Energy Balance of a Country: An Indian Scenario

ABSTRACT

Indian energy policymakers need a detail analysis of latest energy balance of country to meet energy challenges and for making correct energy policy. However, Indian policy makers not having latest energy balance sheet of India. Hence this article informs that an immediate energy balance of India is required so that India can have its correct energy policy as well as an effective plan to meet the energy challenges.

INTRODUCTION

All over the world, increasing energy consumption, liberalization of energy markets and the need to take action on climate change are producing new challenges for the energy sector. At the same time there is increasing pressure for research, new technology and industrial products to be socially acceptable and to generate prosperity. The result is a complex and dynamic set of conditions affecting decisions on investment in research and new energy technology. To meet these challenges Indian policymakers immediately need appropriate analyses of existing energy balance of India. Keeping energy balance of a country as a theme this article covers fact sheet of Indian Energy sector, importance of an energy balance and dimension of energy balance. This article also discussed energy balance of India and what should be methodology for carrying out energy balance in India.
In the coming years India faces great challenges in energy and environment. With rapidly increasing population and economic development the demand for energy and vehicular usage is expected to go up. The path of development chosen by the region, upon which lies the future growth of energy and emission trajectories, would be greatly influenced by technological developments, economic cooperation between countries, and global cooperation in limiting greenhouse gas emissions.

The global energy scenario has undergone a drastic change in the last two decades. Due to ever growing demand of energy and shortage of supply, the cost of fossil fuel (coal, oil and natural gas) is increasing day by day. Nevertheless, increasing consumption has led to environmental pollution resulting in global warming and ozone layer depletion. Consequently, the era of fossil fuel is gradually coming to an end and the attention is focused on the conservation of energy and search for renewable sources of energy, which are environmentally benign.

Energy play a major economical and political role as an important resource traded worldwide. Energy consumption in the developed countries has been more or less stabilized whereas in developing countries like India it is increasing at a high rate. To analyze the issues related to country's energy independence there is immediate need to quantify and evaluate India's dependence on imported

energy and to analyze the seasonal character of this dependence from the point of view of the country's energy security. Another main objective is to analyze energy consumption for different types of energy, breaking the analysis out for various end uses and into different consumer categories, in order to identify and evaluate the potential energy savings. The Statistics Department of India currently does not prepare energy balances, so the relevant data should be collected from different sources and compiled into an aggregate balance.

Energy balance is the main instrument for analyzing a country's dependence on external energy imports. In case of India the main factor of energy security is its dependence on fossil fuel imports from oil and gas producing countries. Another critical factor of country's energy dependence is the pronounced seasonality of its energy consumption and supply patterns that would reflect the typical expected consumption patterns in the nearest time. Therefore, in India, there is an immediate need to undertake an in-depth analysis of the India scenario in terms of the availability of various energy sources and its handling and utilization pattern in the various sectors.

FACT SHEET OF INDIAN ENERGY SECTOR

Rapid economic expansion will continue to drive up India's energy needs. Power generation accounts for much of the increase in primary energy demand, given surging electricity demand in industry and in residential and commercial buildings, with most new generating capacity fuelled by coal. Among endues sectors, transport energy demand sees the fastest rate of growth as the vehicle stock expands rapidly with rising economic activity and household incomes. In the absence of strong policy action, higher energy demand will drive up imports of oil, gas and coal, and green house gas emissions.

1. In the Reference Scenario, primary energy demand in India more than doubles by 2030. Power generation capacity, most of it coal-fired, more than triples between now and 2030. Coal remains India's most important fuel, its use nearly tripling between 2005 and 2030.
2. Much of India's coal needs from now to 2030 will have to be met by imports. India will continue to rely on imported coal for reasons of quality in the steel sector and for economic reasons at power plants located a long way from mines but close to ports. In the Reference Scenario, hard coal imports are projected to rise almost sevenfold.
3. *Before 2025, India overtakes Japan to become the world's third largest net importer of oil, after the United States and China. Net oil imports also grow steadily, to 6 mb/d in 2030, as proven reserves of indigenous oil are small. The share of imports in oil demand climbs to 90% in 2030. Yet India's importance as a major exporter of refined oil products will also grow, assuming the necessary investments are forthcoming.*

4. Gas production is projected to peak between 2020 and 2030, and then fall back. A growing share of India's gas needs is, therefore, met by imports, entirely in the form of liquefied natural gas. Further pricing reform will determine whether the requisite supply infrastructure is built in a timely manner.
5. Between now and 2030, India needs to invest about $1.25 trillion (in year2006 dollars) in energy infrastructure – three quarters in the power sector. Gross power generation capacity additions exceed 400 GW.

