Data Gaps in India's Energy Sector

Prayas (Energy Group)
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Prayas (Energy Group) is a member of the energy data management sub-group of the Sustainable Growth Working Group (SGWG) constituted under the Indo-US energy dialogue. This report has been submitted to the SGWG for its consideration.

Preparation of this report has benefited from the feedback received at a workshop organized by the Ministry of Statistics and Program Implementation in September 2015 that was attended by providers as well as users of energy data in India. In addition, discussions with experts from various energy data and analysis agencies in the US provided useful insights. The authors would like to thank all of them for their valuable inputs.

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List of Acronyms

ASI	Annual Survey of Industries
BEE	Bureau of Energy Efficiency
CBECS	Commercial Buildings Energy Consumption Survey
CCO	Coal Controller's Organization
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CIL	Coal India Limited
CMPDI	Central Mine Planning and Design Institute
DGH	Directorate General of Hydrocarbons
EDM	Energy Data Management
EIA	Energy Information Administration
GIS	Geographic Information System
GoI	Government of India
MECS	Manufacturing Energy Consumption Survey
MNRE	Ministry of New and Renewable Energy
MoC	Ministry of Coal
MoP	Ministry of Power
MoPNG	Ministry of Petroleum and Natural Gas
MoSPI	Ministry of Statistics & Programme Implementation
NITI	National Institution for Transforming India
NPD	Norwegian Petroleum Directorate
NSSO	National Sample Survey Organization
PNGRB	Petroleum & Natural Gas Regulatory Board
PPAC	Petroleum Planning and Analysis Cell
RECS	Residential Energy Consumption Survey
SCCL	Singareni Collieries Company Limited
SERC	State Electricity Regulatory Commission
SGWG	Sustainable Growth Working Group
UNFC	United Nations Framework Classification

List of Figures

List of Boxes

Table of Contents

1 Introduction

Given the close links between energy use and development (IIASA, 2013), it is imperative for a nation's energy policy to be in sync with its developmental goals. Energy data is a critical enabler for policy makers and the research community in formulating and analyzing energy policies. National energy data systems need to be robust and efficient in delivering such energy data useful for research and policy formulation.

In this context, the Sustainable Growth Working Group (SGWG) of the Indo-US Energy Dialogue created a sub-group on energy data management to identify ways to improve India's energy data management (EDM) system. As part of this exercise, we studied the institutional and legal framework of India's EDM – its current structure, data collection and dissemination mechanisms – and suggested mechanisms to strengthen the institutional framework (PEG, 2014). It was found that data is largely collected for administrative purposes and there is a weak mandate to disseminate the data. Many gaps exist, particularly on the consumption side as it is more difficult to gather this data. Insufficient capacity and mandate to validate and disseminate data results in lack of coordination among the various data and energy sector institutions. We found wide variation in data dissemination practices across different sub-sectors due to the decentralized nature of energy and data management systems in India.

Simultaneously, Pacific Northwest National Laboratory (PNNL) of the United States government studied international best practices in EDM as part of the SGWG. This study examined EDM systems in four countries – the U.S., United Kingdom, Canada and Germany (PNNL, 2014). The countries studied rely on codes of practices to help agencies within their systems maintain a common understanding of purpose, uphold quality standards, and build credibility and trust. Codes of practice and principles for data management in different countries have many similarities in their core elements, and these details may be useful to India as it strengthens its own EDM. Despite the similarities in underlying principles, these countries have adopted diverse EDM models with differing degrees of centralization.

In this report we undertake a deeper investigation of public dissemination of energy sector data in India, compare this with what should ideally be available and contrast with international best practices. We look at data gaps on the supply side and important sub-sectors on the demand side. These gaps were presented at a workshop organized by National Institution for Transforming India (NITI) Aayog and the Ministry of Statistics & Programme Implementation (MoSPI) in September 2015. At the workshop, feedback was sought from data users from the energy research, policy analysis and modeling communities and officials representing concerned data agencies. Some strategies to address these data gaps as well as immediate improvements that can be implemented with minimal effort were also discussed at the workshop. Suggestions from the workshop have been incorporated in this report.

The intended audiences of this report are data agencies within various ministries under Government of India (GoI) that deal with energy data in the country. We suggest several improvements that can be undertaken by the agencies to address the identified gaps in a phased manner. We hope that the data agencies consider implementing these suggestions seriously to help improve data availability in India's energy sector.

2 Approach

What is energy sector data and how do we define its availability? One expansive definition could be all data that has any link to the energy sector, with as much granularity and frequency as can be recorded. However, it is not practically possible to satisfy this requirement. On the other hand, for an EDM system to be relevant, it needs to satisfy the needs of a wide variety of data users. Different stakeholders may have specialized expectations of the EDM system. A government department may be looking at data purely from an administrative point of view. An environmentalist may be looking specifically at data related to environmental impacts of the energy sector. An investor may be interested only in data that relates to financial returns from the sector. It is important to balance the different stakeholder needs with what is practically achievable.

2.1 Definition

For this analysis, we define data gap as "*data useful for policy research, formulation, program monitoring, or decision making by various stakeholders, but not accessible in the public domain at desired granularity or frequency in a convenient form*". Different aspects of this definition are described below.

For data to be "*accessible in a convenient form*", it needs to be available freely or at a reasonable cost in convenient, machine-readable formats, through user-friendly avenues such as public websites. Recent advances in browser and visualization technologies should be used for improving data accessibility in a cost effective manner (see Box 1). "*Public domain*" refers to public availability of data through government data sources. "*Desired granularity and frequency*" depend on the kind of data under consideration. For example, data on coal reserves is needed for each block, while data on wind potential is needed at least at the level of a 1 km x 1 km national grid. In this report, unless mentioned otherwise, **all data is expected to be available annually for each state**. Any data requirement at a different granularity (e.g. district, village etc.) or frequency (e.g. monthly, quarterly etc.) has been specified against the corresponding data item.

2.2 Relevance to Policy Priorities

Data needs to be "*useful*" for policy research and formulation, for performance monitoring of a program or policy, for public interest advocacy or for decision making. In addition, data provision is a pre-requisite to improved governance as it plays an important role in increasing transparency, accountability, and public participation in government processes. To define boundaries for an 'ideal' data set, we examine the links between India's energy data needs and developmental needs. With regard to the energy sector, the following aspects of India's developmental strategy are relevant:

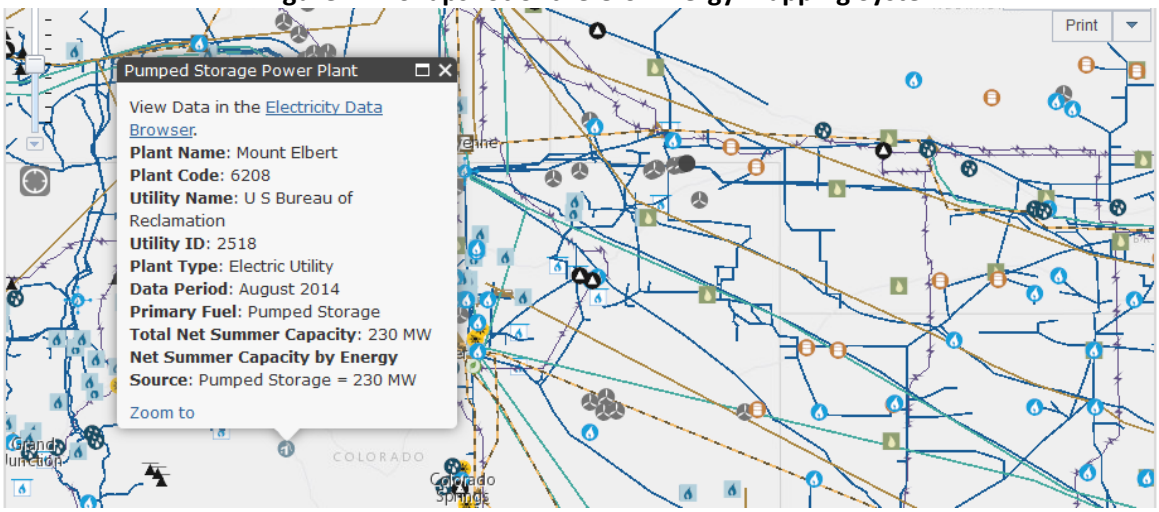
a) Provision of modern, clean and affordable energy services to all citizens;
b) Development of the sector through robust planning, policy and regulatory processes;
c) Provision of a level playing field for investment related decision making;
d) High standards of operational performance (technical and financial efficiency) and optimal utilization of resources;

e) Socially and environmentally sustainable development by addressing local and global impacts.

Box 1: Data Accessibility

Widespread use of data communications through the Internet and evolution of web technologies have led to availability of much of the world's information in digital form over the World Wide Web. Collecting, processing and sharing information digitally has significantly reduced the time, effort and money required by data agencies to fulfil their functions. One striking result of this progress is the rapid strides made in web-based mapping and visualization infrastructure in recent years. EIA's Energy Mapping System is an excellent example of such a system. EIA packs a wealth of information regarding the energy infrastructure in US and shares it through an intuitive mapping interface (see Figure 1). The map features several layers such as fossil resources, coal fields and sedimentary basins, solar/wind/geothermal potential, biomass resources, coal mines, all power plants (even those as small as 1 MW), transmission lines and oil and gas wells, refineries, pipelines, and storage facilities. Clicking on an entity on the map results in a pop up with basic information about that installation and a link to other EIA portals with more detailed data such the coal data browser described in Box 2.

Figure 1: A Snapshot of the U.S. Energy Mapping System



Source: http://www.eia.gov/state/maps.cfm, retrieved on November 19, 2015

2.3 Stakeholder Needs

Based on the overarching goals listed above, energy data can be sought from three analytical perspectives – energy systems, finances and socio-environmental impacts. Energy data that is relevant to each of these perspectives are explained in greater detail below. Most energy sector analyses involve one or more of these perspectives.

