Guidelines for developing Energy Efficiency Indicators in Thailand

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1. Objective of the report

This report is part of Phase 2 of the TGP-EEDP project that aims at developing Energy Efficiency Indicators (EEI) for the industrial sector, commercial buildings, residential buildings, as well as the transport sector in Thailand. The goal of TGEP-EEDP (Thai-German Programme on Energy Efficiency Development Plan) is to promote the increase of energy efficiency in industry and buildings by assisting the Thai Government in the implementation of the Energy Efficiency Development Plan 2011-2030 (EEDP).

The project partners of TGP-EEDP include the Energy Policy and Planning Office (EPPO), the Department of Alternative Energy Development and Efficiency (DEDE) and the Thailand Greenhouse Gas management Organization (TGO).

This report aims at explaining how to develop EEI with supporting data, calculation procedures, tables, charts, etc. as input for the local team to start collecting data and build the databases.

The report will explain in a first part what should be the content and organisation of the spreadsheet data base. It will then list for each sector the list of indictors to be developed and the supporting data required for the EEI, including their definition. It will then introduce the calculation of indicators and their mode of calculation. The document will rely on the results of Phase 1. It will be updated regularly in the course of the project, if needed, to clarify and complement it according to the clarification asked by the local team. The report will consist in a kind of guidelines to make easier the work of the local consultant in the data collection and the calculations of the indicators. The report will also introduce for each sector some data controls which will be integrated in a second step in the Excel data template to validate the data that should be entered.

This template is adapted from the ODYSSEE data template that all EU member countries fill in to update the ODYSSEE data base.

The data template will combine top-down data coming from the various statistical sources, identified in Phase 1, as well as bottom-up (BU) data coming from the reporting of large industrial consumers and buildings to DEDE. It will include the reconciliation of these two types of data to derive additional indicators.

2. Proposed data template

2.1. Organisation of data template

The data template could be developed on Excel and made of one data sheet per sector, i.e. 5 sheets, plus one data sheet containing cross sectoral data and indicators (e.g. GDP, population, energy balance data) as follows:

i. Industry
ii. Services
iii. Households
iv. Transport
v. Macro

The sheet industry will include all data related to manufacturing, mining and construction. For construction, the data reported on consumption to DEDE for designated buildings under the category “construction” should actually be part of the industry sector as it relates to the construction sector, that is, according to TSIC classification or international classification, part of industry.

In the sheet **households** will go data related to residential buildings, including large condominiums apartments condominium that are classified in the commercial sector in DEDE energy consumption statistics, as they are considered as designated buildings.

Indeed, according to international practices, the energy consumption of the residential sector should include all types of apartments and houses where households live. Energy efficiency indicators currently considered in that sector relate the energy consumption of the residential sector to the private consumption expenditure of households or the number of dwellings (or number of households), that, by definition, include all households. For both indicators it is important that the consumption of condominiums is well included in the residential energy consumption

In the sheet **macro** will be included macro-economic statistics and energy balance data from NESDB and DEDE as well as the type of indicators already published by DEDE.

2.2. Organisation of data sheet

Each data sheet should have the same structure. Based on Enerdata's experience with other energy efficiency data bases[1], the following structure is proposed (Table 4):

- Column 1: Title
- Colum 2 : Unit
- Columns 3 to n: Annual values (one column per year)
- Colum n+1: Source (short source to characterize each data serie, usually the acronym of the organisation, e.g. DEDE, EEPO, NESDB),
- Colum n+2: Note (used to detail and document the source).

Each data sheet is organised in 3 parts; one dedicated to the input data; another section for the data control and a last part for the calculation of indicators.

Input data

The data template will combine top-down data coming from the various statistical sources, identified in Phase 1, as well as bottom-up data coming from the reporting of large industrial consumers and buildings to DEDE. It will include the reconciliation of these two types of data to derive additional indicators. Each data serie should be well documented with a unit, a source and a reference (Table 1).

Table 1 : Organization of the data sheet: case of service sector data

Services						
Top -down data						
Energy consumption of the service sector		units	2009	2010	2011	source
LPG consumption of tertiary sector		ktoe				
electricity consumption of tertiary sector		ktoe				
Total consumption of tertiary sector		ktoe				
Electricity consumption by branch and type of buildings						
Total Consumption		GWh				
Health sector		GWh				
Hospitals		GWh				
Wholesale and retail trade		GWh				
Department stores		GWh				
Retail stores		GWh				
Wholesale stores		GWh				
Hotels and restaurants		GWh				
Hotels		GWh				
Restaurants		GWh				
Fiancial institute		GWh				
Floor area in service sector buildings						
hospitals		Mm2				
hotels		Mm2				

[1] The structure and organisation proposed for the data template is based on the experience with the ODYSSEE data template used by all EU member countries and of the data templates used by UN-ECLAC for Latin American countries and Medener for Mediterranean countries, as well as templates developed for national energy efficiency agencies in Algeria, Brazil, India and Turkey.

Data and indicators controls

Data controls should test the consistency between detailed data and aggregate ones:

- In industry, the sum of industrial sub-sector with total of industry for energy consumption and value added; the information of a sub-branch and the total of the branch;
- In services, the sum of data provided by sector (for electricity consumption, employee, value added) and the data provided for the total service sector, etc);
- In transport, the sum of modes (road, rail, air, water) with the total consumption of transport; the sum of fuel by modes with the total consumption of transport by fuel; the sum of cars by fuel with the total stock of cars;
- Control of the sum of the share of value added of services, industry and agriculture in GDP; the sum of these 3 value added should represent around 90% of the GDP.

The difference between the sum of sub-sectors and the total of a sector should be expressed in %. If the deviation is too important (> 5%), the data need to be checked (Table 2).

Table 2 : Data controls: case of service sector data

	2009	2010	2011
Data control			
Top down data			
Electricity consumption by branch			
Sum of all branches compared to total			
Sum of all buildings of a branch with branch total			
VA by branch			
Sum of all branches compared to total			
Employement by branch			
Sum of all branches compared to total			
Bottom-up vs top-down data			
Electricity consumption by type of building			
Sum of all buidlings from BU data compared to top-down data			

A second control is to check for all indicators the annual variation (%/year) over the 5 last years. Automatic colouring of cells can be set up so that if the variation between t and t-1 is above a certain threshold the cell is coloured (e.g. above 20%) (Table 3).

Table 3 : Controls of indicators trends: examples

Main Indicators		variation of the 5 last year (%/year)				
		2007/2006	2008/2007	2009/2008	2010/2009	2011/2010
Energy consumption per unit of private consumption	koe/M$93					
Electricity consumption per unit of private consumption	koe/M$93	-1%	8%	1%	-6%	-3%
Electricity consumption per electrified households	kWh/household	0%	2%	-1%	-5%	0%
Unit consumption of households per dwelling	toe/dw.	2%	0%	-1%	-4%	0%

Calculation of indicators

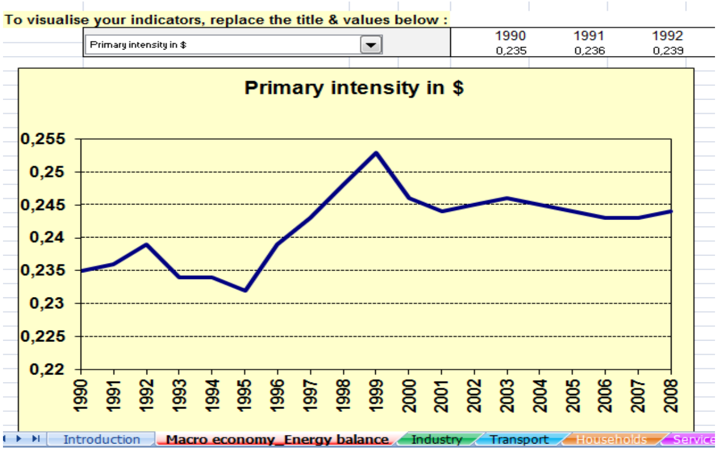
Indicators should be directly calculated in each sectoral file to allow any user to check the trends and relate the indicators to the supporting data (Table 4).

