EMEE Ex. 08

Energy indicators as a measure of comparison between the ES

Objective: To understand how to objectively compare the EC with each other.

What we would like to solve?

a) How to compare individual energy system with each other?

b) How to calculate the material production of a given territorial unit (territory, state, and continent) which is supplied by the Energy System (ES) of a given territory?

Ad a)

The individual ***ESs*** are compared by the method of elementary technical analysis, which consists of three main analyzes:

1. **Analysis of absolute indicators -** state and flow quantities of the system:

   These quantities in ***ES*** are energy flows from imputing sources (Primary Energy Sources – ***PES [power units]***) to the outputting (Final – "utilization" – Energy Sources **= *Final Energy Consumption – FEs [power units]***), which are consumed by energy users of them for personal use (residential use) or for realization of Gross Domestics Product - ***GDP***), (non-residential use) – **Fig. 1** – where power units = Mtoe "tons of oil equivalent".

   These indicators are the total sum quantities for a certain Time period (***T***) of the time (***t***) in ***ES***:

   - Total ***PES*** consumption of ***ES*** for the period ***T*** of 1 year.
   - Total ***FES*** consumption for the period ***T*** of 1 year = ***t***.

ESF II project of the University of West Bohemia in Pilsen, reg. number: CZ.02.2.69/0.0/0.0/18_056/0013239

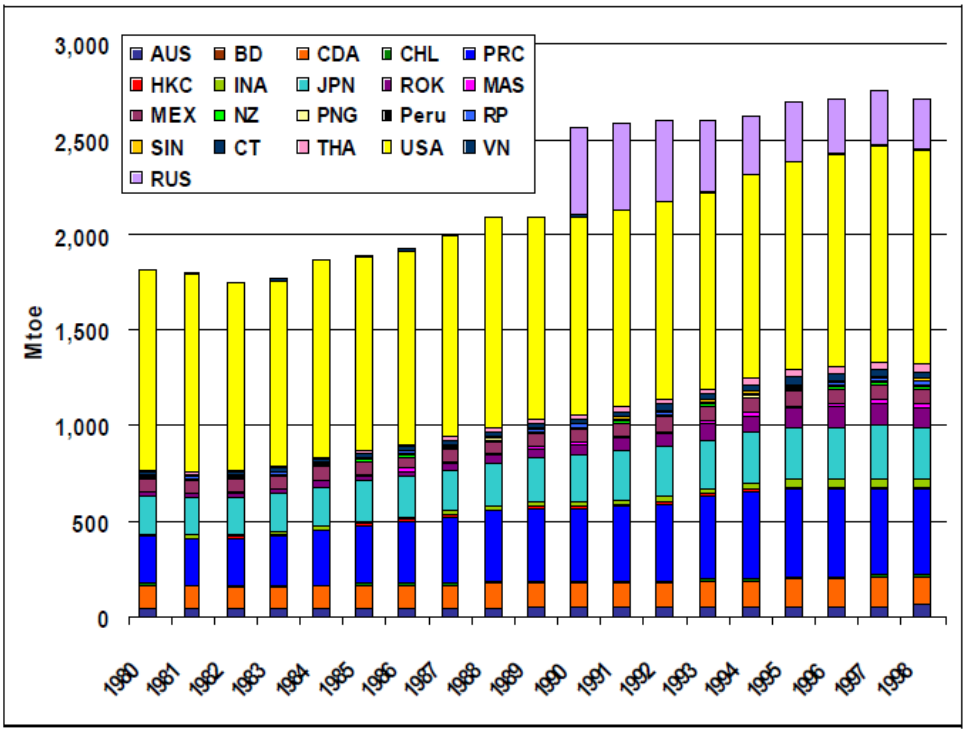


Fig. 1: Whole Economy Energy Consumption (GDP) in APEC Economies (Asia-Pacific Economic Cooperation).

2. **Analyzes of difference indicators -** differences between individual inputs and outputs – Fig. 2, in individual parts of the system - i.e. in the ***ES*** these are energy losses – **Eq. 1**. It is thus possible to determine the energy efficiency of individual system elements as the ratio of outputs to inputs **Eq. 2**.

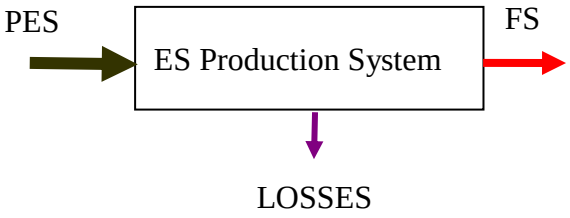


Fig. 2: Energy flows via ES.