2.3.1 Energy Systems Analysis

Energy systems analysis involves data on energy reserves or potential, transformation, transportation and consumption, and encompasses energy flows from resources to end-use. From this perspective, an ideal data set would include:

- Resources & Production (Coal, Crude Oil & Natural Gas):
  - Total and at-present resources and recoverable reserves: Geographically mapped
  - Production: Quantity and quality
- Transformation:
  - Electricity: Generation potential, installed capacity and generation, equipment technology and technical details, fuel supply – quantity and quality
  - Petroleum products/Refined natural gas/Coal washeries: Fuel input and output – quantity and quality
- Transmission & Distribution:
  - Coal, Crude oil, Natural Gas: Fuel dispatch/transport – quantity and quality
  - Electricity, Petroleum Products: Quantity supplied, intermediate losses and final sales
- Consumption:
  - Data for each end-use consuming sector and energy resource, along with data on type of consumption, hours of usage and appliance-specific data

Forward-looking data such as projections is excluded from our definition of data even though regular availability of such data can help improve energy sector planning. Survey or sampling based data such as resource potential and consumption data that are estimated on the basis of certain assumptions are considered as 'data' in this report.

2.3.2 Financial Analysis

From a financial point of view, data is required to evaluate investment needs of the sector, economic efficiency of energy activities, fiscal burden on governments and energy companies, and affordability of energy for ordinary people. The following data is sought:

- From entities involved in energy-related activities:
  - Income/revenues, investment/expenditure, tariffs/prices, debt & sources of investment
  - These numbers should preferably be itemized – for example, fixed costs data should include debt servicing, return on equity, interest during construction etc.
- From governments:
  - Taxes/duties, expenditure/subsidy/incentives (incl. revenue foregone)

2.3.3 Socio-environmental Impact Analysis

Socio-environmental data helps measure the positive and negative impacts of energy sector activities on environmental and social well-being. Such data includes:

- Social aspects:

- Employment provided by energy-related companies/utilities under various categories (Skilled/Unskilled, Contract/Permanent etc.)
- Project-affected people for each project: Number of people displaced by energy projects, and share (%) of them compensated, rehabilitated and resettled by govt./developer
- Land and water requirement/discharge: Project-wise

- Environmental aspects:
  - Environmental impact assessment reports, along with environmental and forest clearances for projects
  - Project-wise (for each stage/phase) data on pollution (land, water and air) and GHG Emissions

The data listed above is critical to help assess the energy sector's performance and answering questions such as the following: How do technical efficiencies of energy generation, transmission and distribution processes in India compare with those of global best practices? Is fuel supply to power generating stations optimally routed? What are the trends in energy commodity prices and the underlying causes of those trends? How affordable are energy services? How is energy consumption distributed across income deciles? What are the impacts of various energy sector programs on the exchequer? What public and private investments are needed to meet planned expansion in provision of energy services? What are the land and water needs of the energy sector under various scenarios? What are the social and environmental costs of various energy sector activities? What are the implications of different energy supply trajectories on employment?

2.4 Scope of the Report

Ideally, data should be available with regard to all three perspectives mentioned above. However, this report is primarily is addressed to energy-related data agencies which deal directly with energy supply and use. Hence, we focus only on the first two analytical perspectives: energy systems and economic/financial. Since socio-environmental data lies outside the purview of these agencies, it has been excluded from this report even though such data is crucial to understand the full implications of the energy sector on the country's development and environment.

In addition, certain kinds of information should be publicly available for improved governance and transparency. For example, contractual documents such as fuel supply agreements and power purchase agreements can help understand vital linkages within and outside the electricity sector. Likewise, clearances obtained from different government bodies can help monitor compliance with various social and environmental laws and regulations. While availability of such data can certainly help improve governance, such transparency needs have not been dealt with in this report.

The focus of this report is on data availability, and issues related to data accuracy and consistency have not been dealt with here. For example, while coal dispatch data is published by Coal India Limited (CIL) and data on coal receipt at power plants is published by Central Electricity Authority (CEA), we have not checked if there are inconsistencies between the two data sets.

2.5 Organization

For the purpose of this report, energy data is categorized into supply and consumption sectors. Supply data is categorized further into four sub-sectors: coal, petroleum and natural gas, electricity and renewables. There is overlap between electricity and renewables since renewables primarily contribute to power generation. This categorization is based on the way energy-related ministries are organized in India. Nuclear power is excluded from this exercise due to its sensitive nature and general unavailability of nuclear data. The consumption sector is broken up further into five end-use sub-sectors: agriculture, residential, commercial, industry and transport.

For each sub-sector, a list of ideal data relevant to analysis, research and policy making was arrived at based on interactions with stakeholders, international best practices and Prayas (Energy Group)'s experience in and understanding of the energy sector. Energy data collection and dissemination practices in India have mostly been compared with those in the US[1], specifically at Energy Information Administration (EIA) – a specialized independent organization with an EDM mandate. EIA publishes data through a variety of reports such as the monthly and annual energy reviews[2]. The ideal data set was compared with data disseminated by various energy data agencies in India to arrive at data gaps for each sub-sector.

We present a subset of the supply-side gaps in Section 3. See Annexure A1 for a more comprehensive list of supply side data items sought (the ideal data set) and gaps identified. Gaps on the consumption side are listed in Section 4.

3 Energy Data Gaps: Supply Side

As stated above, the supply sector is categorized into four sub-sectors. The important data gaps in each of these sub-sectors are described below in detail.

3.1 Coal

Operations in the coal sector include estimation of reserves, production, trade, washing, transport and consumption. Ministry of Coal (MoC) is responsible for policies governing the coal sector, while Coal India Limited (CIL) is the monopoly public sector coal producer which produces about 80% of domestic coal. Reserves are estimated and mining operations are studied by Central Mine Planning and Design Institute (CMPDI) – the technical arm of CIL. The Coal Controller's Organisation (CCO), an agency within the MoC, is responsible for collecting and disseminating data.

CCO collects data on the coal sector periodically from CIL and other coal producers through its '*Annual Survey of Coal & Lignite Industry*' and publishes data annually in the form of a '*Coal Directory*'. Some

[1] One exception is that for upstream hydrocarbon data, Norway was used as a benchmark since the Norwegian Petroleum Directorate has adopted some of the best practices in data dissemination in the sector.
[2] EIA's website is http://www.eia.gov. Survey forms used by the EIA are available at surveys are at http://www.eia.gov/survey. The Annual Energy Review can be found at http://www.eia.gov/totalenergy/data/annual/index.cfm and Month Energy Review is available at http://www.eia.gov/totalenergy/data/monthly/index.cfm.

data such as a monthly coal production summary are available on the MoC website and data such as coal dispatch to end-users is available on Coal India Limited (CIL) website (CCO, 2014a; CCO, 2014b; MoC, 2015a; CIL, 2015). Data on United Nations Framework Classification (UNFC)-classified reserves is available on the website of Central Mining Plan and Design Institute (CMPDI) based on a one-time exercise undertaken by the agency for blocks held by CIL (CMPDI, 2014).

Surveys undertaken for coal companies as well as annual and monthly review reports and coal-specific reports or other such data published by EIA[3] were looked at for comparison.

Data gaps in the coal sector

Following are some of the data gaps in the coal sector. A more detailed list of gaps is included in Annexure A1.1.

- Data on coal reserves is patchy and reserves are classified through two different methods – the historically used proved-indicated-inferred classification and the recently adopted UNFC. From the available data, it is difficult to accurately estimate the current coal reserves in the country (Batra & Chand, 2011).
- GIS maps of reserves and coal producing areas are not available.
- Block-wise quantity and quality of coal produced along with quantities of coal transported along major routes split into different transport modes such as road and rail.
- No data is available on energy used to extract coal which is an important metric in determining efficiency of the coal extraction process.
- Block-wise data on coal production costs is not available without which, financial efficiency of coal production cannot be assessed. This gap is also significant given that the monopoly producers in the country, CIL and SCCL, are public sector companies.
- No data is available on the equipment used in coal production such as the type, number and utilization factors. This data is useful in determining production efficiency with respect to capital equipment and capital needs for increased production, and comparing with international best practices.
- Data on quality and value of coal imports by consuming sector is not available, making it difficult to assess prudence of import contracts and price impacts on various consuming sectors.
- No data is available on quality of input coal washed coal making it impossible to assess the performance of the few washeries that are in operation.

Some of the data listed above may be scattered across various entities such as CMPDI, the coal companies and industry associations. CCO should collect and publish this data in one place, while it should make efforts to collect data that does not exist.

[3] Coal data published by EIA is available at http://www.eia.gov/coal/data.cfm.

Box 2: EIA's Coal Data Browser

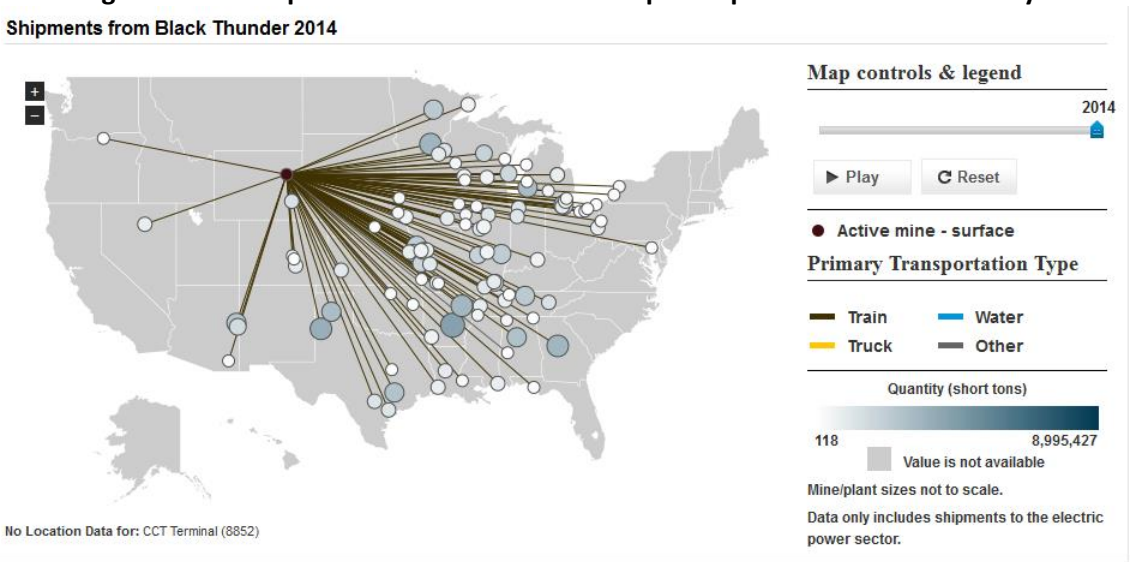
EIA recently launched an interactive portal called the Coal Data Browser[4] with an intuitive interface to find, graph and map coal data in the United States. Data is available in the form of data sets that include production, imports and exports, shipments to power plants and individual mine-level data and maps that include world trade, national, basin, state and supplier networks.