THE ENERGY BALANCE OF A COUNTRY

Energy balances is an attempt to tabulate energy data to account for the entire energy throughput in a nation's economy. The International Energy Agency has produced annual energy balances for 134 countries since the 1970s and has developed a detailed methodology for accounting for the energy flows in an economy. Berkeley Lab has largely relied on the conventions used by the IEA for its work in developing the CALEB database. Additionally, a United Nations report provided an extremely thorough review of the methodological issues surrounding the construction and presentation of energy balances. That document was particularly helpful for elucidating methodological issues surrounding energy transformation and the calculation of primary energy inputs to power generation from non-fossil fuels.

Infact, the Energy Balance is an advanced spreadsheet, where, a country, on one page has an overview of the total:

- Fuel consumption
- Energy conversion
- Distribution
- End-use
- Emissions
- Renewable Energy

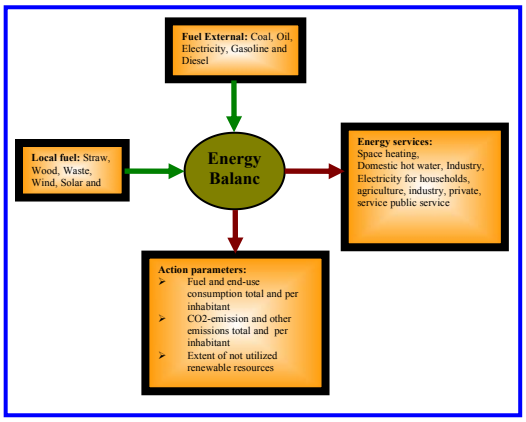

Fig. 1: Construction of energy balance of the country

The simplest construction of energy balance is shown in Fig. 1. The external fuels and Local fuels are input to the energy balance. The energy services and external parameters are output of the energy balance study.

Importance and Needs of Energy Balance of a Country

Aggregate energy balance is the main quantitative parameter used for characterizing the country's energy supply. It reflects supply of all types of energy carriers (electricity, natural gas, liquid gas, carbon products, coal, firewood etc.) and energy consumption of different economic sectors and the population. Based on such energy balance studies the country's energy situation is evaluated and the energy policy and strategic energy plans are defined in parallel with the economic policy. Energy balances give an opportunity to assess energy consumption and therefore energy efficiency of enterprises and industries, as well as greenhouse gas emissions. For comparison and evaluation purposes international organizations regularly publish the main parameters of aggregate energy balances of all countries, including India, showing the development level and characteristic features of the energy sector and the economy of the country.

Unfortunately the Department of Statistics of India has stopped drawing up aggregate energy balances, which means that this extremely important information is no longer used for planning the country's social and economic development. Energy balances worked out by different specialists are often based on unofficial data, hence are not very accurate and can be used only for academic purposes. This kind of disregard of objective information may lead to undesirable results.
Below we are giving several examples that demonstrate the necessity of elaborating and giving due consideration to energy balances in India.

1. Imported energy resources comprise the main part of India's energy supply, where the share of imported natural gas is 1.8 billion m^3 and the share of imported oil products -1 million ton oil equivalent (20-25%). As a result of such strong dependence, the country's economic development implies considerable political risks. Thus, the country can be forced to take certain undesirable actions unless its energy dependence is duly reduced. Therefore, higher energy independence of the country is achieved through better energy efficiency and use of internal renewable energy resources is justly recognized as the main priority of the energy sector development.
2. Firewood plays an important role in India's energy consumption. According to experts' evaluation the share of firewood in the energy balance of the country equals, and according to some data even considerably exceeds, the share of electricity generated by the whole energy system. All experts agree that in reality the volume of wood felling is significantly higher than the volume shown in the official sources and several times exceeds the allowed norms of using forest resources, thus constituting a huge threat for the ecology. At the same time, firewood is used by a big part of the population to satisfy its basic needs - cooking and heating. Hence, its consumption can not be reduced dramatically unless a reasonably affordable alternative is offered. Failure to take this situation into account caused well known problems during the

implementation of the forestry reform. This problem can be solved only stage by stage, after complex implementation of gasification, introduction of efficient wood stoves, weatherization of houses and other energy efficiency measures.