Table 4 : Calculation of indicators: case of service sector

Main indicators	
Top down	
Total energy intensity and unit consumption per employee	
Energy intensity of services	kep/MIxx
Energy consumption of services per employee	tep/emp
Electricity Intensity and unit consumption	
Electricity intensity of services	MWh/MIxx
Electricity intensity of health sector per employee	kWh/emp
Electricity intensity of wholesale and retail per empl	kWh/emp
Electricity intensity of hotels, restaurants per emplc	kWh/emp
Electricity consumption per employee	
Electricity consumption of services per employee	kWh/emp
Electricity consumption of health sector per employ	kWh/emp

Indicators trends can be visualized through predefined graphs to detect easily possible data disruptions.

Figure 1: Predefined graphs of indicators



The following chapters present for each sheet and sector the requested data, their definitions and the indicators calculated using such data.

3. Industry

3.1. Classification by sub-sector and type of industrial products

Based on the findings of phase 1 it is proposed to consider 9 main industrial sub-sectors[2], that corresponds to the two digits ISIC or TSIC classification as follows:

1. Food
2. Textiles
3. Wood
4. Paper and printing
5. Chemicals
6. Non metallic minerals
7. Chemicals
8. Basic metals
9. Fabricated metals &equipment

Fabricated metals products include machinery, electric and electronic equipment as well as transport equipment (automobiles).

In each sub-sector a specific focus will be given on energy intensive products:

i. Ice, sugar (in food)[3]
ii. Paper (in paper and printing)
iii. Plastics and rubber (in chemicals);
iv. Cement (in non metallic);
v. Steel (in basic metals);
vi. Electronics (in fabricated metals);
vii. Automobile (in fabricated metals);

For each sub-sector and energy intensive products the data should be collected from national statistics, from DEDE, EEPO and NESDB, etc... (i.e. top-down data).

Data will also be collected for designated industries from DEDE (bottom-up data). The list of industries to be monitored will depend on the classification used at DEDE. It can be larger than the list of products mentioned above. DEDE data on designated consumers will be used for cross checking and to estimate national data from bottom-up data

Bottom-up data will be defined by type of product whereas top-down data will relate to sub-sectors according to TSIC classification.

3.2. Industry indicators

Two types of indicators will be produced in industry coming from two different sources:

- Top-down indicators by sub-sector (according to TSIC classification) or type of products;
- Bottom-up indicators based on data collected on the sample of factories monitored through the reporting of designated factories to DEDE;

Three types of top-down indicators will be considered

- Indicators of **specific energy consumption** per unit of production index by industrial sub sector describing energy efficiency trends at sub-sector level[4];
- Specific energy consumption for energy intensive products (energy consumption of industrial sub-sectors per unit of physical production);
- An indicator of **energy intensity of industry at constant structure** showing the impact of changes in the industry structure (structural changes).

[2] Manufacturing sub-sector is also referred as a branch.
[3] Non exhaustive list to be detailed later, especially for food.
[4] For 2 digits sub –sectors only production index can be used to characterize the volume of production; physical production can only be considered for homogenous production at 3 to 5 digits levels.

Bottom –up indicators will only be specific energy consumption per unit of physical production.

3.2.1. Specific energy consumption by sub sector

Indicators of specific energy consumption by sub-sector are ratios relating the energy consumption to the output of the sector measured with the index of industrial production. The indicators proposed are indicated in Table 5. As in fabricated metals, electricity is by far the dominant energy (82% in 2011), therefore an indicator on electricity uses only is proposed.

3.2.2. Specific energy consumption by product

Indicators of specific energy consumption by industrial product are ratios relating the energy consumption to the output of the sector measured in physical units (toe/tonne, GJ/t, kWh/t, kWh/unit). This approach only works if there is a dominant output (e.g. cement, steel , paper).

The following indicators are therefore proposed (Table 5). For cement, for which electricity is needed for a specific end-uses (grinding of materials), an indicator on electricity uses only is also proposed so as to enable international benchmarking.

Table 5 : Top-down indicators on industry[5]

food	E/IPI
ice production	EL/P
non metallic	E/IPI
of which cement	E/P , EL/P
chemical	E/IPI
basic metal	E/IPI
steel	
fabricated metals	E/IPI
electronics	EL/IPI
automobile	EL/IPI
paper	E/P

Bottom up indicators will be expressed in the same way as the specific consumption, as indicated in Table 2.

3.2.3. Energy intensity of industry at constant structure

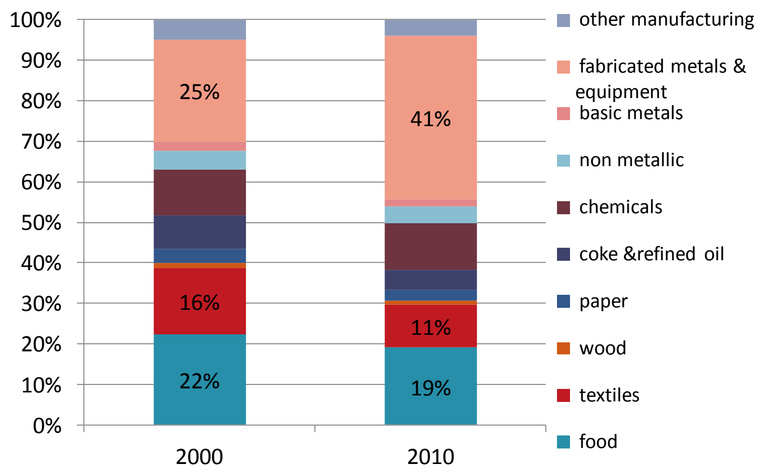
DEDE calculates an energy intensity of industry, as a ratio relating the energy consumption of industry to the value added of industry (koe/Baht). A decrease of the ratio means that industry requires less energy to generate one unit (i.e. one Baht) of value added, thus that industry use energy more efficiently from an economic viewpoint but not necessarily from a technical viewpoint.

All industrial sub-sectors do not require the same amount of energy inputs to produce 1 Baht of value added. Some industrial sub-sectors are very energy intensive, such as non metallic minerals (cement, bricks, glass), primary metals (steel), chemicals and paper. Others require muck less energy per Baht of value added, such as electronics (up to 10 to 20 times less than the energy intensive sub-sectors).

[5] E/IPI: total energy consumption divided by production index; EL/IPI: electricity consumption divided by production index; E/P: total energy consumption divided by physical production; EL/P: electricity consumption divided by physical production.

Industrial development is not uniform among sub-sectors: some sub-sectors grow faster than others. As a result, the share of each sub-sector in the total industry value added change over time: this is what is called structural changes (Figure 2). If less energy intensive sub-sectors grow faster than other sub-sectors, this will reduce the overall energy intensity of industry all other things being equal.