A query on the portal results in a table consisting of time series data along with visualization in graph or map form. Data is provided at various temporal and spatial granularities and includes data such as calorific value, ash and sulfur content and prices. The interactive, clickable, colour-coded map interface is rich with features such as bubbles proportional in size to the associated data and a play button that triggers animation of time series data.

Metadata is mentioned where applicable. Data is accompanied by information such as the source of the data – the underlying surveys from which the data was collated – and caveats for provisional estimates. Provisional data is dynamically updated and is typically marked final within 9 months after the calendar year. Missing data is marked with reasons for the same. For example, some commercially sensitive pricing data are marked as "withheld to prevent disclosure". There are very few missing values due to non-response.

The snapshot in Figure 2 depicts the richness of the interface.

Figure 2: Coal dispatch from a mine to various power plants across the country



Source: http://www.eia.gov/beta/coal/data/browser/#/shipments/mine/4800977

[4] EIA's coal data browser can be accessed at http://www.eia.gov/beta/coal/data/browser.

3.2 Petroleum & Natural Gas

Similar to coal, petroleum and natural gas sector operations include exploration and estimation of reserves, production, trade (imports/exports), transformation (refining/fractionating), transportation, stocks and end-use. Ministry of Petroleum and Natural Gas (MoPNG) is the ministry responsible for the oil & gas sector. Directorate General of Hydrocarbons (DGH), an administrative unit of MoPNG, provides technical input to GoI and regulates upstream operations on GoI's behalf. Petroleum & Natural Gas Regulatory Board (PNGRB) is an independent downstream regulator responsible for transport and distribution of petroleum products and natural gas. The oil and gas industry is dominated by public sector entities such as Oil and Natural Gas Corporation, Gas Authority of India Limited and Indian Oil Corporation, although the role of private sector has grown since the 1990s.

Upstream data is collected by DGH and downstream data is collected by Petroleum Planning and Analysis Cell (PPAC) – the technical arm of MoPNG for downstream operations. In addition, PNGRB collects and publishes some data on downstream operations. MoPNG publishes the annual "*Indian Petroleum and Natural Gas Statistics*" (MoPNG, 2014). DGH publishes an annual report on "Hydrocarbon Exploration and Production activities" with data on reserves, production and block status (DGH, 2014). DGH publishes block-wise data such as exploration work undertaken, relinquished area and discoveries through its website. However, the data is dated and not accessible in a downloadable format, and the portal does not specify when the data was last updated. PPAC publishes monthly data on production, import/export, distribution, sales and pricing of petroleum products and natural gas in csv/excel formats. PPAC follows some of the best data management practices among all energy-related data agencies in India. In addition, the Commerce Ministry (through the Export/Import Data Bank) as well as Ministry of Shipping publish data on quantity and value of imports and exports by port and source/destination nation.

In addition to EIA's surveys and reports[5], we looked at the data published by the Norwegian Petroleum Directorate (NPD) given its reputation as an agency following some of the best data dissemination practices for upstream data (see Box 3).

Data gaps in the hydrocarbon sector

Following are some of the data gaps in the oil and gas sector. A more detailed list of gaps is included in Annexure A1.2.

- Only aggregate reserve data is published. Instead, annual reserve data should be published at least at basin as well as block level. Reserve classification should be as per international standards.
- Block-wise data provided on DGH website should be updated in a timely manner and in user friendly formats such as csv. The last updated date should be published as well.

[5] Hydrocarbon data published by EIA can be accessed at http://www.eia.gov/petroleum/data.cfm and http://www.eia.gov/naturalgas/data.cfm.

- Detailed block-wise status of important milestones should be published along with any missed deadlines, reasons for the delay and any penalties that were levied. These milestones include phase-wise exploration activity, discoveries, appraisals, declarations of commerciality and field development plans.
- Monthly production data should be published for all producing wells (see Figure 3 for example from Norway).
- Company-wise availability of capital intensive drilling equipment such as deep water rigs should be published. Availability of such equipment determines the extent of exploration and production activities that can be carried out simultaneously. This data is important given that there have been concerns regarding shortage of rigs effecting drilling operations (Kumar, 2008).
- Block-wise investment in exploration, development and production, and revenues from sale of hydrocarbons should be published. This data is particularly important for blocks under the Production Sharing Contract (PSC) regime where there are implications for government's share of the profits.
- Data on refinery-wise throughput, capacity utilization, product-wise output and storage, and exports is not available.
- Data on quantity and value of natural gas and petroleum product imports by consuming sectors is not published. This data is important given India's high import dependence on oil and gas imports.
- Data on transport of hydrocarbons is not easily accessible as it is either not publicly available or, when available, is scattered across various websites. Major hydrocarbon transportation routes and quantities shipped across those routes should be published. Transportation tariff data is available on PNGRB website, but is scattered over several pages.
- Capacity and quantity of strategic petroleum reserves should be published.

Figure 3: Monthly well production report on Diskos public portal

Installation allocated production/injection report

Monthly - by Installation | Yearly - by Installation | Monthly - total | Yearly - total

Produced | Injected

NO | UK | Total

All | Gas | Oil

Previous 1 2 3 4 5 6 7 Next

CSV | EXCEL | XML

Installation	Month	Oil	Gas	Condensate	Oil Equivalents	Water
		Sm^3	Sm^3	Sm^3	Sm^3 o.e.	Sm^3
ALVHEIM FPSO	01/2015	424 142	67 392 661		491 534	615 660
ALVHEIM FPSO	02/2015	414 799	61 120 772		475 919	584 549
ALVHEIM FPSO	03/2015	417 189	62 321 386		479 510	595 939
ALVHEIM FPSO	04/2015	393 161	59 664 612		452 825	583 595
ALVHEIM FPSO	05/2015	366 185	49 876 734		416 062	509 136
ALVHEIM FPSO	06/2015	401 935	57 327 077		459 262	590 047
ALVHEIM FPSO	07/2015	413 673	54 684 142		468 357	620 061

Box 3: Open data standards for upstream oil and gas operations – the example of Norway

Norway follows some of the best practices in managing and sharing upstream oil and gas data. Norway Petroleum Directorate (NPD), the upstream regulator, recognizes that access to high quality data is key to exploiting resources efficiently. NPD has legal authority to require companies to report their upstream activities in the formats and routines specified by NPD. NPD formulates these reporting requirements based on its regulatory needs and the needs of the industry and follows open standards as much as possible, while keeping them flexible enough to meet changing needs and to encompass future technologies.

NPD also publishes information about all oil and gas activities on a website with detailed time series information on reserves, producing fields, exploration wells, discoveries, etc.[6] NPD also hosts an interactive mapping portal with a detailed map of the Norwegian continental shelf showing all fields, discoveries, areas awarded and areas that have been opened for exploration activities[7].

Several countries with oil and gas reserves have adopted open standards to collect, store and share exploration and production data that they maintain in their respective National Data Repositories (NDRs). An NDR can include a wide array of data such as well logs, seismic surveys, production data, and geological maps and models. Maintaining an NDR involves collecting, storing and releasing large quantities of data – a process that can be eased by standardized reporting, storage and transmission of the data. Norway was a pioneer in its attempts at overcoming some of these challenges and was instrumental in forming an NDR work group that promotes collaboration amongst regulatory agencies on oil and natural gas data management standards[8]. India was among the nations involved in the formation of this work group in 2008.

The Norwegian NDR for Petroleum Data, Diskos, has been operational since 1995 and is often used as a benchmark for regulators setting up NDRs in their respective domains. Diskos has a public portal where detailed production and stock data at wells, fields and terminals are published[9] (see a snapshot of well production report in Figure 3). The website states that public will have access to well data and seismic data as well in the future. Until then, this data can be obtained through an email request.

[6] http://www.norskpetroleum.no/en/
[7] http://factpages.npd.no/factpages/Default.aspx?culture=en
[8] http://www.energistics.org/regulatory/national-data-repository-ndr-work-group
[9] http://www.diskos.no/public-portal

3.3 Electricity

Ministry of Power (MoP) at the Centre and departments of energy within state governments are responsible for the conventional electricity sector in India. The Central Electricity Authority (CEA) is the technical arm of MoP responsible for planning and analysis in the power sector. Power sector operations are primarily undertaken by generation, transmission and distribution utilities, most of which are public sector companies. Central and State Electricity Regulatory Commissions (CERC and SERCs) regulate various aspects of the sector such as licenses, tariffs, performance and markets. Power is procured through power purchase agreements as well as short and medium term trading and spot markets. Power System Operation Corporation Limited (POSOCO), Regional Load Dispatch Centres (RLDCs) and State Load Dispatch Centres (SLDCs) are responsible for grid operation and power management.