3. From the point of view of electricity consumption India is significantly behind developed countries, as well as many developing countries. In India, per capita electricity consumption is about 1800-1900 kWh, while in developed countries this parameter is at least 3-4 times higher. Therefore, it is expected that the power consumption level will increase together with the economic growth and the country's energy system must be prepared for this in advance.
4. Energy consumption in India is very seasonal. Natural gas import increases three-four times in winter when it is used both for electricity generation and heating. Thus, energy dependence also increases dramatically in autumn/winter period, proving once again the necessity of reducing this risk. Measures that can be taken for achieving this purpose include (among others) construction of a gas storage facility, weatherization of buildings, introduction of solar, geothermal and other renewable technologies.
5. There is seasonal imbalance of electricity supply/demand in the country. In summer power generation of hydro power plants considerably exceeds the country's internal demand. Due to this reason, big quantity of water has been spilled for years. In winter, local hydro resources are not enough and gas fired thermal power plants are started using imported gas. Such seasonal imbalance between demand and supply creates an obstacle for the development of both hydro and thermal generation, since the local market is not big enough for any of these sectors. This needs to be followed by establishment of stable long-term mechanisms. Thus, international cooperation and formation of a stable regional electricity market are necessary preconditions for the rational development of the Indian energy sector.

Even the above simple analysis clearly demonstrates that development of energy balances is very important for making decisions that could be vital for the country. A more detailed review can provide an opportunity to identify specific problems and work out solutions at energy generation, transformation, transmission, distribution, and consumption levels.

Based on the above, we believe that there is no alternative to professional development of official energy balances. By drawing up aggregate energy balances the Department of Statistics will greatly support development of the country's energy sector and economy as a whole, identification and solution of goals during their strategic planning, as well as solution of smaller, more specific issues.
By reinstating elaboration of aggregate energy balances India will restore the practice widely used in other countries which plan the development of their energy sector and economy based on full understanding of their current reality. Integrated vision formed on the basis of the energy balances will also provide an opportunity for aligning the efforts of the public and government bodies around the shared priorities, including energy efficiency and utilization of indigenous renewable energy sources.

Dimensions of Energy Balance of a Country

Energy balance databases arrange data into three principal dimensions: (1) products, (2) flows, and (3) time.

Products are simply the various energy sources. They consist of natural gas, crude oil and petroleum products, coal, electricity, and other minor energy sources. This research distinguishes between primary electricity from sources such as hydro, wind, and solar photovoltaic and secondary electricity produced from converted thermal energy. This distinction prevents double counting of the energy in the fossil fuels (and other heat sources) that is converted to electrical energy.

Flows refer to processes of supplying, transforming, and consuming energy. These three broad categories of flows constitute the "phases" of energy within a balance. Generally, *supply* flows (such as indigenous production, import, export, and stock withdrawal) are listed at the top of the balance.
The *transformation* phase refers to the energy used to extract and process energy resources, as well as the energy inputs themselves that are transformed into secondary sources (for example the crude oil that is refined into petroleum products). The *Consumption* phase signifies all of the end uses of energy throughout the economy. A wide range of dis-aggregation is possible within this phase, depending on the level of detail available in the underlying data. These flows are commonly divided into at least four major sub-sectors: (1) industry, (2) transportation, (3) residential, and (4) services.
Time denotes the calendar year or years of the energy data available. An energy balance per se consists of a balancing of supply, transformation, and consumption data in a given year. Table 1 shows a simplified energy balance. The positive sign (+) indicates where energy is produced or imported and the negative sign (-) indicates where energy is consumed or exported. Not all fuel types are used to produce each type of energy shown in the balance, and this is indicated by "N/A" for "not applicable." While an energy balance database allows a user to see a time series of flows for a given product (e.g., the supply, transformation, and consumption of natural gas over some range of years), the complex methodological issues stem from the need to balance all flows, across all products, for a single year.