Figure 2: Share of sub-sector in the total value added of manufacturing (Thailand)

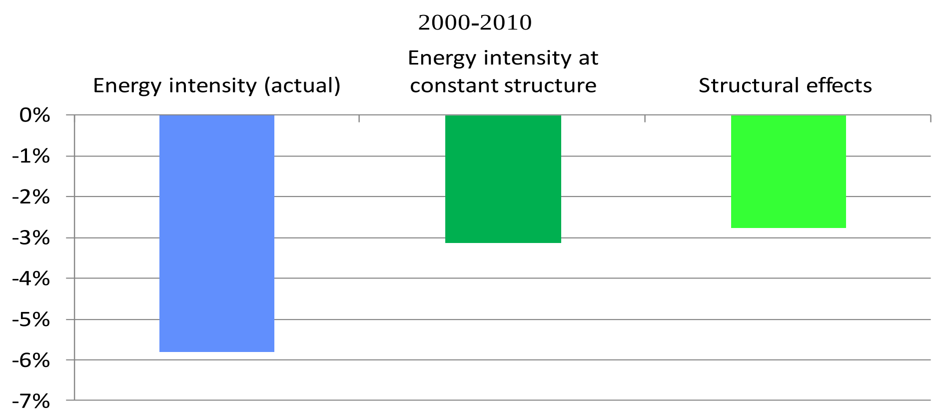


To quantify the impact of structural changes on the overall intensity of industry, the usual approach is to calculate a fictive energy intensity at constant structure, i.e. assuming that the structure did not change compared to a reference year.

Two main methods can be used to calculate this intensity at constant structure, depending on what year is the reference for the constant structure: a fix base year (e.g. 2000) or, a moving reference year. The fix base year is less accurate but is simpler to implement and it is proposed in the first step to start with it. In that case, the intensity at constant structure of industry is calculated at year t with the sectoral intensities of year t and the value added structure of the base year (e.g. 2000), as shown in Box 1.

The comparison of the annual variation of the energy intensity with the annual variation of the intensity at constant structure shows the impact of structural changes, the so called "structural effects" as shown in Figure 3. In the example, almost half of the reduction in the energy intensity is due to structural changes and one half only to energy efficiency improvements.

Figure 3: Impact of structural changes on the energy intensity trend of industry



Box 1: Calculation of the energy intensity of industry at constant structure

$IEs = \Sigma(VAi/VA)o * (Ei/VAi)t$
with :
IEs : intensity at constant structure
VAi: value added of sub-sector i;
Ei: energy consumption of sub-sector i
o :base year (e.g. 2000) and t: current year

3.3. Data for industry

Four types of data will be included by sub-sector:

- energy consumption,
- industrial production index,
- physical production for selected products,
- value added at constant prices.

3.3.1. Energy consumption by sub-sector

This section will provide for each sub-sector the energy consumption by type of energy (electricity, oil products, gas, lignite, biomass). Data will come from DEDE for 2 digits sub-sectors[6].

EPPO provides more disaggregated electricity consumption by product, with in particular a breakdown DEDE sub –sector "fabricated metals" between electronics and automobile, which together represent around 75% of the electricity used in that sub-sector. It provides electricity consumption data for cement, ice production, textiles, plastics, rubber.

3.3.2. Production index

The **production index** by sub-sector is the most common indicator used to measure the industrial output; it is usually measured in relation to a base year (e.g. index base 100 in 2005 for instance) or in relation to the previous year. It is well covered in national statistics. This index usually measures the changes in the volume of physical production: it is calculated from index of change in physical production at a very detailed level (4 to 5 digits) measured with different units (e.g. number of litres of milk processed, of tons of meat produced for the food industry) and aggregated at the sub-sector level (e.g. food) into a production index on the basis of the weight of each sub-branch in the value added of the branch in the base year (2005).

3.3.3. Physical production

The physical production corresponds to a dominant output of the sub-sector and is usually measured in ton (e.g. crude steel, cement, clinker, ice) or in number of units (automobile, textile).

3.3.4. Value added at constant price

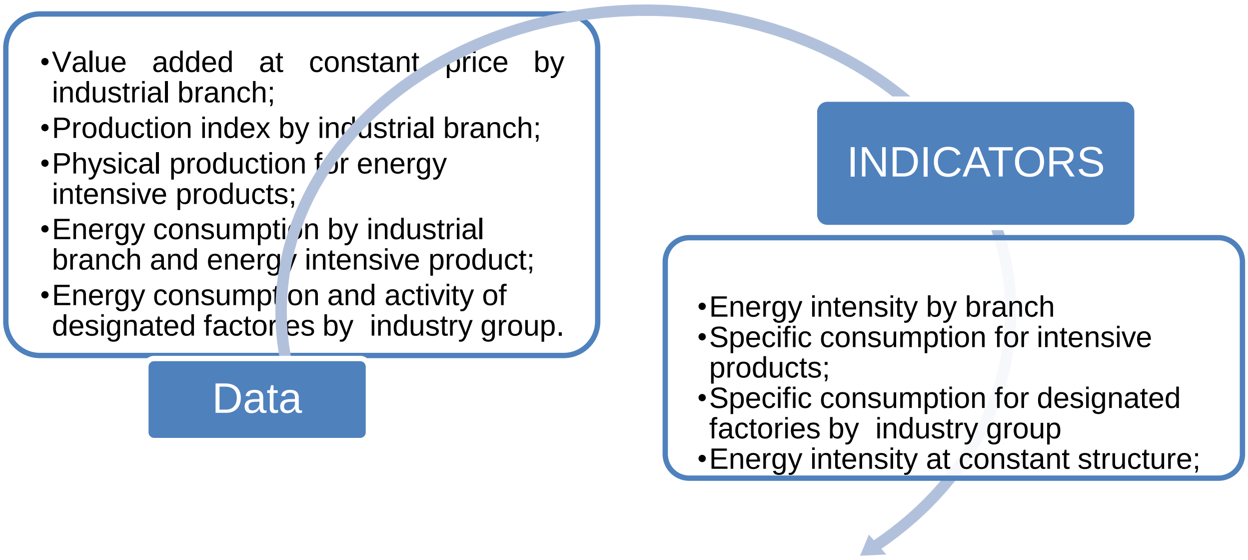
The **value added at constant price** by sub-sector (also called in real terms) measures the industrial output in monetary value. It is available at the two digits level and should be provided for the 6 sub-sectors[7].

[6] Food and beverages and non metallic minerals are the two largest sub-sectors, with respectively 34 and 28% of the energy consumption of manufacturing in 2011. They are followed by chemicals (8.5%), basic metals and fabricated metals (6.5% each). For electricity, fabricated metals rank first with 22%, followed by food and beverages (17%), chemicals (14%), textiles, basic metals and non metallic minerals (around 10% each) (source : DEDE, Thailand Energy Efficiency Situation 2011, Table 12).

[7] Value added at constant prices is ether provided directly in national statistics or given in current price with volume index: value added at constant price for year t is equal to the value added at current price for the base year of the index multiplied by the volume index at year t (and divided by 100).

3.4. Summary of data and indicators

The following scheme summarizes the data requested in industry and the related indicators.



4. Service sector buildings

This sector includes buildings in the public sector and commercial sector[8].

4.1. Classification by sub-sector and types of buildings

Based on the findings of phase 1 it is proposed to consider 3 main sub-sectors[9]:

- Wholesale and retail trade,
- Hotels and restaurants
- Health and social work activities.

