acreage Licensing Policy (OALP) for O&G blocks and bidding of coal blocks for coal while ensuring that basic approvals for activities are taken before allotment to increase investments.
- Focus international acquisition efforts on a few geographical clusters and engage on a government-to-government level.
- Consider long-term contracts for crude oil, especially given the changing international dynamics due to the decreased import dependence of the US.

- Create a much-improved technology, manufacturing and services ecosystem to enable production for tougher environments and increase recoveries.
- Continue “open data” efforts through making relevant energy data available to investors and public in an analysis-friendly format.
- Continue setting up strategic oil reserves to mitigate short-term supply risks; consider diversification of import countries and trade routes, and use of Indian tankers for import and storage of oil.

How quickly and to what degree India moves on these fronts will determine the outcome on overall energy security.

### **INSTITUTIONAL MECHANISMS**

Executing these initiatives will also require effective institutional mechanisms for continuous inter-ministerial coordination, a stronger technology ecosystem and greater involvement and investment from the industry. Specifically:

- Though efforts have been made recently to consolidate energy ministries, there are multiple stakeholders in energy decisions (Ministries of Power, Coal, RE, Oil & Gas as well as states). A mechanism for continuous coordination is needed to ensure that the stakeholders make coordinated policy choices, and most importantly, enable quick decisions. India could consider setting up an energy mission, a cross-ministerial body on energy, or appoint a central minister in charge of all energy issues to coordinate between ministries.
- Reliable market mechanisms and ease of doing business are necessary to improve the returns of private enterprises doing business in the energy space. Market-linked prices, stable tax regimes and transferring energy subsidies directly to people who really need them are some steps that could help in this direction.
- Technology has become central to all aspects of the energy value chain. India needs to focus on increasing technology depth in the energy space through greater R&D investment, technology collaborations and incentives for local manufacturing and services.
- Strong global energy companies, especially PSUs, will be the necessary foundation for India’s energy security. Ensuring financial strength, providing freedom to acquire and develop global talent, and facilitating international corporate acquisitions are potential enablers for the success of these companies.

Adoption of this holistic energy security index, with reasonable targets, combined with a concerted set of actions, and supported by the few key enablers that are described above could make a big difference to India’s energy security.



## APPENDIX: METHODOLOGY AND DATA SOURCES

One of the design principles used while selecting the parameters is availability of data from public sources. This was included to ensure complete transparency in the calculation of the index. This section elaborates on the methodology, assumptions and data sources used for calculating each of the 15 index parameters.

- **Parameter 1A: Years of secure fossil fuel supply remaining**

The metric used to quantify this parameter:

$$\frac{R}{P} \text{ for domestic fossil fuels} + \frac{R}{P} \text{ from international sources owned by public Indian companies} + \text{years of fossil fuel supply through long-term and infra linked contracts}$$

R/P stands for the reserves to production ratio. Although long-term and infra-linked and self-equity reserves owned outside India are not as secure as domestic reserves, they are more secure than spot contracts/trading. The domestic reserves and production data has been taken from the *BP Statistical Review*, published annually. The data for international reserves owned by Indian companies has been taken from the annual reports of the O&G companies that have international assets. Data for long-term gas contracts (duration and volume) has been taken from the Cedigaz database and is also available in public sources. India does not currently have any international gas pipelines for importing gas.

- **Parameter 1B: Dependence on imports for meeting energy needs**

The metric used to quantify this parameter is “net energy imports as share (per cent) of primary energy supply”. We consider net energy imports (and not energy imports) because India exports a lot of refined petroleum products. Data for both the net energy import and total primary energy supply (TPES) has been taken from the IEA website.

- **Parameter 1C: Mitigation of supply risks through diversification of import base (countries) and fuel mix**

The metric used to quantify this parameter:

Average of

( HHI (Herfindahl-Hirschman index) for India’s net energy imports (per cent – by country) weighted for country’s political risk )

**and**

( HHI (Herfindahl-Hirschman index) for India’s energy sources (per cent – by sources) )

HHI is a very common index used to quantify diversification globally, across different fields. The HHI adds the squares of various percentages, which are weighted by political risk in country-diversification and not weighted by anything in the energy source-diversification.

The smaller the percentage of each country/source, the smaller are their squares, and the smaller is the overall HHI number. The political risk index has also been normalised (between 0 and 1) such that politically stable countries have a lower political risk index value. This metric consists of three distinct data—India’s share of energy imports by country, political risk rating of different countries and India’s share of energy supply by sources.

The data for the share of energy imports by country has been taken from the publically available UNCommTrade database and that for share of energy sources from IEA. Finally, World Bank’s political risk rating index has been used.

- **Parameter 1D: Availability of safety stocks to absorb short-term supply shocks (disruptions)**

The metric used to quantify this parameter is “average of coal stock in power plants (in days of coal consumption at plant) and strategic, commercial oil reserves (in days of national oil consumption)”. The impact of short-term supply shocks (due to disruptions, or periods of very high price) for oil can be absorbed through strategic reserves and commercial stocks of crude oil and refined products in refineries and depots. Coal stocks in power plants serve the same purpose for coal supply shocks. The data for coal stock in power plants is taken from the CEA website. The data for strategic crude reserves is taken from the annual reports of ISPRL, the government-mandated company for construction and maintenance of strategic reserves. The data for commercial stocks has been taken from a response filed against queries in Rajya Sabha; and it might not be available annually going ahead.

