Guidelines for the Presentation of Energy Data in Bank Reports

October 1982
GUIDELINES FOR THE PRESENTATION OF
ENERGY DATA IN BANK REPORTS

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October 1982

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The World Bank
1818 H Street, N.W.
Washington, D.C. 20433
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GUIDELINES FOR THE PRESENTATION OF ENERGY
DATA IN BANK REPORTS

ABSTRACT

The growing importance of energy issues in national economic management has led to increased coverage of the energy sector in many types of reports. However, there is still no clear, consistent and standardized format for the presentation of energy sector information. This paper reviews the problem and proposes guidelines to meet the needs of policymakers as well as operational staff dealing with energy issues.

The paper is divided into three parts: the first part sets out the basic framework within which aggregated energy data should be presented—"the national energy balance"; the second part deals with the use of appropriate units and conversion factors to construct such a balance from raw demand and supply data for the various fuels; and the third part briefly discusses some special problems posed by: (i) the differences in end use efficiency of various fuels; (ii) the inclusion of wood and other non-commercial energy sources; and (iii) the conversion of primary electricity into its fossil fuel equivalent.

Sample energy balances and a list of the calorific content of major fuels is provided in the Annexes.
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I. ENERGY BALANCES

1. An energy balance is a convenient framework for recording and analyzing the patterns of energy supply and consumption. It enables one to trace through, for any given fuel, the relative contribution of indigenous production and imports, the losses that are incurred in transformation and distribution, and the distribution of that fuel among the various final users. Also, as the data are generally presented in common energy units, such a balance can be used to assess, either for any particular consuming sector or for the economy as a whole, the relative contribution of different fuels to total energy supply. An energy balance also serves two other useful purposes. First, if rigorously designed, it can serve as an exacting test of the internal consistency of the basic data. And second, by showing the interrelationships between supply, transformation and final use, it provides a basis on which to construct forecasting models either for each energy industry separately or for all forms of energy taken together. Even if such models are not used in the actual process of forecasting, they are an invaluable tool for testing the basic consistency and plausibility of forecasts made by other methods.

2. Energy balances may be constructed in a whole host of different ways. No one format is right and the others wrong; and, different formats may be useful for different purposes. At the same time, a variety of formats makes the cross country comparison of national and regional energy sector information unnecessarily difficult. Fortunately, there appears to be a growing recognition of this problem in the international community and a move towards the adoption of a standardized format for the presentation of energy balances.

3. The format that many international organizations are adopting is based on the one developed by the OECD and the International Energy Agency after consultation with those member countries with experience in this field. A similar format (but one which also incorporates noncommercial energy sources) has also been used in many of the Bank's own reports (Energy Assessment Reports, other sector studies, etc.). A sample energy balance is attached as Annex 1. It is recommended that henceforth this general format be adopted for the presentation of energy balance information in all relevant Bank reports. At the same time, it must be recognized that this format may not be completely applicable to all country situations, and there will have to be some flexibility in applying this general rule.

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1/ A number of other methods can also be utilized to present energy data. One which is used in some reports is an energy flow diagram which is a more graphic representation of the same type of information. An example of such a diagram is included as Annex II.

2/ See Part II below on the choice and construction of standard energy units.
4. Although most energy balances give the same basic information, a number of points—other than growing international acceptance—can be made in favor of the recommended format. First, by clearly separating the supply, demand and transformation sectors for all fuels individually and together, it allows the analyst to draw attention easily to the areas which require policy revision and action. Second, its format is such that the rows and columns can be readily collapsed to provide a more aggregated picture if required. And finally, its disaggregated nature allows one to focus on the specific gaps in information which will inevitably be encountered in many developing countries. While these gaps will mean that the format may have to be simplified initially, they will also serve to guide and direct the efforts to build up and augment the energy sector data base. However, even where the relevant data are available, a number of problems will need to be overcome in transforming these data into an integrated energy sector balance. These problems are discussed in the following sections.