In each sub-sector a specific focus will be given on certain types of buildings: on hotels in the sub-sector hotels and restaurants; on hospitals in the sub-sector health and social work and on department store, retail store and wholesale store in the wholesale and retail trade sub-sector.

For each sub-sector and types of buildings the data should be collected from national statistics, from DEDE, EEPO and NESDB, etc... (i.e. top-down data).

Data will also be collected for designated buildings from DEDE (bottom-up data). The list of buildings to be monitored will depend on the classification used at DEDE. It can be larger that the types of buildings mentioned above (i.e. hotels, hospitals, department store, retail store and wholesale store) and include for instance large office buildings.

Bottom-up data will be defined by type of buildings whereas top-down data will relate to sub-sectors according to TSIC classification (hotels and restaurants, health and social work activity).

4.2. Indicators in service sector

Two types of indicators will be produced coming from two different sources:

- Top-down indicators by sub-sector (according to TSIC classification) or type of buildings;
- Bottom-up indicators based on data collected on the sample of buildings monitored through the reporting of designated buildings to DEDE;

As the dominant source of energy is electricity (around 80% of the total), the focus will be on electricity indicators. If data collected on LPG at the bottom-up level used can be extrapolated at national level indicators covering the total consumption may also be considered by allocating the LPG consumption by sub sector.

4.2.1. Top-down indicators

Four types of top-down electricity indicators can be considered in service sector buildings (commercial or public buildings):

- Indicators of electricity intensity in kWh per Baht (in constant prices);
- Indicators of specific electricity consumption in kWh per employee by sub sector;
- Indicators of specific electricity consumption per unit of activity for hotels and hospitals; kWh per person-nights in hotels, and per bed in hospitals;
- Indicators of specific electricity consumption in kWh per m^2 by sub sector or type of buildings.

[8] The energy consumption of the sector only includes the energy used in buildings and excludes the consumption of vehicles. It includes the energy consumption of transport buildings, as well as the electricity consumption for public lighting and water distribution.

[9] The service sector is classified by type of activity (i.e. by sub-sector), according to the TSIC classification.

Given the uncertainty about the possibility to get data on floor area it is proposed to focus for top-down indicators on the three first indicators for which data on employment or value added can be derived from macro–economic statistics and data on activity are available. Indicators of specific electricity consumption per m^2 will only be considered for bottom-up indicators by building type.

All these indicators by sector combine the effect of energy efficiency improvement but also of increase comfort and labour productivity: a decreasing value means improved efficiency; however energy efficiency may take place even with an increase of the specific consumption (for instance if saving for air conditioning are offset by an increasing diffusion of ICT appliances. More accurate indicators to capture energy efficiency improvement would have to be defined by end-use (e.g. air conditioning, lighting), but would require more detailed data, that are not available for the moment.

It is proposed to produce the electricity indicators shown in Table 6.

Table 6: Indicators on service sector buildings[10]

Wholesale and retail trade	EL/EMP or EL/VA
Hotels and restaurants	EL/EMP or EL/VA
Hotel	EL/PNIGHT
Health sector	EL/EMP or EL/VA
Hospitals	EL/NBED

4.2.1.1. Energy intensity

The **energy intensity** is defined for the service sector or by sub-sector as the ratio between the final energy consumption of the sector (or by sub-sector) and the value added measured in constant prices. The energy intensity can also be expressed at normal climate (see methodology for climatic corrections in part 3.3.2).

4.2.1.2. Specific energy consumption per employee

The **specific consumption per employee** is defined for the service sector or by sub-sector as the ratio between the energy consumption of the sector or the sub-sector and the number of employee (total or by sub-sector).

4.2.1.3. Specific energy consumption per unit of activity

In hotel, the usual indicator is the **electricity consumption per person-night,** i.e the ratio between the electricity consumption and the number of person-night (kWh per person-night).

In the health sector, the usual indicator is the **electricity consumption per bed,** i.e. the ratio between the electricity consumption and the number of beds occupied in hospitals (kWh per per bed).

These indicators also combine the effect of energy efficiency improvement but also of increase comfort and labour productivity.

4.2.1.4. Specific energy consumption per m^2

The **specific consumption per m^2** is defined for service sector's sub-sectors as the ratio between the energy consumption of the sub-sector and the floor area of buildings.

[10] EL/EMP: electricity consumption divided by employment; EL/VA: electricity consumption per unit of value added; EL/IPI: electricity consumption by production index; EL/PNIGHT: electricity consumption by number or persons-nights; EL/NBED: electricity consumption by number of beds in hospitals.

4.2.2. Bottom- up indicators

Two types of bottom-up indicators can be considered in designated buildings:

- Indicators of specific consumption per unit of activity (e.g. kWh per person-nights in hotels, and per bed in hospitals);
- Indicators of specific electricity consumption per m^2 by type of buildings.

These indicators will be calculated for electricity and for fuels (mainly LPG separately).

4.3. Data for service sector

Energy consumption and activity data will be included by sub-sector

4.3.1. Energy consumption

Electricity consumption by sub –sector is monitored by EPPO

4.3.2. Activity data

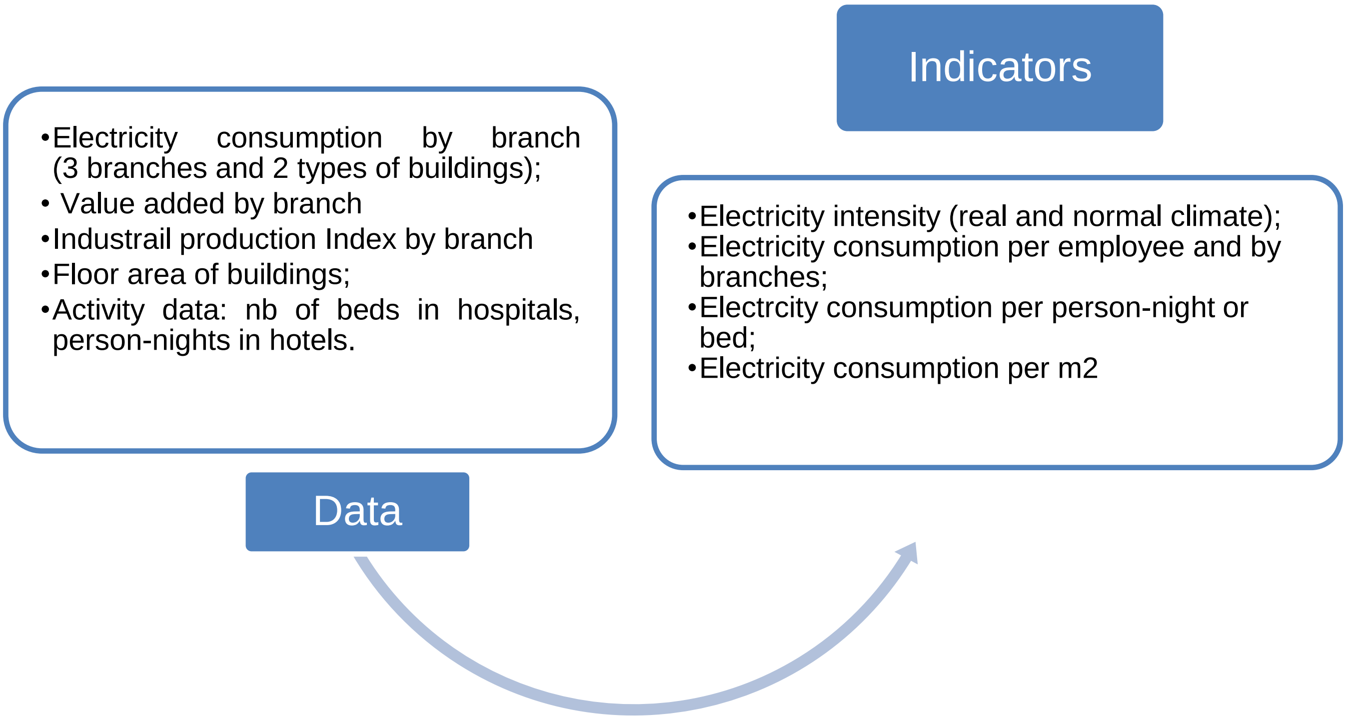
The activity data required in services are:

- The value added by sub-sector for the three main sub-sectors: wholesale and retail trade, hotels and restaurants, and health and social work activities.
- The industrial production index for the three main sub-sectors
- The number of employees by sub-sector for the three main sub-sectors;
- The floor area size (m2) in hotels and hospitals;
- The number of beds for hospitals and number of person-nights for hotels,

The **floor area** represents the floor space that needs to be cooled or illuminated; it is measured in m2 .

The **employment** is usually expressed in full-time equivalent (Full-time equivalent employees equal the number of employees on full-time schedules plus the number of employees on part-time schedules converted to a full-time basis).

4.4. Overview of data and indicators



5. Residential buildings

Residential buildings will be considered as a whole and for three categories of buildings:

- All dwellings
- Large condominiums and apartment buildings
- Other dwellings than large condominiums/apartment buildings

5.1. Indicators for households

Top-down energy indicators for the total consumption (electricity and fuels) can only be considered for the household sector as whole.

Top-down electricity indicators can be considered for the three categories and the household sector as a whole, whereas bottom-up indicators are only available for large condominiums and apartment buildings.

5.1.1. Top-down energy indicators for the whole sector

- **Energy intensity (total energy, electricity)**

Relates energy consumption to private consumption expressed in constant prices.

- **Unit consumption per dwelling**

The **unit consumption per dwelling** relates the energy consumption of the household sector to the number of permanently occupied dwellings. This indicator can also be calculated for electricity consumption only.

- **Electricity consumption per electrified households;**

The electricity consumption per electrified household relates the electricity consumption to the number of households with access to electricity. Change in the electrification rate will increase the electricity consumption per dwelling.

- **Diffusion indicators**

Two categories of diffusion indicators can be considered:

i. the penetration of solar water heaters, i.e. the percentage of dwellings equipped and the total surface of solar water heaters installed per capita.
ii. The share of efficient equipment in sales of appliances for refrigerators, air conditioners and rice cookers.

For solar water heaters, **t**he percentage of households with solar water heaters should be calculated from the total installed area in m2 divided by the average size of a solar panel for each dwelling (e.g. 3 m2 or 4 m2/dwelling)[11].

5.1.2. Top-down energy indicators by type of dwelling

- **Specific electricity consumption per dwelling**

The specific electricity consumption per dwelling for large condominiums relates the electricity consumption of large condominium to the number of permanently occupied dwellings in large condominium.

The specific electricity consumption per dwelling for other dwellings relates the electricity consumption of other dwellings than large condominium to the number of permanently occupied dwellings outside large condominium.

The **unit consumption per dwelling and end-use** (water heating, cooling, cooking, electrical appliances) relates the energy consumption by end-use to the number of permanently occupied dwellings. Such data are presently not available.

5.1.3. Bottom-up indicators for large condominiums

Two types of indicators may be considered: the specific electricity consumption per dwelling for large condominiums and per m2.

5.2. Data for households

5.2.1. Dwellings and characteristics

- **Number of households**

The **number of households** is similar to the number of occupied dwellings and can be a proxy for that variable; the main difference being people living in community (military, religious). It is usually available from the National Statistical Office (NSO) either for years of housing surveys (every 10 years) or on a yearly basis. If not available on a yearly basis can be interpolated/extrapolated from the population and an average number of persons per household, indicator that is changing slowly and smoothly.

- **Stock of dwellings**

There exists different statistics related to the **stock of dwellings**. The most common ones relate to the total stock and to the stock of permanently occupied dwellings. The difference between the two data corresponds to summer/week-end residences plus vacant dwellings. For energy consumption analysis, the relevant data to handle is the stock of permanently occupied dwellings. Such statistics are usually available from the national statistical office (see above number of households).

The electrification rate is the percentage of dwellings or households with electricity. It is available from household surveys and/or energy administration.

[11] Data included in the sheet "parameters" in data template (line 34).

5.2.2. Household electrical appliances and lighting

- **Stock, ownership, and sales of household electrical appliances**

The household electrical appliances considered are refrigerators, washing machines, air conditioners and TV[12].

The annual **stock of appliance** can be estimated in two ways:
- Either with a stock model from annual sales and an average lifetime.
- Or from annual household survey on equipment ownership (i.e. % of households owning one or several appliances).

Equipment ownership ratios for refrigerators and washing machines correspond to the % of household with the appliance. For TV and fans equipment ownership ratios should include multi equipment and correspond to the average number per household.

Equipment ownership ratios are usually available from the National Statistical Office (NSO) either for years of housing surveys (every 10 years) or on a yearly basis ; they may also come from surveys carried out by electric utilities. If they are not available on a yearly basis they can be linearly interpolated/extrapolated as they are changing slowly and smoothly. Yearly statistics may also come from surveys sponsored by equipment manufacturers associations (or by the energy administration;

The **sales of electrical appliances** represent the number of appliances sold every year. The information comes from equipment manufacturers associations

- **Sales/market share of efficient appliances**

The market share **of efficient appliances** represent the percentage of appliances sold corresponding to the most efficient label classes . The source of information may be the monitoring of programme, survey from the energy administration, or consumer panels.

- **CFL**

For CFL different information is asked: sales, number of CFL per household and % of households that have at least one CFL: all aim at quantifying the penetration of CFL. Sales of CFL may come from industry associations (e.g. association of lighting manufacturers/ importers/ distributors. The equipment ownership for CFL may come from the monitoring of programme, from survey of the energy administration or from housing survey of NSO**.** The stock of CFL can be calculated from the equipment ownership and number of households or from a modelling based on annual sales and average life time.

5.2.3. Household electricity consumption by end-use

The electricity consumption of households for **air conditioning** is estimated on the basis of surveys on the diffusion of air conditioners and modelling, taking into account the intensity of use (number of hours) and their average rated power.