In addition to the three principal dimensions, other dimensions can also be presented in an energy balance database. For example, the IEA's database contains data on several countries and regions. Although the CALEB database only covers a single region, it offers the possibility of displaying the data in various units. Data are entered in the CALEB database as physical quantities, but the resulting balances can be shown in physical quantities, energy units, or CO_2 emissions equivalents.

Table-I: Simplified Energy Balance

	NG	CO	OPP	Coal	PE	SE
Energy Supply						
Production	+	+	N/A	+	+	N/A
Import	+	+	+	+	+	6+
export	-	-	-	-	-	-
Bunker Fuels	N/A	N/A	-	N/A	N/A	N/A
Net stock Withdrawals	+/-	+/-	+/-	+/-	N/A	N/A
Transformation						
Electric Plants	-	N/A	-	-	N/A	+
Oil refineries	-	-	-	N/A	N/A	-
End Use Consumption						
Industry	-	-	-	-	-	-
Transport	-	-	-	-	-	-
Residential Building	-	-	-	-	-	-
Commercial	-	-	-	-	-	-

Building						
Electricity Output (GWh)	+	+	+	+	+	+

Where; NG: Natural Gas, CO: Crude Oil, OPP: Other Petroleum Products, PE: Primary Electricity, SE: Secondary Electricity

ENERGY BALANCE IN INDIA

In order to measure the amount of energy saved by energy efficiency on national level, Indian government needs to draw the national energy balance. This is a two-step process:

- First, this process requires sourcing and analysis of the statistical information on all kinds of energy flows in India.
- Secondly, this data is needed to be applied to a standard format to report national energy consumption and to publish a national energy balance.

In this regard, work has already been done and after a detailed analysis, three formats have been selected:

- IEA/OECD
- Eurostat
- TERI
- UN

UN, IEA/OECD and Eurostat are international formats, which are well established and accepted international standards with clear definitions and a consistent system. Eurostat is a most comprehensive useful energy balance scheme, which has been developed, tested and being widely used by large number of countries. The disaggregation level (29 different energy carriers in 41 steps) is clearly higher than the level of IEA (10 energy carriers), UN schemes (13 energy carriers in 36 steps).

TERI is Indian format, which has clear definitions as per Indian situation. It has 17 energy carriers in 20 steps.

IEA/OECD takes into account non-commercial energy, but TERI clearly states that it is only a commercial energy balance. However IEA has only one single carrier by the heading "Combustible renewable and waste" where we have to account all non-commercial energy.
As per the information available up to now, these are some of the gaps in data.

1. There is a major gap in biomass production and utilization data.
2. There are also gaps regarding quantification of the share of diesel used in road traffic and in generators.
3. Another gap is the auto-consumption from co-generation in sugar mills for which there is no data.
4. The consumption data regarding the household sector is not complete.
5. The consumption data regarding the agriculture sector is not complete.
6. As numbers of players which give supply related data are less (excluding electricity) so supply data is better than transformation and consumption data.
7. Information collection on non-commercial energy sources is completely missing.
8. There are also significant gaps in the information collection process, in particular respect to "energy consumption" data for all carriers.

In the light of above observations, we feel that these are the necessary steps to be taken in order to calculate the Energy Balance of the India.

1. To analyze all the above stated formats, carrier and step wise,
    - For data availability.
    - To point out the missing data.
    - To point out the gaps in data collection process.
2. Design and carrying out of survey for collection of missing data
3. Signing of MOUs and collection of secondary data from different sources

Design of methodology for calculating the energy balance, compilation of data and calculation of energy balance of the national. From Indian point of view the following objective can be required to fulfill so that India can draw its own energy policy.

1. Assessment of three formats Eurostat, IEA/OECD and TERI to report national energy consumption and complete analysis of their differences, advantages as well disadvantages.

2. Preparation of an overview how energy data is reported in India. Under this preparation of a list, with references of publications or URL which Indian institutions are
    - Providing energy data
    - Receiving energy data, aggregating such data and analyzing such data
    - Publishing such data

3. Agreements/MOU will be drawn which are to be signed with these organizations for seamless transfer of data to BEE.

4. All gaps in the essential data will be identified and the process to estimate the data, including surveying requirements are proposed to be developed. In depth survey will be designed to fill these gaps. The surveys will be designed to be carried out on all India basis and will be complete with questionnaires and working methodology.