II. COMMON UNITS AND CONVERSION FACTORS

5. The first step in preparing an energy balance, once the basic data have been collected, is to transform these raw data into comparable common units. The need for common units for energy measurement arises because the units in which various fuels are most naturally measured (tonnes for coal, tonnes or barrels for oil, kilowatt hours for electricity, cubic metres for natural gas or fuelwood) are disparate. In principle, any one of these (or of many others) could be used as a denominator, as long as the relevant conversion factors were applied. In practice, however, neither the choice of a common unit nor of the appropriate conversion factors is straightforward.

6. The generally accepted convention for converting measurements of different fuels into common units is to use their calorific value which measures the potential heat energy that could be derived from a unit of that fuel. The actual mechanics of effecting this conversion are, in general, straightforward. The calorific content of most primary fuels—gas, coal, petroleum—can be determined relatively easily although care must be taken to ensure that any "standard" values used actually correspond to the types of coal, gas, etc. found in the particular country. This is important because for most fossil fuels there can be substantial variation in calorific content across different deposits, and for fuelwood across different species. Moreover, how the physical quantity of a fuel is measured could also affect its calorific content (moisture content, stacked or solid wood, wet or dry gas, run-of-mine or saleable coal, etc.) Data reporting conventions vary across industries and countries and it is important to specify how the raw data have been converted in any particular instance. Finally, care should be taken to clarify that "net" (or lower) calorific values are used on a consistent basis.1/ Annex IV to this note provides a list of the calorific values for the major fuels which should be used in Bank reports.

1/ As opposed to gross (or upper) heat values which include the heat of condensation of the vapor produced in the combustion process.
7. Having converted physical fuel quantities into their heat equivalents, there remains a question of what units these heat equivalents should be presented in. There are basically two groups of units to choose from. The first group comprises those units which have traditionally been used to measure heat energy; the most common of these being the calorie, the joule and the BTU. Units in the second group are also heat-based but they are defined in such a way that the unit size relates more closely to the actual calorific content of a physical unit of a particular fuel. The principal units in this group are the tonne of oil equivalent (TOE), which is variously defined as being equal to 10 to 10.5 million kcal; and the tonne of coal equivalent (TCE) defined as being equal to 7 million kcal.

8. While the selection of any one of these units as the base will be somewhat arbitrary, it is clearly advantageous to adopt just one unit. The unit that is increasingly being used by most agencies and the one that is recommended for use in Bank reports, is the TOE.1/ The basic justifications for using the TOE are:

(i) its widespread and growing and international acceptance;

(ii) its unit size which is closely related to a physical fuel and thus appears more tangible; and

(iii) the fact that many of the important issues in energy analysis today are closely linked to petroleum.

It is important to emphasize, however, that the TOE should be defined in terms of a specific calorific content and is basically a unit of convenience. Thus, in all future Bank work, one TOE will be defined as being equal to 10.2 million kcal.

9. Energy sub-sector information should continue to be presented in the units which are most widely used for the fuels concerned--barrels for crude oil; liters or gallons for refined petroleum products; cubic meters or cubic feet for natural gas; kilowatt hours and kilowatts (or some multiple thereof) for electric power; tonnes for coal; and cubic meters or cubic feet for firewood. However, the corresponding TOE values for these fuels should also be presented in parentheses where these are referred to in the general discussion of the energy sector, although this will not generally be necessary in chapters or sections of reports devoted to the discussion of specific fuels. It is also necessary to include on the front inside cover of the report a complete list of the corresponding conversion factors used for the different fuels.

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1/ Other agencies which use the TOE are the OECD, the EEC Commission and the UN.
III. SPECIAL PROBLEMS

End-use Efficiency

10. The problem of end-use efficiency arises because different fuels lose, as waste heat, different proportions of their theoretical energy content when they are transformed into useful heat, light or motive power at the point of final consumption. Such losses depend not only on the type and quality of fuel used but also on the purpose, conditions, duration and intensity of their use. Intuitively, it makes sense to account for the heat lost by considering only the useful energy supplied from different fuels in determining their contribution towards meeting national energy needs. The demand for coal, electricity or oil is derived from the demand for light, heat and various forms of motive power. The problem is further compounded when non-commercial energy sources such as firewood or vegetable wastes are included in total energy supply because the appliances that are used to burn them transform, in general, only 5-15% of the energy content of their fuel as useful energy.