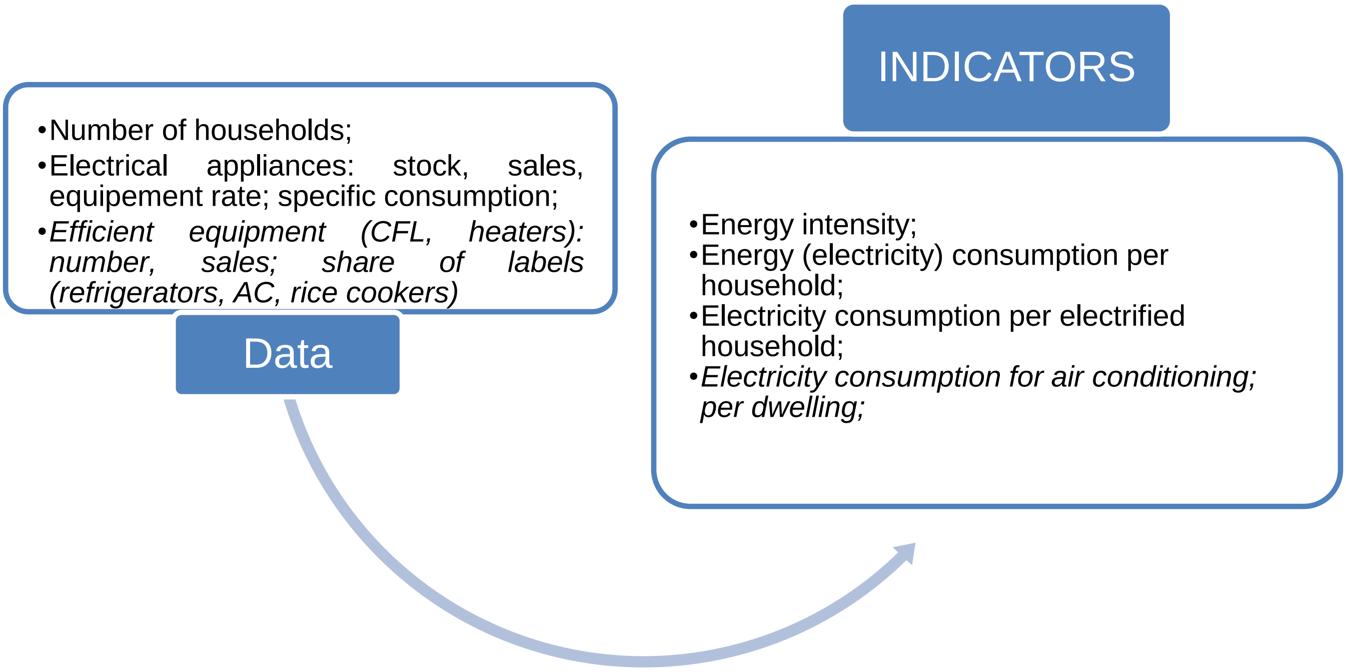
The electricity consumption for lighting is usually estimated from modelling taking into account the number of lighting points, or the average lighting power and an average number of hours of lighting per year[13].

5.3. Overview of data and indicators

The following scheme summarizes the data requested in households and the related indicators calculated.

[12] Depending on the countries, other large appliances may be considered, such as: freezers, dishwashers or dryers.

[13] A default value can be 1000 hours per year.



•Number of households;
•Electrical appliances: stock, sales, equipement rate; specific consumption;
•*Efficient equipment (CFL, heaters): number, sales; share of labels (refrigerators, AC, rice cookers)*
Data
INDICATORS
•Energy intensity;
•Energy (electricity) consumption per household;
•Electricity consumption per electrified household;
•*Electricity consumption for air conditioning; per dwelling;*

6. Transport

6.1. Indicators in transport

Sectoral indicators for transport can be calculated by separating road transport, rail transport (including urban rail transport such as subway and skytrain), water transport and air transport. For each mode the consumption can be related to a number of vehicles (road transport) and/or an indicator of traffic (ton-km, passenger-km and passengers).

The following indicators are proposed in transport:

- Energy consumption of road transport per vehicle in toe per vehicle
- Energy consumption of road transport per car equivalent (total, gasoline, diesel)
- Unit consumption of rail transport in koe per gross ton-km
- Unit consumption of passenger rail transport in goe per passenger-km
- Unit consumption of rail transport of goods in goe per ton-km
- Unit consumption of water transport in koe per ton-km
- Unit consumption of air transport per passenger

6.1.1. Energy consumption of road transport per vehicle

It is calculated as the energy consumption of road transport (car, truck, bus, light duty vehicles, motorcycles and three-wheelers) divided by the number of vehicles. It is expressed **in toe per vehicle.**

6.1.2. Unit consumption of road transport per equivalent car

The unit consumption of road transport per equivalent car relates the total consumption of road transport to a fictitious stock of all road vehicles, measured in terms of a number of equivalent cars. It is measured in toe/car equivalent.

The data required are the following:

- The total energy consumption of road transport.
- The stock of road vehicles by type.
- Coefficients reflecting the difference in average yearly consumption between each type of vehicle and a car.

The coefficients of conversion of each type of vehicle in terms of car equivalent reflect the difference in average yearly consumption between each type of vehicle and the car. If, for instance, a bus consumes on average 15 toe/year and a car 1 toe/year, one bus is equal to 15 equivalent cars.

These coefficients can be derived from surveys (or estimates) of distance travelled and specific consumption (l/100km) for selected years; they can also be adapted from similar countries in terms of vehicle characteristics and patterns of use[14].

Compared to the previous indicator, the indicator per car equivalent takes into account the change in stock composition towards light vehicles or heavier vehicles and is a better proxy to assess the efficiency of total vehicle stock.

This indicator, calculated for each type of fuel, can be used to estimate the energy consumption per type of vehicle.

[14] Default values can be: 1 truck and light vehicle = 4 cars equivalent; If trucks and light vehicles are considered separately, a truck=15 car equivalent and a light vehicle= 1.8 car equivalent; 1 bus = 15 car equivalent and 1 motorcycle = 0.15 car equivalent

6.1.3. Unit consumption of rail transport

The **energy consumption of rail transport in koe per gross ton-km** is calculated as the ratio between the energy consumption of rail transport and the total traffic, measured in gross ton-km.

The **total rail traffic in gross tonne-km** is calculated by converting the traffic of passengers and goods in the same unit, in gross ton-km hauled (gtkh), reflecting the total weight to be moved, including the weight of locomotives and carriages. For this purpose, a coefficient is used that express the average gross weight per passenger and per ton of goods[15].

The **unit consumption of passenger rail** is calculated as the ratio between the energy consumption of passenger trains and the passenger traffic, measured in passenger-km (pkm).

The **unit consumption of rail transport of goods** is calculated as the ratio between the energy consumption of goods trains and the traffic of goods, measured in ton-km (tkm).

6.1.4. Unit consumption of water transport

The energy consumption of inland waterways transport in koe per ton-km is calculated as the ratio between the energy consumption of domestic freight ships and the inland waterways traffic, measured in ton-km. Inland waterways include transport on rivers and coastal areas.

6.1.5. Unit consumption of air transport

The energy consumption of air transport per passenger is the ratio between the energy consumption of air transport (international + domestic) divided by the total number of air passenger (embarked + disembarked). We can also calculate this indicator just for the domestic air transport.

6.2. Data in transport

6.2.1. Energy consumption of transport

Energy consumption of transport is usually split in the energy balance by main transport infrastructures:

- Road transport
- Rail transport
- Water transport
- Air transport[16]

The fuels considered in the template for transport are the following:

- LPG
- CNG (Compressed Natural Gas)
- Motor spirit (gasoline)
- Diesel oil
- Electricity
- Biofuels (bioethanol and biodiesel)
- Jet fuel
- Fuel oil

The official energy statistics provide the **energy consumption of rail transport**, as a whole, without a differentiation between passenger and goods. If no data is available on the

[15] A default value can be used as follows: 1.7 gtkm per passenger-km for passengers and 2.5 gtkm per ton-km for goods.

[16] International air should be considered in the database. IEA excludes international air transport.

consumption of passenger rail transport separately, one approximation can be to express the traffic of passengers and goods in the same unit, in gross ton-km hauled (gtkh), reflecting the total weight to be moved, including the weight of locomotives and carriages. For this purpose, a coefficient is used that express the average gross weight per passenger and per ton of goods[17]. The total energy consumption of rail transport is then allocated between passenger and goods traffic according to the share of passenger and goods traffic respectively in the total traffic in gross ton-km hauled[18].