5. Selection of the most appropriate Energy Balance scheme and Development of complete methodology on how to use the scheme to the Indian situation, with following aims:

- International standard and comparability
- Easy understanding
- Clear definitions and consistency
- Disaggregating level
- Possibility to develop appropriate energy efficiency indicators and a useful energy balance.

6. Collection of the necessary data and calculation of the Energy Balance of the country based on selected format.

7. To write the complete report for presentation.

Methodology and Work Plan for Energy Balance

If energy balance of India is considered as a project the following explained methodology and work plan has to be adopted:

1. First the above stated formats and carriers have to be analyzed for their differences and advantages as well as disadvantages. For this purpose all the three formats will be taken and their data for each and every carrier and step will analyzed. This requires analysis of the method used for data collection, its source, its reliability and other aspects. The missing data for energy conservation would be identified and further, a scheme would be formulated for obtaining it and to incorporate it in the existing format.

2. A list of all the institute, organizations working on any aspect of the energy data as identified in the first step will be prepared. All possible information will be collected from these sources on their methods, resources and legal status. Here highly trained research associates, will be visiting these places and will collect information. They will be collecting information by informal interviews and study of the material available. We will also study the condition on which they provide data. Based on these facts the agreements/ MOUs to be signed with them will be analyzed.

3. For identified gaps in the data fresh primary surveys will be designed. The surveys will be designed on all India basis. The first step will be to prepare a latest list of all villages state wise, district wise, taluka wise with some relevant information on them. Then a list of villages will be prepared by representative selection from each of the district and taluka.

4. The selection will be done by taking at least 1 % sample. A proper selection criteria will be designed to select the representative sample to avoid any bias. The selection of representative villages will be based on secondary data and its statistical analysis using normal curve theory and T scores for normalization and standardization. It is a well known fact that the normal curve is a rather good fit to an astonishingly large number of distributions of real data in a wide variety of sciences. Some important characteristics of normal curve are: all normal curves are symmetrical; that is, the left half of the normal curve is a mirror image of the right half. They are unimodal, with

the mode at the centre. The area included within the range of ± 3 σ comprises approximately 99.7% of the total area under the curve. It may also be noted that for a normal curve:

σ VALUES BETWEEN	% AGE OF CASES
-0.6 σ to + 0.6σ	45.14
-.6σ to -1.8σ or +.6σ to +1.8σ	23.84
-1.8σ to -3σ or +1.8σ to +3σ	3.46
TOTAL: -3σ TO 3σ	99.74

The above fact is utilized to select the representative cases.

5. A detailed study format will be prepared to collect information from each of the selected villages. Pretesting of the Performa will also be done by conducting survey of a few villages. Based on the pre-testing the format will be finalized. The format used will be open structure schedule. Schedule will have several major parts as per requirements.
6. All the primary and secondary data collected will be tabulated and analyzed for calculating the Energy Balance of the country.
7. A detailed report will be prepared fulfilling all the objectives.

CONCLUSIONS

This article successfully evaluate that aggregate energy balance is the main quantitative parameter used for characterizing Indian energy supply. It reflects supply of all types of energy carriers (electricity, natural gas, liquid gas, carbon products, coal, firewood etc.) and energy consumption of different economic sectors and the population of the India. Based on such energy balances the Indian energy situation is evaluated and the energy policy and strategic energy plans are defined in parallel with the economic policy. Energy balances give an opportunity to assess energy consumption and therefore energy efficiency of enterprises and industries, as well as greenhouse gas emissions. This article emphasizes that energy balance of India is not only essential but, is an immediate requirement for attaining energy independence. Nevertheless, this article also lays down methodologies and plans for drawing up energy balance of India.

REFERENCES

1. ***Hans Larsen and Leif Sonderberg Petersen, ,"Future options for energy technologies", Risø Energy Report - 6, 2007.***
2. ***PIER Project Energy Report, "Development of Energy Balances for the State of California", Lawrence Berkeley National Laboratory, 2005.***
3. ***Mudjiandoko, "Energy Balance of Indonesia: Coordination Issues", International Workshop in Energy Statistics, Indonesia, 2008.***
4. ***Project Report, "Energy Balance for Piaseczno Poland" Department of Plan Energy, Denmark, 2005.***