The Electricity Act (2003) ushered in a significant focus on transparency in the electricity sector. As per the Act, the Central Electricity Authority (CEA) is the statutory authority responsible for collection and dissemination electricity data and has the authority to collect data from any licensee or power generator (MoP, 2003, pp. 37-39). Consequently, CEA is a significant source of electricity data in India. Regulatory commissions at the central and state levels also collect a lot of important data even though dissemination is not part of their mandate. Regulatory data is scattered over several petitions and orders and is tedious to collate.

We looked at data collected and published by CEA as well as data provided by Central Electricity Regulatory Commission (CERC), few state electricity regulatory commissions (SERCs)[10], Forum of Regulators (FoR) and power exchanges.

Data gaps in the electricity sector

Some important data gaps in the electricity sector are listed below. More detailed list of power sector gaps is listed in Annexure A1.3. Unless stated otherwise, data is sought for each distribution utility area or state, whichever is applicable. Renewables in the electricity sector are covered in Section 3.4.

- Data on power supply quality and reliability is not published. Voltage and outage data should be published at the feeder level in addition to technical and commercial losses at transformer and feeder level, so that consumers can monitor the supply quality in their area. This is particularly important given the poor supply quality across the country, particularly in rural areas. Large grants are provided to improve electricity access and to reduce losses in distribution networks through programs such as Deen Dayal Upadhyay Gram Jyoti Yojana (DDUGJY) and Restructured Accelerated Power Development and Reforms Programme (R-APDRP) which also mandate installation of such metering and data collection systems. Therefore, providing such data should be easy.
- A lot of important data is scattered across various regulatory documents and is difficult to find. This data should be collected by CEA and time series data should be published in one place.

[10] Data available on websites of three SERCs was looked at – Maharashtra (http://www.mercindia.org.in/), Gujarat (http://www.gercin.org/index.php/en/) and Andhra Pradesh (http://www.aperc.gov.in/).

Some examples of such data are given below. See Box 4 for an example of coordination between EIA and federal electricity regulator.

  - Itemized fixed and variable costs for cost-plus infrastructure projects and tariffs for competitively-bid projects[11];
  - Source-wise quantity and per-unit cost of power purchase for each distribution utility area;
  - Data on energy sold, billed and realized by the distribution utility for each division within the utility's jurisdiction and for each consumer category;
  - Connected load of consumers that migrated to open access regime and wheeling and other charges levied by the distribution utility on these consumers[12].

- Details of power plant fuel linkages and fuel supplied under these linkages are not available. Fossil fuel supply is a major area of concern, especially given domestic shortage of coal and gas and increasing dependence on imports over the past few years (Bhaskar & Singh, 2011; Thakur, 2014).
- Equipment details of power generating units[13] and plant characteristics such as station heat rate, ramp up/ramp down rates, rated calorific value of fuel and cooling systems are not available. Such data is needed, for example, to analyze and simulate power system operation under different scenarios with varying fuel availability and renewable generation penetration.
- Hydroelectric capacity addition plans are based on a ranking of sites with hydroelectric potential undertaken by CEA (CEA, 2003). However, underlying hydrological data is not available in the public domain[14], making it difficult to independently analyse recent hydroelectric expansion plans, mostly in India's Northeast region, to meet peak demand and to assist in grid balancing with increasing share of renewables (WB, 2012; Sasi, 2015). It is also important given that large dams have significant social and environmental impacts (Vagholikar & Das, 2010).
- There is almost no data available on generating systems with capacity under 1 MW. Some data on installed capacity is available for systems for which subsidies were disbursed. However, there is no data on how much power is generated by these systems. Given the increased push towards onsite generation through systems such as rooftop solar, it is important to put in place uniform data collection systems to track generation from such systems. This applies to backup generating systems as well.

[11] Cost-plus infrastructure projects include both generation, transmission and distribution operations whose tariffs are determined by the regulator based on the actual costs incurred during these operations. Tariffs for competitively-bid projects are determined through the bidding process, but this data is not available in one place as bidding happens at state or sub-state jurisdictions.

[12] State-wise open access details are published on Forum of Regulators website, but this data has not been updated since 2009.

[13] Equipment refers to the main equipment in a generating unit such as boiler-turbine-generator for a thermal power plant.

[14] Even though some data is available through WRIS (http://www.india-wris.nrsc.gov.in/wris.html), flow data for rivers in the Northeast is patchy.

Box 4: Coordination among data agencies in the US

Coordination among data agencies in the US is necessitated by the provisions of the Paperwork Reduction Act of 1995 (PRA) which require federal agencies to obtain Office of Management and Budget (OMB) approval before collecting information from the public. An Information Collection Request (ICR) must be furnished by agencies, which consists of a set of documents which describe what information is needed, why it is needed, how it will be collected, and how much collecting the information will cost the respondents and the government". This process ensures that OMB – a central agency that is part of the President's Executive Office – regulates the burden that information collection agencies can impose on the public and ensures that no data collection is duplicated across all federal agencies.

In 2008, the Federal Electricity Regulatory Commission (FERC), equivalent of the CERC in India, decided to eliminate its Form No. 423 which collects cost and quality of fuels for steam electric generating plants larger than 50MW, due to its infrequent use by the commission[15]. However, this data was being used by EIA. Hence EIA incorporated these questions related to cost and quality of delivered fuel into a new survey – EIA-923 – that was formed by merging two other forms related to power plant operations. The corresponding ICR that was submitted to the OMB illustrates the documentation furnished by EIA to justify its Electric Power Surveys[16].

3.4 Renewables

In this section, we look at data on renewables used for power generation and for non-power energy needs such as biomass for cooking and solar collectors. Renewables sector in India is governed by the Ministry of New and Renewable Energy (MNRE) which publishes data on the renewables sector through its website. National Institute of Wind Energy (NIWE) and National Institute of Solar Energy (NISE) provide technical support to MNRE and publish data on wind and solar resource potential respectively. The Indian Renewable Energy and Energy Efficiency Policy Database (IREEED) maintained by MNRE is an excellent example of an effort to bring together information from disparate sources and make it publicly accessible through an intuitive, easy to use interface (MNRE, 2015). The IREEED portal presents information on RE and EE policies and programs announced by central and state governments and orders related to renewable energy from various regulatory commissions. In addition to MNRE, CEA publishes data on electricity capacity and generation from renewable energy.

EIA collects data on renewables from electric utilities and publishes the data in monthly and annual reports on US energy outlook[17]. EIA publishes monthly estimates of small scale renewable generation (see Box 5).

[15] See http://www.ferc.gov/CalendarFiles/20080311163449-RM07-18-000.pdf
[16] See http://www.reginfo.gov/public/do/PRAViewDocument?ref_nbr=200709-1905-003
[17] Renewable energy data published by EIA is available at http://www.eia.gov/renewable/data.cfm.

Following are some gaps in the renewables sector. Refer to Annexure A1.4 for a detailed list.

- GIS mapping of resource potential of renewables factoring in constraints such as technical feasibility and land availability[18];
- Source-wise monthly generation of renewable energy (RE) systems including small scale units;
- Where regulations apply, daily wind/solar generation planned (day-ahead) and actual generation.
- Data on solar collectors (such as water heaters) installed and operational status
- Production and consuming sector-wise use of biofuels
- Biomass supply and consuming sector-wise use

Box 5: Capacity and generation from small scale renewable sources

In December 2015, EIA started publishing monthly estimates of small scale solar PV capacity and generation in the Electric Power Monthly (EPM) report[19]. With this, generation of all renewable energy is available by source and state, categorized according to the generating sector, i.e., utilities, IPPs, commercial, industry and residential consumers. Due to the distributed nature of this generation, it is not possible to have actual data, hence EIA estimates this generation through simulation models and corroborates the data through surveys. Regarding estimation of solar PV generation, EIA says[20]:

"EIA uses its surveys of electric utilities to collect information on the number of customers with distributed PV systems and the aggregate capacity of those systems. Because electric utilities do not necessarily know how much electricity is generated by rooftop PV on their distribution systems, generation from these systems must be estimated. To make comprehensive estimates of monthly generation for all small-scale solar PV at the state level, EIA developed methods that use the data it collects from electric utilities and third-party owners (TPOs) in conjunction with other information. TPOs are energy service providers that own rooftop PV systems located on customer premises and provide electricity directly to ultimate customers.

The National Renewable Energy Laboratory's System Advisor Model and PVWatts tools were used to develop estimates of generation for a number of weather locations around the United States and provided effective insolation data—essentially, how much solar energy reaches the PV systems—on a monthly basis. Data from the California Solar Initiative on commonly used tilt angles and orientations for PV systems were used as inputs to be representative of tilt angles and orientations in other states. Data reported to EIA on utility service territories and capacity were used to estimate monthly state generation. EIA's generation estimates were then compared with reported TPO data."

[18] It was announced in December 2015 that a GIS platform with wind resource potential at 100m hub height and solar radiation map at ground level will be available at NIWE website. See http://pib.nic.in/newsite/PrintRelease.aspx?relid=132643.
[19] See EIA press release at http://www.eia.gov/pressroom/releases/press430.cfm.
[20] "Today in Energy" bulletin dated December 2, 2015 at http://www.eia.gov/todayinenergy/detail.cfm?id=23972.

4 Energy Consumption Data

Consumption data is available through two kinds of data agencies. On one hand, consumption-related surveys are undertaken by the National Sample Survey Organization (NSSO), an institution under MoSPI. NSSO specializes in designing and conducting surveys for various specific needs, collecting data and publishing it at regular intervals. In addition, some data on end-use consumption is also published by the sectoral ministries such as Ministry of Agriculture, Ministry of Railways, Ministry of Steel and the Ministry of Chemicals & Fertilizers.

For the purposes of this exercise, consumption data covers energy consumption in five sectors: residential, industrial, commercial, transport and agriculture. We only consider data provided by government or public sources for this gap analysis. Therefore, even though surveys such as India Human Development Survey (IHDS) provide useful data, these have not been considered.