The **energy consumption of water transport** corresponds to domestic transport by ships on sea or rivers; it excludes the fuel used for international sea transport include in a specific category in the energy balance called "marine bunkers". The consumption of water transport is currently available from official energy balance statistics.

The **energy consumption of air transport** is currently available from official energy balance statistics. I should include domestic and international energy consumption.

The **total energy consumption** of road transport is available from the energy balance. It is the sum of energy consumption of cars, trucks, light vehicles, bus and motorbikes.

6.2.2. Stock of vehicles

The **stock of road vehicles by type** (cars, trucks, light-duty vehicles, buses, three-wheelers, motorcycles) is available from national statistics. It corresponds to the number of road vehicles registered at a given date (usually at the end of the year or the middle of the year) in a country and licensed to use roads open to public traffic[19].

It should refer to the number of vehicles really on the road (i.e. in circulation and that consume motor fuels). Official data often relate to all registered vehicles, i.e. including vehicles that have been scrapped and are not used any more, as they cumulate all the new registrations to the existing stock of vehicles without retiring the vehicles that are no longer used. This often overestimates the real stock of vehicles in use by some 30%.

To get the real stock on the road, several approaches are possible:

- Use other sources that better correspond to vehicles in use (from fiscal registry if annual fees are paid);
- Or modelling using a survival law;

Cars should also include taxis. Light duty vehicles also called light commercial vehicles have a useful load below a certain threshold (e.g. < 3 t). Trucks correspond to medium and heavy trucks (generally > 3 t useful load); trucks should also include road tractors that pull trailers (articulated vehicles, also called trailer truck)

Both stock and sales should be available by fuel type to ease the allocation of motor fuels (e.g. gasoline and diesel) consumption by type of vehicles.

6.2.3. Passenger traffic

The **passenger rail traffic** is measured in passengers-km. It is a usual transport statistics covered by national and international statistics. A **passenger-kilometre**, abbreviated as **pkm**, is the unit of measurement representing the transport of one passenger by a defined mode of transport (e.g. road, rail, air, sea, inland waterways) over one kilometre.

Total traffic for rail should be the sum of passengers traffic in train, in tramway and metros.

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[17] A default value can be used as follows: 1.7 gtkm per passenger-km and 2.5 gtkm per ton-km for goods.

[18] Depending on the definition of energy consumption statistics the electricity consumption of metro and tram may be included in rail transport. Therefore the calculation of the gross ton-km should be consistent with the coverage of the energy consumption. Ideally, it would be better, if the information is available to well separate the consumption of trains from that of metro and tramways.

[19] Military vehicles are usually excluded from the statistics.

The total **traffic of air transport** represents the number of passengers embarked and disembarked.

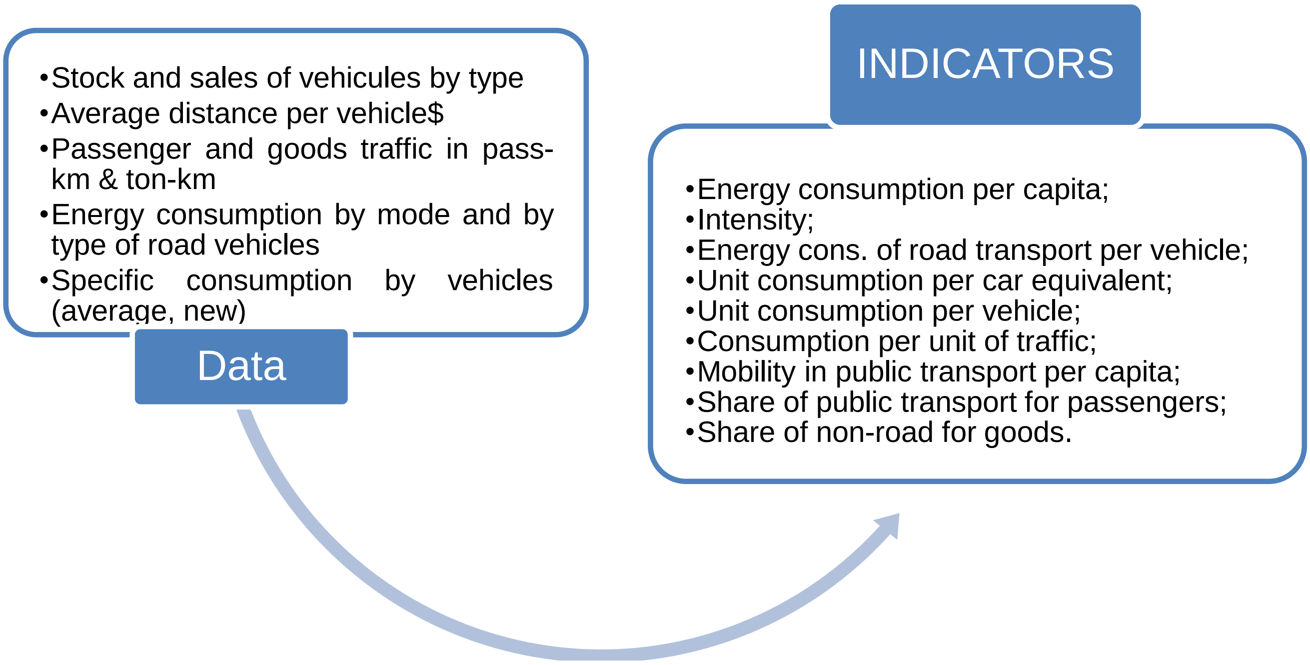
6.2.4. Traffic of goods

The t**raffic of goods** is measured in tonne-km. It represents the transport of one tonne over one kilometre.

The **rail and inland waterways traffic of goods** measured in ton-km are usual transport statistics.

6.3. Overview of data and indicators

The following scheme summarizes the data requested in transport and the related indicators calculated.



7. Macro economy and energy balance data

7.1. Indicators of energy intensities

This sheet will include macro-economic indicators, such as the ones published by DEDE in its brochure, called “Thailand Energy Efficiency Situation”[20], as well as basic indicators published by EEPO[21]:

- Total final energy intensity to GDP
- Energy intensity of agriculture
- Energy intensity of industry
- Energy intensity of commercial sector
- Energy intensity of transport

It is proposed to include a few additional macro indicators, such as an indicator of energy intensity for the residential sector, an intensity of manufacturing industry, and to calculate in a different way the transport intensity, as explained below.

7.1.1. Primary and final energy intensities

The **primary energy intensity** is the ratio between the total energy consumption of a country and the GDP at constant price. It measures the total amount of energy necessary to generate one unit of GDP.

The **final energy intensity** is the ratio final energy consumption and the GDP. The difference between the primary and final intensity is explained by the consumption used in energy transformations.

Different trends in primary and final energy intensities can be explained by five factors:

i. changes in the energy supply mix, mainly linked to changes in the electricity generation mix: an increase in the share of thermal power generation increases the gap between the two intensities; in contrast, an increasing share of hydropower or wind narrows this gap.
ii. changes in the efficiency of transformations: for instance, greater efficiency of thermal power plants (e.g. development of gas combined cycle power plants), reduces the ratio of primary to final intensity.
iii. changes in the share of secondary energies (mainly electricity) in final consumption.
iv. changes in the percentage of energy for non-energy uses, as these consumptions are included in the primary intensity but excluded from the final intensity.
v. finally changes in the share of imported secondary energies: any increase, for instance, in electricity imports will decrease transformation losses and narrow the gap between the two intensities.