- **Parameter 2A: Burden of energy imports on India's balance of trade**

The metric used to quantify this parameter is “energy imports as a percentage of total exports”. The data for energy imports and total exports has been taken from the publically available UNCommTrade database.

- **Parameter 2B: Energy subsidy burden on government budget**

The metric used to quantify this parameter is “petroleum-products and electricity subsidy (including government expenditure towards under-recoveries) as a percentage of budgetary spending”. The data for electricity subsidies has been taken from three annual reports of the Power Finance Corporation (PFC) titled *The Performance of State Power Utilities*. The earliest available data for electricity subsidies is for FY10. Data for subsidies on petroleum-products includes fiscal subsidies by the government, oil bonds (2005–10) and cash assistance by the government to downstream companies. The data for all these factors has been taken from Petroleum Planning & Analysis Cell (PPAC).

- **Parameter 2C: Cost effectiveness of India's primary energy mix**

The metric used to quantify this parameter is “weighted average of real cost of energy in INR/TOE for India's fuel mix (fuel cost for fossil fuels and levelised cost per kWh for renewables)”. The data for the energy mix, or share of different fuels in the energy mix is obtained from IEA. The cost data for all major sources is obtained from public sources, i.e., websites of PPAC, IOCL and CIL

- **Parameter 2D: Attractiveness of the energy sector for investments**

The metric used to quantify this parameter is “return on Invested Capital (RoIC) for 20 leading energy sector companies”. RoIC is the ratio of NOPLAT (net operating profit adjusted for tax) to total invested capital. Financial data for each of these 20 companies is obtained from their annual reports. The 20 companies have been selected based on their revenues in FY12 revenues. We have included the four largest renewables companies in the list, even though they were not in the top 20 by revenues, to cover all types of companies.

- **Parameter 3A: Access of households to electricity**

The metric used to quantify this parameter is “percentage of households electrified through grid or distributed generation (Solar PV etc.)”. The data for grid-electrified households is taken from the five-yearly NSSO surveys, and interpolated due to non-availability of any other source of data. It is worth noting that the NSSO reports the number of households using electricity as the primary source of energy, and not the total number of households that have electricity connections. In the absence of any other data, this data source is commonly used as a proxy for household electrification.

- **Parameter 3B: Access to LPG/PNG and bio gas as cooking fuel**

The metric used to quantify this parameter is “percentage of households using LPG/PNG and bio gas fuels (for cooking)”. The data for the number of households using LPG, PNG and bio gas as the primary cooking fuel is taken from the five-yearly NSSO survey data, which is interpolated for intermediate years.

- **Parameter 3C: Disruptions caused due to shortfall of supply**

The metric used to quantify this parameter is “SAIDI/(8,760), where SAIDI is the System Average Interruption Duration Index in hours”. The total number of houses in a year is 8,760. The CEA has been reporting the data for this metric annually, but only began in 2008. The quality of the data is poor because only 25 to 30 per cent of all the utilities across India send their data to CEA. However, this data has been used as it is the standard parameter used to quantify outages globally, and since no other reliable metric is available.

- **Parameter 3D: Affordability of energy for lower-income segments**

The metric used to quantify this parameter is “per capita spend on essential energy/ per capita income (for lowest income decile)”. We take the amount of essential energy as defined by the erstwhile Planning Commission’s Integrated Energy Policy in terms of LPG and electricity. The historical price of electricity has been taken from utility-wise public data (and then averaging for all-India level), for the price of the bottommost consumption group (subsidised price).

The price of kerosene has been taken as the subsidised PDS price. The data for per capita income has been taken from NSSO surveys. It is worth noting that no public data source (including NSSO) captures decile-wise income. They instead capture monthly per capita expenditure (MPCE) instead and use it as a proxy for income. This is definitely true for lower income segments where savings are negligible.

- **Parameter 4A: Contribution of renewable resources to energy supply**

The metric used to quantify this parameter is “share (per cent) of renewables (solar, wind, hydro and clean biofuel) in total primary energy supply”. Data for the metric is obtained from IEA website. Different countries/organisations use different conventions for defining renewables, especially around the inclusion of large hydro, nuclear and non-commercial biomass. For this parameter, our definition of renewables includes large hydro, but does not consider nuclear or non-commercial biomass like firewood and cow dung.

- **Parameter 4B: The economy’s efficiency in converting energy to end-output**

The metric used to quantify this parameter is “energy consumption per unit real GDP (TOE/’000 USD GDP)”. The data for this metric has been taken from the IEA website.

- **Parameter 4C—CO<sub>2</sub> emission intensity of primary energy mix**

The metric used to quantify this parameter is the “amount of CO<sub>2</sub> emitted per unit of primary energy consumption (tCO<sub>2</sub>/TOE).” The data for this metric has been taken from the IEA website.





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