11. The main obstacle to computing the shares of different fuels on the basis of "useful" energy is that at present only sparse and unreliable statistics are available on average utilization efficiencies and on the different purposes for which fuels are used in many consuming sectors. The following table gives a broad indication of the range of efficiencies and it also demonstrates just how wide this range can be for most fuels:

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Range (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid</td>
<td>5 - 80</td>
</tr>
<tr>
<td>Liquid</td>
<td>15 - 90</td>
</tr>
<tr>
<td>Gas</td>
<td>60 - 65</td>
</tr>
<tr>
<td>Electricity</td>
<td>60 - 95</td>
</tr>
</tbody>
</table>

12. The other argument that can be made against presenting energy supply data in terms of useful or final energy shares is a conceptual one. If the purpose of the exercise is to trace the requirements of the economy for different energy forms which have to be imported or produced as primary fuels, then it may indeed make sense to express the demand for energy by final users in terms of the demand for the primary fuel input before allowing for losses in transformation (at either the intermediate or final stages). These losses are an integral part of the process of getting primary energy to the final user in the form in which he prefers to consume it, and should, therefore, be allocated to him as "consumption".
13. In view of these problems, it is not a good idea to present energy supply information in terms of useful energy alone. Where such data are available, this information can be presented in addition to the conventional presentation in terms of primary fuel input; the underlying assumptions should, however, be clearly outlined in a footnote. Annex III provides a sample energy balance table which is based on "useful" energy estimates. The energy flow diagram (Annex II) also represents energy data in both primary and final energy terms.

Non-Commercial Energy Sources

14. The basic problems posed by the inclusion of wood and other non-commercial energy sources into an integrated national energy balance are as follows. First, in primary energy terms the contribution of these sources in national energy supply in many developing countries is often in excess of all the commercial fuels taken together and can be as high as 90%. This tends to dwarf the numbers for the various commercial fuels and makes it difficult for one integrated balance to cover both types of fuels adequately. Second, the problem is exacerbated by the fact that data on non-commercial energy supply are generally less reliable and even small errors in their estimation could lead to a large bias in the overall energy balance because of their large share in the total. And finally, as indicated above, primary energy equivalence for non-commercial fuels is particularly misleading because in general they are burned at a much lower efficiency than commercial fuels in most developing countries and their share in useful energy consumption is consequently lower. Given these problems, some agencies restrict their compilation of energy balance tables to the commercial fuels alone. However, this is not a recommended practice for Bank work. The main reason for this is that fuelwood and other non-commercial fuels are in fact the most important single energy source for most developing countries, even after allowance is made for differing end use efficiencies. Moreover, this is also a source of energy which needs to be more closely interrelated in the policy and investment analysis for the energy sector as a whole. Including these sources in an integrated energy balance highlights the close linkages that exist in this area and assists in focussing the attention of policymakers on the policy issues and investment priorities that need to be urgently addressed. Consequently, relevant Bank reports should continue to include non-commercial energy sources in the national energy balance table wherever this is at all feasible.
Primary Electricity 1/

15. The energy equivalent of primary electricity can be measured in one of three ways:

(i) as the amount of fossil fuel that would be required to generate the same amount of electricity in conventional thermal stations;

(ii) as the amount of fossil fuel that has the same energy content as the theoretical maximum heating value of the electricity which is generated from the primary sources; and

(iii) as the actual energy content of the primary fuels used—in the case of hydropower, this would reflect the energy released by a given mass of water falling a given distance and in the case of nuclear energy it would reflect the amount of energy released by the fission of nuclear material or by the difference between production, net trade and stock changes in fissionable material.