7.1.2. Sectoral energy intensities

The final energy intensity by main sector (industry, agriculture, services) is calculated as the ratio between energy consumption by sector and value added at constant prices. Usually services are much less intensive than industry or agriculture (around a factor 10), which means that much less energy is necessary to generate one unit of value added in services than in industry. This means that if services are growing faster than industry this will contribute to decrease the total final energy intensity, all things being equal. This phenomenon is known as the effect of structural changes in GDP.

[20] The present issue is “Thailand Energy Efficiency Situation 2011”. The indicators of energy intensities are published over the period 2007-2011, and relating energy consumption by sector to GDP by sector in ktoe/ million Baht.

[21] EEPO is also publishing indicators of per capita consumption by sector, that are not really EEI.

An intensity of **manufacturing industry** by relating the energy consumption of manufacturing from DEDE to the value added of manufacturing published by NESDB. As industry is mainly made of manufacturing and construction, the intensity of manufacturing is generally much higher than the intensity of the total of industry because construction has a high valued added and a small energy consumption[22].

The **transport intensity** is presently calculated by DEDE by relating the energy consumption of transport to the value added of transport; it is better to relate the consumption of transport to the total GDP as all economic activities are responsible for transport consumption, whereas the value added of transport only accounts for the activity and traffic of transport companies (railways, bus and truck companies, airlines and shipping companies) and does not reflect transport by cars and by vehicles belonging to administrations or industries. The approach of using total GDP for calculating the transport energy intensity is in line with international practices (e.g. ODYSSEE).

An indicator of energy intensity for the **residential sector** by relating the energy consumption of the sector (from DEDE) to the private consumption of households (or household final consumption expenditure).

7.2. Macro data

The data required are coming from the energy balance and national economic accounts.

7.2.1. Energy consumption data

- The **primary energy consumption** represents the total consumption of a country (total consumption of coal, oil, gas, primary electricity (nuclear, hydro), electricity production from renewable (wind, solar, geothermal), solar heat , import / export of electricity and biomass).

- The total consumption of oil includes the production of crude oil minus net exports plus the net imports of oil products minus oil sued for international bunkers

- The **final energy consumption** measures the consumption of final energy consumers. They are broken down into several sectors: industry (excluding non energy uses), transport, residential, services and agriculture.

- **Final consumption of industry** covers all industrial sectors, e.g. iron and steel industry, chemical industry, food, drink and tobacco industry, textile, leather and clothing industry, paper and printing industry, etc., with the exception of transformation and/or own use of the energy producing industries. It excludes the fuel consumption of all modes of transport, and also excludes energy products employed for non energy uses (e.g. raw materials, lubricants).

- The **final consumption of transport** is the total consumption of all modes of transportation regardless of to whom they belong, and to what purpose the transport serves. International air transport is included in energy consumption of transport.

- The **final energy consumption of residential** includes the energy used by households in their dwellings.

- **The final energy consumption of services** sector includes the consumption for public (public sector) and private services (commercial sector).

[22] Industry is the sum of 4 main sub-sectors: mining, manufacturing, construction and electricity, gas and water. Most of the energy consumption is in manufacturing and the bulk of the value added is shared between manufacturing and construction.

- **The final energy consumption of agriculture** includes agriculture stricto sensu (i.e. farming, cattle breeding), fishing and forestry.

7.2.2. Macro-economic data

- **GDP**

The GDP, Gross Domestic Product is the usual indicator to measure the economic output of a country. It is either measured at market prices or at factor costs.

The GDP at market prices is equal to the sum of value added (VA) of the 3 main economic sectors (agriculture and fishing activities, industry and services[23]) + indirect taxes (about 10%)[24]. The GDP at factor cost is equal to the sum of value added of agriculture, industry and services. Therefore the GDP at factor cost is equal to the GDP at market prices minus indirect taxes.

- **Value Added**

Value added are defined at constant price.

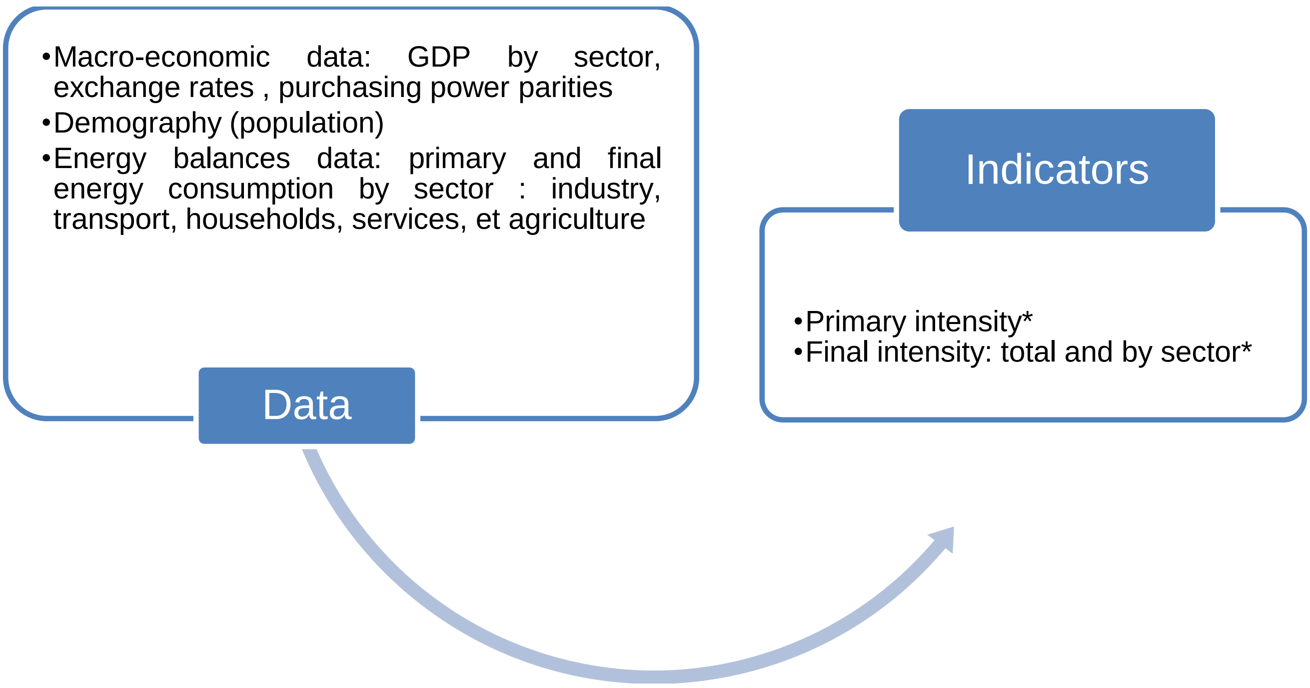
- **Private Consumption of households**

The private consumption of households, also called household final consumption expenditure, is the main component of the GDP expenditure: it usually represents about 50-60% of GDP; the other components being the gross investment, the government consumption and the balance import – export.).

- **Population**

The total **population** usually corresponds to the mid-year population

7.3. Overview of data and macro indicators



[23] The service sector, also called tertiary sector, include administrations and commercial activities.
[24] It is also measured at factor cost; in that case, the GDP is strictly equal to the sum of value added (VA) of the 3 main economic sectors (agriculture and fishing activities, industry and services).