Consumption data is mostly collected through surveys that are expensive to administer due to the human effort and time involved. Hence sample surveys are usually conducted once in a few years. Data from these surveys is extrapolated, perhaps using other data available at greater frequency such as supply side data or macro-economic indicators, to estimate consumption at the desired spatial and temporal resolution. It is expected that this extrapolated data is disseminated at the desired frequency.

Energy consumption can vary over the duration of a year based on factors such as seasonal climatic variations. Hence, it is important to capture consumption data at different times during the year. This can be done in a cost effective manner by staggering data collection over the year while adhering to the sample design and keeping in mind the different agro climatic regions of the country. Survey designs should cater to this.

The surveys recommended here are consumption surveys undertaken at end use as opposed to sales surveys. Surveys administered at the consumer end provide valuable disaggregated data that is extremely useful for formulating policies, analyzing policy impact and for understanding consumer behaviour. Having said this, sales surveys done at producers and dealers are also very useful and play a complementary role in augmenting quality of data from consumption surveys.

EIA collects consumption data through residential, commercial and manufacturing consumption surveys[21]. EIA directly surveys end users to collect detailed data on energy consumption as well as on associated information such as appliances and building characteristics. Given the tradeoff between data accuracy and expenditure to administer these surveys, EIA has reviewed and refined these surveys from time to time (NRC, 2012).

[21] See http://www.eia.gov/consumption/data.cfm. A separate transport energy consumption survey that was administered earlier was cancelled in 1994 and personal transport questions were included in RECS (NRC, 2012, p. 24).

4.1 Residential Sector

Household Consumption & Expenditure Survey, conducted by NSSO approximately once every 5 years, captures demographic data of households along with various details about consumption and expenditure patterns including some energy related information. A list of surveys that collect data on residential energy consumption is given in Annexure A2.1.

Through these surveys, data on fuel consumption and expenditure (except for on-site power generation systems) and appliance ownership and purchase are available. However, there are several important gaps (listed below). Data on household-based private transport is also included here. Household energy consumption data needs to be strengthened either through a dedicated survey or by enhancing the existing surveys.

Household Features

For each home type (horizontal or classified into floor-bands) and by Energy Conservation Building Code (ECBC) rating, data should be collected on the number of homes, share (%) of homes used for commercial activity, average age, average size, number of windows, construction material for wall/floor/roof, and type of insulation.

Appliances

Data on appliance ownership and use is important for a wide variety of applications such as efficiency programs, load research, and power system forecast and planning. Given that appliance use may vary seasonally, it is important to capture appliance usage patterns around the year and surveys should be designed to capture seasonal variations across all agro-climatic zones. Currently, no appliance use data is available in the public domain.

For each appliance owned, following data should be collected (and disseminated): age, star rating, daily frequency and duration of use, and cost; share (%) of second-hand appliances among total number, and major fuel(s) used (if applicable) and major use(s) (if applicable) for each of the following appliance types (model/make-wise) on quarterly basis. Appliances include lights, cook stoves, water heaters, refrigerators, drudgery reducing appliances such as washing machines, mixers and grinders, household electronics such as televisions and computers and appliances for space comfort appliances such as fans and air conditioners. As mentioned earlier, quarterly data can be collected by staggering household surveys within each agro-climatic zone.

Vehicles/Mobility

Similar to appliances, there is very little data available on non-commercial private vehicle ownership and use. For each vehicle owned and non-motorized transport undertaken, the following data should be collected and disseminated: vehicle size, age, emission standard, monthly number of trips, major purpose(s) of trips and distance travelled as well as share (%) of second-hand vehicles.

Energy Consumption & Expenditure Details

The following data should be collected for each energy source/fuel (including transport fuels and electricity) on quarterly basis:

- Number of households using the fuel, average quantity consumed and average expenditure
- Major uses of the concerned fuel/energy source
- Fuelwood/biomass: Time spent in collection per household per week
- On-site power generation by source: Number of systems, average capacity and average running hours per day

4.2 Commercial Sector

NSSO surveys on service sector, especially the survey conducted in 2006-07 (MoSPI, 2009b), and the Economic Census, held once every 7 years (MoSPI, 2001; MoSPI, 2008; MoSPI, 2014b) are sources of data on energy use in the commercial sector in India. These surveys capture some data on primary fuel(s) and energy-related expenses in service/non-agrarian enterprises. A list of all applicable surveys/census is given in Annexure A2.3.

Following is a list of recommendations for the commercial sector.

- **Buildings:** For each commercial activity type and by ECBC rating, data should be collected and disseminated on the number of units, floor space per unit, average hours of use per month/week, age of building/complex and energy performance index (EPI) values.
- **Appliances:** For each commercial activity type, data should be collected and disseminated on the average number of appliances per unit, age, star rating, daily frequency and duration of use, share (%) of second-hand appliances among total number and major fuel(s) used (if applicable).
- **Energy Consumption & Expenditure Details:** For each commercial activity type, data should be made available on the number of units using the fuel/energy source, average quantity consumed and average expenditure incurred for each fuel/energy source on quarterly/annual basis (as applicable). For on-site power generation systems, data should be available on the number of systems, average capacity and average running hours per day for each fuel/energy source.
- Commercial sector in India consists of a large unorganized sector, for which data is difficult to collect. As with residential consumption data, commercial sector data can be improved with an additional survey or enhancement of existing surveys. As the electric grid is modernized, automated collection of electricity consumption data may be explored. However, surveys are still needed to collect data on electricity use by service type (lighting, cooling, etc.).

4.3 Industrial Sector

In the industrial sector, data on energy consumption and expenditure, captive fuel production, onsite power generation and energy intensity of operations should be available in the public domain. This is particularly important for planning and analysis purposes in view of the recent 'Make in India' initiative to increase manufacturing in India.

NSSO surveys are important sources of energy consumption data, particularly the Annual Survey of Industries (ASI) for industries in the organized sector (MoSPI, 2015a) and a survey conducted on unincorporated non-agrarian enterprises in 2010-11 (MoSPI, 2012b). ASI includes data on fuel-wise consumption and expenditure for coal and electricity, even though it does not cover all industries (MoSPI, 2015a, pp. T5-1-T6a-32). A list of surveys relevant to the industrial sector can be found in Annexure A2.2.

In addition, data is collected by the Bureau of Energy Efficiency (BEE) under the Perform, Achieve and Trade (PAT) scheme that mandates reduction in specific energy intensity of 478 designated consumers across 8 industry categories (MoP, 2012, p. 3). In addition, data on specific energy consumption of major industrial sectors such as steel, cement and fertilizers is available in the Working Group reports of the erstwhile Planning Commission – prepared once every 5 years – and in industry specific publications (MoS, 2015, p. 41; MoS, 2011, p. 140; MoC&I, 2011, p. 33; MoC&F, 2011, p. 30; MoC&F, 2015, p. 91). .

Industry energy data already available (as listed above) should be collected and published in one place. In addition, following gaps were found. For each industry category by capacity range:

- Fuel-wise: No. of units consuming the fuel, average fuel consumed and average expenditure. A subset of this is available through the ASI. However, energy consumption in the unorganized sector is not available and ASI doesn't capture data on disaggregated use of petroleum products
- Number of units with captive fuel production, average production – for each fuel source
- Number of units with on-site generation systems, average capacity and generation – for each energy/fuel source
- Energy savings (energy source-wise, industry category and technology-wise) achieved, number of certificates traded and average trading price under the PAT scheme

4.4 Agriculture Sector

Agriculture is a very important and politically sensitive sector in India for reasons of food security and livelihoods. It is also a major consumer of electricity and diesel, primarily for irrigation pumps and other farm equipment. Hence, data on how these energy forms are used and for what crops is important.

Irrigation data is provided by Agriculture Census (conducted once every 5 years) (MoA, 2014) and the Directorate of Economics & Statistics under the Ministry of Agriculture which publishes agricultural statistics on an annual basis (MoA, 2015). Livestock Census and a few NSSO surveys collect some data on farm equipment used (MoA, 2014). A list of surveys and statistics applicable to agricultural energy consumption is given in Annexure A2.4.

Following are the gaps in energy consumption data in the agriculture sector[22]:

- For each crop type and farm size class: % of area irrigated by canals, tanks, wells, tube wells and other sources

[22] Number of tubewells and wells with and without (diesel and electric) pumpsets is disseminated as part of the Agircultural Census, Minor Irrigation Census and States' Directorates of Economics and Statistics.

- For each fuel type and by age class – average pump size, hours of use, average fuel quantity consumed and expenditure incurred
- For each farm equipment type by age class – number of equipment, average power rating, hours of use, fuel quantity consumed and expenditure incurred

4.5 Commercial Transport Sector

Data on commercial transport is available through a handful of surveys conducted by NSSO and through data and reports published annually by state road transport corporations (SRTCs) and the Indian Railways (MoR, 2015; MoRTH, 2015). In addition, Directorate General of Civil Aviation (DGCA), the civil aviation regulator, conducts an annual survey on fuel consumption in the airlines sector (DGCA, 2013).

Ideally, data should be available on the number of vehicles, average capital cost, power rating, hours of use, distance travelled, load factor, and fuel/energy consumption and expenditure for each vehicle or service type (airways, bus, rail, trucks, cars, auto rickshaws, two-wheelers/three-wheelers, cycle rickshaws etc.) by vehicle size, age and emission standard.

Except data on fuel/energy consumption by SRTCs and the Indian Railways, no other data is available in the public domain, including energy consumption data in the aviation sector which is collected by DGCA.

5 Suggestions to plug data gaps

Following are a few suggestions to help address the gaps and to improve public energy data dissemination.

5.1 Improvements in the short term

Improvements listed below are with respect to data that is already available with data agencies and whose dissemination is likely to involve minimal effort.

Coal

- UNFC-classified grade-wise reserve data for all surveyed blocks and coal bearing areas
- Data on production from all CIL and SCCL blocks and aggregate production from all captive blocks on a monthly basis
- Quantity of by-products in the coal washing process, i.e., middling, tailing and slurry, coal rejects etc.