16. Each of these methods has advantages and disadvantages and each yields different results. In practice, however, the choice is narrowed to the first two because the third method results in an artificial treatment of the primary fuels, especially hydropower. Furthermore, the use of this method makes it more difficult for the policymakers to concentrate on the economic and social aspects of substitution between hydro, nuclear and conventional thermal power generation and on the implications of each type of station for the requirements of indigenous and imported fossil fuels.

17. Between the first two methods, the difference in results can be attributed directly to the fact that roughly two-thirds of the energy content for the primary fuel input for thermal power generation is lost as waste heat during the transformation process. To generate one kilowatt-hour of electricity, with a maximum theoretical heating value of 860 kcals, even the most efficient thermal power stations require a primary fuel input which has an energy content of 2,500 kcal. Therefore, depending on whether the first or the second method were adopted, a million kWh of electricity generated from hydropower would be represented in national energy statistics as the equivalent of 250 TOE or 85 TOE.

1/ Primary electricity refers to the electricity generated through hydropower, nuclear, geothermal and solar power stations.
The choice between the two methods is, in fact, an important issue in analyzing the pattern of energy supply for those countries which rely heavily on hydropower for their electricity generation.

18. There is no "theoretically" correct answer to this and, as is the case for most energy statistics, the appropriate presentation method depends on the purpose for which these statistics are used. For the work of the Bank in developing countries, it is the first convention (i.e. thermal replacement) which is most appropriate. This is because in most developing countries the choice facing policymakers is between the generation of electricity using fossil fuels in conventional thermal stations or through the development of hydro, nuclear or other primary electricity resources. Consequently, the contribution of an additional unit of primary electricity is best measured in terms of the fossil fuel "savings" which it provides to the economy. The second method is appropriate only in those economies which are exceptionally well endowed with primary electricity sources and where these resources have been developed to the point where primary electricity competes with the direct burning of fossil fuels in final use. Even in this case, however, allowance must be made for the higher efficiency with which electricity is generally used at the final point of consumption. As virtually no developing country has reached this stage of electrification, the recommended convention for Bank reports is that primary electricity be converted at its fossil fuel replacement value in the preparation of national energy balances. In keeping with international practice and to facilitate cross country comparisons, a uniform thermal efficiency rate of 34% should be used in this calculation which translates into the figure of 1 TOE = 4,000 kilowatt hours.

1/ For example, in the case of Sri Lanka, where the bulk of electricity is generated from hydropower, the share of hydropower in total 1980 commercial energy supply would vary from 6% to 18%, depending on which conversion factor was adopted.
### Country X:

**Energy Balance 1980**  
*(Thousand Tonnes of Oil Equivalent)*

| Primary Energy | Charcoal | Electricity | Petroleum Products | Gasoline/Heptane | Kerosene | Aviation Fuel | Diesel | Fuels | All | Other | Totals | Litre Totals |
|----------------|---------|-------------|--------------------|------------------|----------|---------------|--------|----------------|-----|-------|------|-------|--------|-------------|
| Fuelwood       | 2000    | 50          | 45                 | 20               | 131      | 4256          |        |                 |     |       | 2470 | 1371  |
| Coal           | 100     | 50          | 16                 | 20               | 145      |                |        |                 |     |       | 145   | 1371  |
| Hydro          | 1500    | 50          |                    |                  |          |                |        |                 |     |       | 1500  | 1371  |
| Crude Oil      | 1550    | 50          |                    |                  |          |                |        |                 |     |       | 1550  | 1371  |

#### Gross Supply
- Production
- Import
- Primary Exports
- Stock Changes

#### Conversion
- Charcoal Production
- Electric Power Generation
- Conversion Losses
- Transmission/Distribution Losses

#### Net Supply Available

#### Secondary Exports
- Mincer Sales

#### Net Domestic Consumption

#### Consumption by Sector
- Industry
- Commerce
- Transport
- Households
- Public/Other
- Agriculture

**Notes:**
(a) Negative flows indicated by parentheses.
(b) Conversion factors listed in Annex 4; hydro electricity converted on thermal replacement basis.
(c) Not all of these fuels are used in every country and actual country energy balances will have to be modified to reflect country-specific conditions. Moreover, in some countries additional fuels or subdivisions may be appropriate; for example, separate columns/rows for associated and non-associated gas, coke, coal versus thermal coal, etc.

**Source:** Mission estimates.
SRILANKA

"Useful" Energy Consumption, 1980
(Thousand toe)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Fuelwood</th>
<th>Electricity</th>
<th>LPG</th>
<th>Gasoline/ Naphtha</th>
<th>Kerosene/ Avtur</th>
<th>Diesels</th>
<th>Furnace Oil</th>
<th>Total</th>
<th>Relative Share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry/Commerce</td>
<td>78.0</td>
<td>65.2</td>
<td>2.2</td>
<td>25.6</td>
<td></td>
<td>15.0</td>
<td>140.7</td>
<td>326.7</td>
<td>47.2</td>
</tr>
<tr>
<td>Transport</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Households</td>
<td>105.0</td>
<td>14.9</td>
<td>2.2</td>
<td></td>
<td></td>
<td>39.9</td>
<td></td>
<td>182.0</td>
<td>26.3</td>
</tr>
<tr>
<td>Public/Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>28.1</td>
<td>4.0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>183.0</strong></td>
<td><strong>108.2</strong></td>
<td><strong>4.4</strong></td>
<td><strong>49.0</strong></td>
<td><strong>67.0</strong></td>
<td><strong>140.6</strong></td>
<td><strong>140.7</strong></td>
<td><strong>692.9</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

Relative share (%) 26.4 15.6 58.0 100.0

End-use efficiency coefficients are as follows:

<table>
<thead>
<tr>
<th>FUEL</th>
<th>SECTOR</th>
<th>EFFICIENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuelwood</td>
<td>Industry</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>Households</td>
<td>7%</td>
</tr>
<tr>
<td>Electricity</td>
<td>Industry</td>
<td>90%</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>90%</td>
</tr>
<tr>
<td>LPG</td>
<td>All</td>
<td>70%</td>
</tr>
<tr>
<td>Gasoline</td>
<td>Transport</td>
<td>20%</td>
</tr>
<tr>
<td>Kerosene</td>
<td>Households</td>
<td>30%</td>
</tr>
<tr>
<td>Avturbo</td>
<td>Transport</td>
<td>30%</td>
</tr>
<tr>
<td>Diesel</td>
<td>All</td>
<td>30%</td>
</tr>
<tr>
<td>Furnace oil</td>
<td>Industry</td>
<td>70%</td>
</tr>
<tr>
<td>Naphtha</td>
<td>Industry</td>
<td>70%</td>
</tr>
</tbody>
</table>

Note that these vary considerably across countries depending on the specific applications, type of equipment and user practices.
## Net Calorific Content of Major Fuels

<table>
<thead>
<tr>
<th>Petroleum Products</th>
<th>Million kcal per Metric Tonne</th>
<th>m³ per/Metric Tonne</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPG</td>
<td>10.8</td>
<td>1.86</td>
</tr>
<tr>
<td>Gasoline/Naphtha</td>
<td>10.5</td>
<td>1.36</td>
</tr>
<tr>
<td>Kerosene</td>
<td>10.3</td>
<td>1.23</td>
</tr>
<tr>
<td>- Jet Fuel</td>
<td>10.4</td>
<td>1.27</td>
</tr>
<tr>
<td>Gas Oil/Automotive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diesel</td>
<td>10.2</td>
<td>1.27</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>9.6 - 9.9 depending on specific gravity</td>
<td>1.05-1.08</td>
</tr>
<tr>
<td>LNG</td>
<td>12.6</td>
<td></td>
</tr>
<tr>
<td>Crude Oil</td>
<td>10.2 average; but varies significantly according to specific characteristics</td>
<td></td>
</tr>
</tbody>
</table>