Petroleum & Natural Gas

- For each block, total and at-present recoverable reserves, actual production and financial data (investments, costs and revenues) for blocks under the PSC regime

- Total number of piped natural gas (PNG) consumers for each city gas distribution jurisdiction by consumer category vis-à-vis targets[23], quantity of natural gas sold and average price on an annual basis
- Mode-wise transport (quantities) of hydrocarbon products – crude oil, natural gas, petroleum products

Electricity

- Annual Itemized costs (fixed and variable) for all regulated cost-plus infrastructure projects and tariffs for competitively bid projects
- Technology make and model of grid connected generating units
- For each meter type, consumer category and division: no. of meters, total energy served[24]
- For each district and state: Number of tribal and Dalit villages/hamlets electrified[25]

Renewables

- Monthly state-wise grid-based renewable capacity and generation by generation source
- Exchange-wise traded quantity and price of RECs by purchaser/seller category and state)

Industrial Energy Consumption

- Data from BEE's PAT scheme:
  - Overall energy savings achieved – By energy source and technology
  - Certificates traded – Number and average price

Commercial Transport Energy Consumption

- Energy consumed by commercial airlines to be published annually

5.2 Process and Institutional Improvements

Several process improvements have been suggested in our previous report (PEG, 2014, p. 23). These are summarized below:

- Data should be provided in easy-to-use machine readable formats such as xls and csv
- MoSPI publishes the annual Energy Statistics report where data published by various line ministries is compiled. However, this publication is not comprehensive and there are several methodological issues (see Annexure A3).
- Quarterly and annual workshops among energy data agencies to
  - harmonize, reconcile data collected
  - share best practices

[23] PPAC publishes consumer numbers, however, data on targets is scattered over several bidding documents on PNGRB website.
[24] CEA gets this data from a monthly survey of distribution metering. The survey format is available at: http://www.cea.nic.in/reports/regulation/furnishing_statistics_returns_inf/format%2051.pdf
[25] CEA gets this data from a monthly survey on progress of village electrification. The survey format is available at: http://www.cea.nic.in/reports/regulation/furnishing_statistics_returns_inf/format%2047.pdf

    - fine tune data collection practices
- Formation of a designated nodal agency to collate, harmonize, reconcile and publish energy data from multiple sources. Such an agency could be housed either in NITI Aayog or MoSPI and should have data management and statistics expertise on one hand and knowledge of the energy sector on the other.

6 Conclusions

The most prominent gaps in availability of energy data in India are with respect to consumption sectors and decentralized small scale generation sources. Even though energy data availability is reasonably good on the supply side, there are several areas of improvement. Some of the gaps identified can be addressed easily as line ministries are already collecting this data and simply need to disseminate the data to the general public in an appropriate form. In many cases, data is scattered over several publications, web pages and regulatory orders. Hence, there should be a concerted effort to publish the data in one place in a coherent manner. A framework can be developed to guide ministries on processes that can be put in place to disseminate data that they already have access to. Any data that is not available with line ministries should be collected through means such as additional surveys.

In addition to addressing gaps in data collection, technology upgradation and process improvements are needed to improve easy accessibility and quality of energy data. All data should be disseminated in commonly used machine readable formats. GIS mapping software and web based visualization tools should be used to improve data accessibility. There is an urgent need to improve capacity at data agencies through acquisition of the statistical and sectoral knowledge needed to undertake these improvements. Given the decentralized nature of Indian energy sector, a nodal agency is needed to coordinate data collection, processing and dissemination efforts across ministries. This agency can organize periodic working meetings among data agencies from line ministries to reconcile data from multiple sources and to share data management practices.

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A1. Annexure 1: Detailed Data Gaps

A1.1. Coal sector

Resource Estimation

Data Required	Example analyses	Gaps
GIS maps detailing location (latitude and longitude, state, coal field) and area of blocks and other coal bearing areas	Spatial analysis of coal resource availability juxtaposed with other features such as demand centers, transportation networks, rivers and forests	GIS maps not available
For each coal block and coalfield: Total and at-present UNFC classified reserves along with quality data (grades) where applicable	Accurately estimate how long coal reserves in the country will last given planned extraction rates	CMPDI provides UNFC classification for a subset of CIL blocks. Data on coal quality is not provided. Data on total accreted reserves is not available.

Coal Production and Washing

Data Required	Example analyses	Gaps
For each captive coal block: Details of end-use plants for which captive blocks were won, signed contracts	- Analysis of coal block auction process - To analyze deviations from reserve and production profile estimates - Seasonal variations in production - Movement of coal - Productivity of Indian coal production and comparison with global practices - Efficiency of the coal extraction process and measures such as Energy return on energy invested (EROEI)	Data not in public domain
For each block, field, state, company and coal type (coking or non-coking): Production by grade, mine type (open cast or underground) and mining method on monthly basis		Grade-wise production not available for any coal block
For each block: Aggregate production (by grade) on monthly basis		No data available at block level[26]
For each allocated block: 'Arrangements' and 'diversions' of the coal produced		
For each producing company: Productivity (ton/person shift), machinery utilization, auxiliary consumption, overburden removal		No gaps. All data is available.
For each coalfield: Energy used to extract coal		No data available.
For each producing company: Total and operational equipment (nos.)		No data available
For each producing company: Itemized costs (e.g. labor, operating, debt servicing etc.) of coal operations		No data available

[26] Aggregate monthly production from captive blocks is published in magazines like "*Coal Insights*", but even this is not published by a government source.

For each grade of coal: Price components outside CIL notified prices (e.g. royalty, clean coal cess etc.)	- Insight into the cost structure of coal operations - Assess washery performance	Data is available
Input & washed coal – Quantity & Quality		Data on quality not available
Quantity of each washery byproduct (middling, tailing or slurry, rejects)		No data available

Coal Trade, Dispatch, Transport and Receipt

Data Required	Example analyses	Gaps
By consuming sector, port of receipt and source nation: Quantity & Value of coal imports	- Assess if coal is transported optimally[27] - Analysis of FSAs	Data not available on value of coal imports by consuming sector
For each consuming sector: Average quality of coal imports		No data available
For each producing company, port of supply and destination nation: Quantity and value of coal exports		Data not available on value of coal exports for each company
Dispatch – For each company: Quantity & Quality of coal for each block and field and by each consuming sector		Data not available for dispatch by block and field
Coal transport: Mode-wise Quantities transported		Data is available
Coal transport: Major routes Mode, source, destination and quantity of coal transported		No data available
Coal supply through Fuel Supply Agreements (FSAs): Aggregate quantity of coal – contracted and supplied – by grade for each consuming sector plus for each individual FSA (at both loading and unloading points)		No data is available except for total contracted coal quantity by consuming sector (without grade) twice each year – and this too accounts for only 60% of its total dispatch, with no clue on commitments under which other half is supplied.

A1.2. Oil & Gas

A1.2.1. Oil & Gas Reserves

Data Required	Example analyses	Gaps
GIS maps of reserves along with classification with associated data (latitude/longitude, field,	- Spatial analysis of hydrocarbon resource availability	GIS maps not provided

[27] Analyze effectiveness of measures suggested in the inter-ministerial task force report on rationalizing coal transport to reduce associated costs through remedial measures (MoC, 2015b). The inter-ministerial task force is based on a full-fledged report on rationalization of coal transport by KPMG, which is not available in public domain.

basin/state, company)		
Total and at-present recoverable reserves		Except for data on aggregate reserves, no other data is available.

A1.2.2. Exploration & Production

Data Required	Example analyses	Gaps
GIS maps of blocks categorized by allocation regime (NELP, pre-NELP, etc). For each block, start date, area (initial, relinquished), contracting companies with participating interest and operating entity, number of exploration and production wells	- Analysis of hydrocarbon exploration and production activities - Investment needs - Contract compliance - Reward/risk of contractors - Government revenue	GIS maps of the blocks are not provided, only maps in the form of images indicating location of blocks.
Field Development Plans for all commercially viable discoveries within the block showing anticipated production profiles. Reserves accreted along with classification.		No data available
Contractual obligations: Minimum & Actual Work Programme (2D, 3D, wells) for each phase and year		Data on minimum work programme and actual achieved is provided on DGH website. However, the data is scattered over many html pages, hence difficult to process.
Block-wise production (oil, natural gas and condensate)		Only company-wise aggregate production of oil, natural gas and condensate is published.
Block-wise expenditure in exploration, development and production phases		No data available
Block-wise revenues, taxes and duties, cost recovery (if applicable), government and contractor share of profit/revenue		No data available
Company-wise total nos. of equipment (rigs etc.) owned and in operation		No data available

A1.2.3. Transformation (Refining/Fractionators)

Data Required	Example analyses	Gaps
For each refinery/fractionator and company: Capacity, input, output, storage capacity and actual storage categorized by each hydrocarbon product (natural gas and petroleum products)	Refinery performance	No data on production of petroleum products by each refinery and on storage

A1.2.4. Trade (Imports/Exports), Transport, Sales and Storage

Data Required	Example analyses	Gaps

Quantity & Value of imports: For each consuming sector, port of receipt and source nation by each hydrocarbon product (oil, natural gas, petroleum products – product-wise)		All data available except for natural gas imports (quantity and value) by consuming sector
Quantity & Value of exports: For each refinery/company, port of supply and destination nation by each hydrocarbon product (natural gas, petroleum products)		Data on petroleum product exports (product-wise) by each refinery not made public.
Quantities transferred: Mode-wise		Some data is available but scattered across various websites[28]. Should be consolidated and published in one place.
Major routes of transport: Mode, source, destination, quantity transferred	- Macroeconomic impacts such as import bill and revenue from exports - Analysis of efficiency in transportation of hydrocarbons - Energy access: availability and affordability - Energy security	No data on quantities transported through major routes.
For each pipeline: Ownership, capacity, throughput, output, utilization, open access, tariffs		Pipeline tariffs available, but scattered across PNGRB website. All other data available.
For each City Gas Distribution network: Number of consumers (target, actual), quantity of Compressed Natural Gas (CNG)/Piped Natural Gas (PNG) sold, average price of PNG/CNG, total number of CNG vehicles and stations (by type and district)		Data on number of consumers and CNG sales are published by PPAC. PNG targets are scattered across bidding documents available on PNGRB website. PNG/CNG price and PNG sales data is not available. Data on CNG network and vehicles is not available.
LPG and petroleum products: District-wise number of dealerships, total sales and prices		State-wise dealerships and sales data of LPG and some petroleum products is published, but not district-wise
Strategic Petroleum Reserves: Capacity and actual quantities		No data available
Sales of natural gas (quantity and price) for each consuming sector		Data available
Company-wise revenues for each petroleum product		Some data available in annual reports, but not in one place

[28] Ministry of Railways publishes data on quantities transported by rail, MoPNG publishes data on pipeline-based transport

A1.3. Electricity

A1.3.1. Tariffs

Much of the data on tariffs in the power sector are available through proceedings of the regulatory commissions at the state and central levels. However, this data is scattered over several petitions/orders and is not compiled in one place, hence is difficult to access.

Data Required	Example analyses	Gaps
Itemized costs for all regulated cost-plus infrastructure including fixed costs (incl. itemized capital costs) and variable costs (incl. itemized fuel costs), and revenues separated into energy and non-energy components	Since costs are passed through to consumers, detailed cost breakup should be in the public domain.	Data available in SERC/CERC tariff orders, but neither present at one place nor in easy-to-access formats.
For competitively bid projects, all qualified bids should be placed in the public domain, along with the winning bid. Any compensatory tariffs granted should be published.	For competitively bid projects, details of the competing bids and the final tariffs from the winning bid should be in the public domain to ensure a transparent competitive environment.	

A1.3.2. Generation

Potential, Capacity and Generation

Data Required	Example analyses	Gaps
GIS-mapped data for potential by each renewable energy source, factoring in technical, land and other constraints and associated details (source of biomass, hub height for wind, solar radiation levels etc.) for appropriate grid size (e.g., 1 km x 1 km)	- RE Potential - Investment decision making - Installed generation capacity - Assess trends in generation performance - Better tracking of subsidies and benefits accrued - Trends in onsite generation particularly rooftop solar	GIS maps not available for any source except solar, though resource estimates for other sources available
Hydroelectric generation potential		Underlying riparian data not available
For each unit/station greater than or equal to 1 MW		
Categorized by fuel/energy source, utility/ownership, entity-type (captive or non-captive, grid or off-grid), state, technology and regime (competitive bidding, cost-plus or merchant): Installed capacity – Planned, added, retired, de-rated/up-rated and slippage		Data not available for capacity by regime
Technology details: Supplier, SHR[29], ramp up/ramp down, cooling systems and other necessary information		Technology details only available for a subset of units
For units with size less than 1 MW (including backup		

[29] SHR stands for Station Heat Rate.

generation) categorized into capacity bands	- Large backup generation in the country due to power supply quality issues.	
Average and total number of installed and operational systems		No data available
Average capacity		No data available
% self and leased systems		No data available
Average number of systems connected to net meters		No data available
For all generation units:		
For each unit/station, entity type (captive or non-captive, grid or off-grid), fuel/energy source, state, capacity regime (cost-plus, merchant, competitive bidding) and technology: Monthly Target & Actual generation and auxiliary consumption for units with sizes >= 1 MW		Data not available for captive power plants on monthly basis.
Monthly Inflow and discharge water levels for each hydro power plant		Data is available.
Aggregate quantity of un-burnt combustibles (bottom ash/fly ash) and its end-use sectoral utilization for each thermal power plant		Data not available for captive power plants.
Quarterly aggregate number and duration for each outage type		Data is available

Fuels: Receipt, Stocks & Consumption

Data Required	Example analyses	Gaps
Fuel receipts, stocks and consumption – Quantity & Quality: For all regulated cost-plus plants by fuel , fuel source (linkage, captive or imported for coal; domestic/imported for gas), transport mode and coal grade	- Fuel supply data at power plants is necessary to analyze shortages - Data on quality is needed to evaluate coal producers' performance against fuel supply agreements (FSAs)	No data available either for domestic source of coal or source of gas supplied, or on the quality of fuel supplied to plants.
Fuel quantity – Contracted and actually received for linkage-based coal: For each plant		Not available for all plants, though actual fuel receipts available for many plants on CEA website.

A1.3.3. Distribution

Data Required	Gaps
Service area map with zones, circles, divisions and sub-divisions for all distribution utilities	Much of this data is not available. Some data such as power purchase costs are available through regulatory documents. However, they are not easy to find. A few examples of unavailable data: meters, energy sales, billing and realization,
Quantity and per-unit cost of power purchase for each fuel – On quarterly basis	
Electricity Demand: Energy & Peak – For each state and region on quarterly basis	
Village Electrification & Pumpset Energization – For each district • No. of inhabited and electrified villages/hamlets – total, tribal and Dalit • No. of households electrified – BPL, non-BPL	

• Average evening hours of supply for newly electrified villages • No. of pumpsets energized	supply quality/reliability at feeder level. CEA collects some of this data from distribution utilities on monthly basis such as energy sales (billing and realization), metering and electrification of hamlets and households by social groups, but does not publish.
Infrastructure: • Substations: Nos. for each voltage category, number of incoming/outgoing feeders along with feeder type (agricultural/non-agricultural) • Distribution lines: Length, Voltage, Capacity & Status ▪ Planned, In pipeline and Actual ▪ For each voltage/capacity category • Line & distribution transformer (DT) Outages: Number and duration for each type – On quarterly basis • Technical and commercial losses at line, transformer and feeder level	
➢ Electricity consumption: For each consumer category on quarterly basis • Consumers: Number of new and total consumers, disconnections and reconnections • Quantity: Total connected load and quantity consumed • Supply quality/reliability at feeder level: ▪ Average daily/evening hours of supply ▪ Duration and frequency of notified and actual power cuts ▪ Number of consumers impacted by power cuts ▪ Reliability indices[30] • Metering: For each meter type and circle/division ▪ Number of meters, % of faulty/zero/average meters and energy served • Tariff – Sales & Average Weighed • Energy sold, billed and realized along with revenues from fixed and energy charges: for each consumer category and circle/division	

A1.3.4. Markets, Trading and Open Access

Power Trading

The following data is needed for transactions at each power exchange:

Data Required	Example analyses	Gaps
Maximum no. and volume of aggregate purchase and sale bids	Transparency essential for proper working of markets	No Gaps
Market clearing volume and price (minimum, maximum and weighted average) for each delivery day/hour		No Gaps
Short-term transactions:		No data available for

[30] SAIFI/CAIFI, SAIDI/CAIDI: SAIFI stands for System Average Interruption Frequency Index, while SAIDI stands for System Average Interruption Duration Index. Similarly, CAIFI stands for Customer Average Interruption Frequency Index while CAIDI stands for Customer Average Interruption Duration Index.

Quantity and price by each category (trader, power exchanges, demand side management, trade between distribution utilities), trader, price slab, power exchange and time slot (round-the-clock, peak, other) for inter-state and intra-state trading		intra-state trading
Major buyers and sellers by inter-state and intra-state trading		
Weighted average trading margin for each price slab by inter-state/intra-state trading		
Congested corridors – Name, quantity of power flow, prices (upstream, downstream and difference)		Data not available for each corridor although aggregate data is available.
Unconstrained and actual cleared power volume		
Actual congestion charge and revenue		

Open Access

Data Required	Example analyses	Gaps
For each consumer category, open access type (transmission/distribution), open access term type (long-term/short-term) and power source (renewable/non-renewable):		
Quantity of power supplied through open access	Impact of open access distribution companies' finances, power purchase planning and grid stability	No data available with public, though some data may be with SERCs as part of regulatory submission by concerned utilities.
Amounts incurred (including wheeling and cross-subsidy surcharge)		

A1.4. Renewables

A1.4.1. Renewable Purchase Obligation (RPO) and Renewable Energy Certificates (RECs)

For all obligated entities:

Data Required	Example analyses	Gaps
RPO: Targets and actual compliance	RPO compliance and a functioning REC market are important in the context of ambitious RE generation targets to meet energy demand in an environmentally sustainable manner	Data available in the IREEED database
REC: By category of purchaser/seller and power exchange a) Obligated and voluntary purchase (number and quantum of power) b) Opening and closing balance c) Traded price (floor, forbearance, average,		Traded number of RECs (and quantum of power) along with price is not publicly available for each category of purchaser/seller and state

minimum and maximum)		for any power exchange

A1.4.2. Other Renewables

Renewables are also used in many off-grid applications – both electric and non-electric. Following is a list of data that should be available:

- Aggregate number of installed and operational systems categorized by system size and sector (residential and industrial):
  - Examples of systems include: Water pumping/wind mills, solar pumps, solar thermal including solar water heater systems, solar photovoltaic: Street & Home lighting systems, solar lanterns, solar cooker
- Subsidy sanctioned and released:
  - For each system and system type

A2. Annexure 2: Consumption Data Sources

A2.1. Residential energy consumption

The list of surveys and/or census reports and questionnaires which collect and provide any data on residential energy consumption and which were referred to for the purpose of this report are as follows:

1. Household Consumption Expenditure Survey (2004-05, 2009-10, 2011-12) (MoSPI, 2007a; MoSPI, 2007b; MoSPI, 2012a; MoSPI, 2014)
2. Housing Condition & Amenities Survey (1992-93, 2002, 2008-09) (MoSPI, 1996; MoSPI, 2004; MoSPI, 2010)
3. Participation & Expenditure on Education Survey (1995-96, 2007-08) (MoSPI, 1998; MosPI, 2010a)
4. Domestic Tourism Round (2008-09) (MoSPI, 2010b)
5. Common Property Resources in India (1998) (MoSPI, 1999)
6. Situational Assessment of Farmers (2003, 2013) (MoSPI, 2005; MoSPI, 2014a)
7. District Level Health Surveys (DLHS-1 in 1998-99, DLHS-2 in 2002-04, DLHS-3 in 2007-08) (IIPS, 1999; IIPS, 2006; IIPS, 2010)
8. National Family Health Surveys (NFHS-1 in 1992-93, NFHS-3 in 2005-06) (IIPS, 2015)
9. National Census (2001, 2011)[31]

A2.2. Industrial energy consumption

The list of surveys/census reports and questionnaires which collect and provide any data on industrial energy consumption and which were referred to for the purpose of this report are as follows:

1. Annual Survey of Industries (conducted annually) (MoSPI, 2015a)
2. Unorganized Manufacturing Enterprises Surveys (2000-01, 2005-06) (MoSPI, 2004; MoSPI, 2007c)

[31] Available on the web link http://censusindia.gov.in/, last accessed on 14th October 2015.