### Coal

<table>
<thead>
<tr>
<th>Million kcal per Metric Tonne</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internationally Traded Steam Coal</td>
</tr>
<tr>
<td>Internationally Traded Coking Coal</td>
</tr>
<tr>
<td>Anthracites</td>
</tr>
<tr>
<td>Lignites</td>
</tr>
<tr>
<td>Peat</td>
</tr>
<tr>
<td>Briquettes</td>
</tr>
<tr>
<td>-Coal</td>
</tr>
<tr>
<td>-Lignite</td>
</tr>
<tr>
<td>-Peat</td>
</tr>
<tr>
<td>Coke</td>
</tr>
</tbody>
</table>

**Charcoal**

| Million kcal per Metric Tonne | 6.9 (average) |

### Fuelwood

<table>
<thead>
<tr>
<th>Million kcal per Metric Tonne</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air-dried</td>
</tr>
<tr>
<td>Green</td>
</tr>
<tr>
<td>Bagasse (30% moisture)</td>
</tr>
<tr>
<td>Dungcakes</td>
</tr>
<tr>
<td>Paddy husks</td>
</tr>
<tr>
<td>Sawdust &amp; Shavings</td>
</tr>
<tr>
<td>Gaseous Fuels</td>
</tr>
<tr>
<td>--------------------</td>
</tr>
<tr>
<td>Natural Gas</td>
</tr>
<tr>
<td>- wet</td>
</tr>
<tr>
<td>- dry</td>
</tr>
<tr>
<td>Town/City gas</td>
</tr>
<tr>
<td>Producer Gas</td>
</tr>
<tr>
<td>Methane</td>
</tr>
<tr>
<td>Ethane</td>
</tr>
<tr>
<td>Propane</td>
</tr>
<tr>
<td>Butane</td>
</tr>
</tbody>
</table>

Source: Energy Interrelationships

Memo Items

1 kcal = 3.968 BTU
1 kcal = 4.19 kilojoules
1 TOE = 10.2 million kcal = 40.5 million BTU = 42.7 million kilojoules
1 TOE = 4,000 kWh on a thermal replacement basis.
EGY PAPER No. 1  
Energy Pricing in Developing Countries: A Review of the Literature by DeAnne Julius (World Bank) and Meta Systems (Consultants). September 1981. 121 pages, includes classified bibliography.

Reviews literature on the theory of exhaustible resources and on sectoral, national and international models for energy demand. Emphasis on project selection criteria and on pricing policy as a tool of energy demand management.

EGY PAPER No. 2  

Contains the edited version of the lectures and discussions presented at the South-East Asian Workshop on Energy Policy and Management held in Daedeok, South Korea, October 27 - November 1, 1980.

Topics that are addressed include: the overall problem of energy policy and its relationship to economic development; the management of energy demand and related data; the role and value of models in energy planning, and the use of energy balances. Transport and rural sectors are also discussed in terms of their relationship to energy planning.

EGY PAPER No. 3  

Study on the effects of energy price change in a developing country. Provides insight into the mechanisms through which energy prices affect other prices in the economy and, therefore, the incomes of rich and poor consumers, profitability of key industries, the balance of payments, and the government budget.

EGY PAPER No. 4  

Presents several alternative fuels used as replacement for conventional (gasoline and diesel) fuels in internal combustion engines. These alternatives, including LPG,
natural gas, alcohols and producer gas, are derivable from natural resources that exist in so many developing countries. Also provides up-to-date information on the newest alternative fuel option currently available and those that are being developed and tested.


Analyzes subsector issues and recommends courses of action for energy project possibilities; identifies renewable energy projects which could create a positive impact in the short to medium term.


Discusses the reasons for high existing levels of power distribution losses in developing countries. Identifies areas within a power system where loss optimization would be most effective. Shows that reducing losses is often more cost effective than building more generation capacity.