3. Unincorporated Non-agricultural Enterprises (excluding construction) (2010-11) (MoSPI, 2012b)
4. District Level Health Surveys (DLHS-1 in 1998-99, DLHS-2 in 2002-04, DLHS-3 in 2007-08) (IIPS, 1999; IIPS, 2006; IIPS, 2010)
5. Micro Small & Medium Enterprises Census (2006-07) (MSME, 2011a; MSME, 2011b)
6. Economic Census (4th Census in 1998-99, 5th Census in 2005-06, 6th Census in 2012-13) (MoSPI, 2001; MoSPI, 2008; MoSPI, 2014b)
7. Working Group report on Steel – 12th Plan (MoS, 2011)
8. Working Group report on Cement – 12th Plan (MoC&I, 2011)
9. Working Group report on Fertilizer – 12th Plan (MoC&F, 2011)
10. Indian Fertilizer Scenario 2014 (MoC&F, 2015)
11. Annual Report, Ministry of Steel (2014-15) (MoS, 2015)

A2.3. Commercial energy consumption

List of surveys and census reports/questionnaires which collect and provide any data on commercial energy consumption and which were referred to for the purpose of this report are as follows:

1. Economic Census (4th Census in 1998-99, 5th Census in 2005-06, 6th Census in 2012-13) (MoSPI, 2001; MoSPI, 2008; MoSPI, 2014b)
2. Unorganized Service Sector Survey (2001-02) (MoSPI, 2003a; MoSPI, 2003b)
3. Service Sector Survey (2006-07) (MoSPI, 2009a; MoSPI, 2009b)
4. Unincorporated Non-agricultural Enterprises (excluding construction) (2010-11) (MoSPI, 2012b)
5. District Level Health Surveys (DLHS-1 in 1998-99, DLHS-2 in 2002-04, DLHS-3 in 2007-08) (IIPS, 1999; IIPS, 2006; IIPS, 2010)
6. Recommendations by TRAI – Approach Paper to Green Telecommunications (TRAI, 2011) – a one-off study aimed at reducing emissions in the telecom sector that looked at some aspects of energy consumption in the telecom sector.

A2.4. Agricultural energy consumption

List of surveys and census reports/questionnaires which collect and provide any data on agricultural energy consumption and which were referred to for the purpose of this report are as follows:

1. Situational Assessment of Farmers Surveys (2003, 2013) (MoSPI, 2005; MoSPI, 2014a)
2. Land and Livestock Holding Surveys (1992-93, 2003) (MoSPI, 2006; MoSPI, 1997a; MoSPI, 1997b)
3. Housing Condition & Amenities Surveys (1993, 2002, 2008-09) (MoSPI, 1996; MoSPI, 2004; MoSPI, 2010)
4. District Level Health Surveys (DLHS-1 in 1998-99, DLHS-2 in 2002-04, DLHS-3 in 2007-08) (IIPS, 1999; IIPS, 2006; IIPS, 2010)
5. Agricultural Census (1995-96, 2000-01, 2005-06, 2010-11) (MoA, 2014)
6. Agricultural Statistics at a Glance (published annually by the Directorate of Economics & Statistics under the Ministry of Agriculture) (MoA, 2015)

A3. Annexure 3: Energy Statistics by MoSPI: Issues & Suggestions

Energy Statistics – an annual publication of MoSPI – is a compilation of data provided by the different supply side ministries such as those for coal, petroleum & natural gas, electricity and renewables, and includes an energy balance. The Annual Energy Review published by EIA and the Digest of United Kingdom Energy Statistics (DUKES) are equivalent reports compiled for the US and UK respectively.

Important data points that are missing from the Energy Statistics report are energy consumption data that is collected by NSSO within MoSPI and energy commodity prices. In addition, there are several issues in the report such as usage of incorrect terminology and a number of inconsistencies and data gaps. We list below some issues in Energy Statistics 2015 (MoSPI, 2015b) followed by suggestions to address them.

A3.1. Short-term improvements

In this section, we focus on improvements which can be incorporated easily. The suggestions can be categorized into three sets of issues.

A3.1.1. Indicative list of data gaps

Table 1: List of data gaps in the Energy Statistics report

Table no.	Description of gap
1.3	Wind potential has been given without any details on hub height
2.3	No source-wise break-up is given for thermal power capacity (coal, gas, diesel, others)
6.4	Data on end-use sectoral coal consumption does not include coal imports[32]
6.7	Although this table looks at end-use sectoral consumption of important petroleum products, liquefied petroleum gas (LPG) is not included.

We suggest that the data gaps mentioned above be addressed immediately as concerned data is available with designated energy ministries, such as for end-use sectoral imported coal consumption (with MoC) or end-use sectoral LPG consumption (with PPAC and MoPNG) (CCO, 2014b, p. 4.36; MoPNG, 2014, p. 71).

A3.1.2. Data Inconsistencies

Table 2: List of inconsistencies in the Energy Statistics report

Table no.	Description of Issues	Suggestions
5.1	Data on India's total primary energy supply does not include natural gas imports	Availability seems to indicate domestic production + imports. If so, natural gas imports should also be listed.
6.1	Data on India's energy consumption does not include coal and natural gas imports,	Energy consumption figures should include the sum of domestic production and imports

[32] Consumption categorized under 'Others' in Table 6.4 is fairly large. Further disaggregation of this category will help.

	while it includes data on petroleum product exports. Also, figures mentioned for electricity consumption do not tally with similar figures available from CEA website.	minus exports. Hence, while coal and natural gas imports should be included, petroleum product exports should be excluded. Data on electricity consumption should be cross-checked.
6.8	Data for natural gas consumption by end-use sector has been given, but covers only domestically produced natural gas.	Either data on liquefied natural gas (LNG) imports consumed by end-use sector should be included in the table or a caveat should be added that natural gas imports are excluded.
6.10	Data given on electricity transmission and distribution (T&D) losses is inconsistent with actual electricity supplied and/or sold, both with Table 6.9 in Energy Statistics and with figures obtained from CEA.	Given that there is a mismatch in electricity sales figures given in Tables 6.9 and 6.10, this data should be verified with CEA and appropriate corrections made to ensure that T&D loss figures are consistent.
7.2	An extremely high geothermal energy use has been given for rail sector. Also, the statistical differences for coal and natural gas are significantly higher – at almost 70% and 200% of India's domestic production.	Statistical differences should be small and only account for consumption which could not be accounted anywhere. Also, typographical errors should be avoided.

A3.1.3. Methodological/Terminology Issues

Table 3: List of methodological issues in the Energy Statistics report

Table no.	Description of Issues	Suggestions
2.3	Capacity given for thermal power includes renewables.	Table 2.3 and 2.4 should be broken up instead into three tables – with each table providing data on capacity by each source (including each source within thermal and renewables) for utilities, non-utilities and combined capacity respectively.
5.1, 6.1	Terms such as "conventional energy" and "availability" have been used, which are not standard.	Renewable energy is increasingly "conventional", and so should be treated on par with other energy sources.
5.1	Electricity has been listed as a primary energy source	Clear distinction needs to be drawn between primary and secondary energy sources – electricity is not a primary energy source, and hence it should not be included in this table.
6.2	There is a methodological error in this table, as primary and secondary (electricity) sources have been added together, though the latter is significantly derived from the former.	The table should be redesigned to only include primary energy sources. This would imply inclusion of only that portion of electricity that is generated from hydro, nuclear and renewable sources.

A3.2. Medium and long term improvements

In the long term, efforts should be made to address the following two kinds of improvements detailed below.

A3.2.1. Data Improvements

- Efforts should be made to incorporate biomass in the Energy Balance published in Tables 7.1 and 7.2. Data from NSSO surveys used to assess energy consumption such as the NSSO Household Consumer Expenditure Survey (MoSPI, 2014) could be used for this purpose. Once the Energy Balance is complete, it should be visually illustrated in the form of a Sankey diagram.
- Statistical errors should be tracked across years and attempts should be made to reduce them. Any accounting errors included under this head should be explained with detailed notes.
- Data on residential energy use/consumption and expenditure obtained from NSSO Household Consumption & Expenditure Surveys should be published. Over time, efforts should be made to obtain similar data for other end-use sectors as well.
- Data on prices/tariffs of energy commodities should be published both at constant and current values.

A3.2.2. Process Improvements

Producing good quality Energy Statistics requires statistical knowledge as well as sectoral knowledge. Therefore, there should be concerted efforts on the lines suggested below to bring in such expertise.

- Quarterly meetings should be undertaken among various energy agencies and MoSPI in order to reconcile data gaps, standardize use of energy terms and concepts, and address various data errors and differences. This can be extremely useful in particular in addressing terminology-related issues.
- Over time, a single designated nodal agency with relevant expertise (both statistics and energy-related expertise) should be established. This agency can not only be responsible to collect and disseminate energy data, but also publish Energy Statistics.