Difference Indicator ***= systems input – systems output =***

PES value – FES value = ES losses [power units/for period T] ***[1]***

ES Efficiency =(systems output / systems input) = η_{ES} ***[-]*** ***[2]***

3. **Analysis of relative indicators** - shows the relationship between two or more absolute indicators according to their share, i.e. in the case of the ***ES*** are the absolute values of material flows (energy flows) for a given time, which are related to population, area, production of pollutants, material production, etc.

The most important relative indicator is ***Energy Intensity Indicators*** (***I_{it}***) – **Eq. 3**, which measure the quantity of energy required to perform a particular activity, which is defined by the production of output - ***GDP***. Energy consumption is linked to the monetary value of the production. Typically physical indicators are constructed at a more disaggregated level than monetary indicators. Energy intensity indicators perform a variety of functions, ranging from the monitoring of energy efficiency, through to policy analysis and evaluation, and the appraisal of new technologies. However the usefulness and effectiveness with which energy intensity indicators can be used is subject to a number of stipulations, particularly in relation to the availability and quality of data.

Energy Intensity = (Total Final Energy Consumption at year t)

divided (GDP value produced by FEC) =

$$I_{it} = FEC_t / GDP_t \quad \textit{[power units / monetary unit]} \qquad \textit{[3]}$$

Energy intensity indicators measure "how well" energy is used in the production of the output.

As **Fig. 3** shows, indicators of energy efficiency can be constructed from aggregated international or national statistics through to output data from individual operating units within a plant. At the highest levels of aggregation - the whole economy and macroeconomic sectors - few indicators of energy intensity can be constructed.

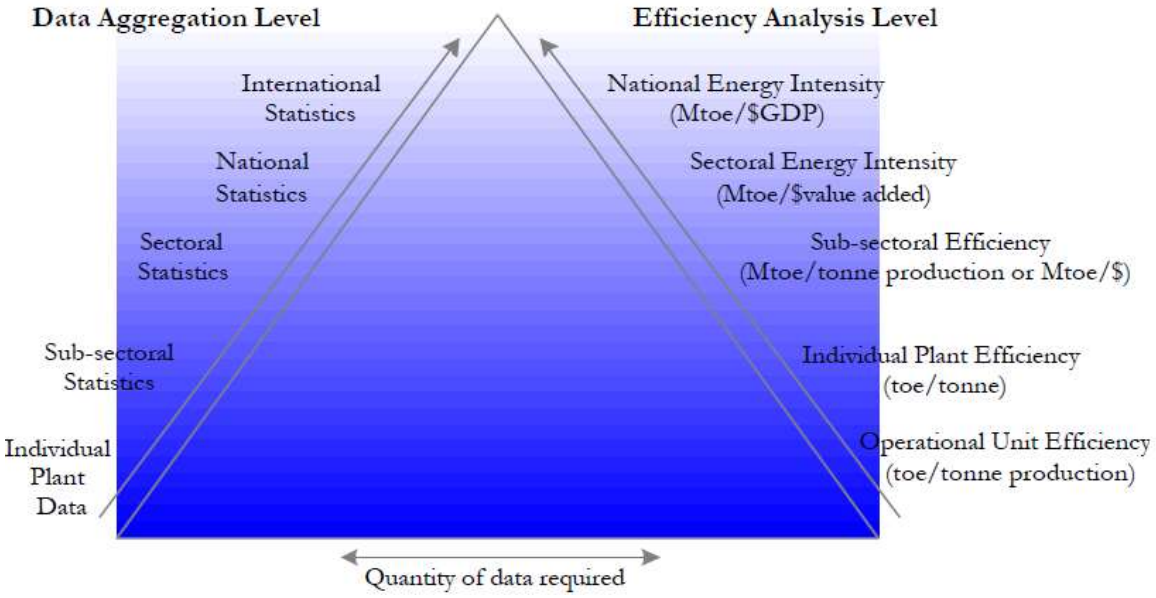


Fig. 3: Energy Efficiency Indicator Pyramid.

Far more objective is the comparison of systems according to relative indicators and especially according to energy intensity indicators.

Our problem in determining the intensity indicators, or relative indicators of ***EES*** and ***ES***, is to determine the need for individual energy forms (primary, final) for material production - ***GDP***. These values can be obtained from the statistical data pertaining to the ***EES.*** Records of consumption of individual energy forms passing through the ***EES*** is a relatively simple matter. Determining the relevant ***GDP*** is more complicated.

Ad b)

Economic intensive indictors are based on material production.
The material production is GDP (Gross Domestic Product)?

Motto:

Gross Domestic Product is not an omnipresent indicator that shows all the bright and dark sides of economic development, but for its easy traceability and interpretability it remains a rich tool for statisticians, a grateful topic for journalists and a strong argument for politicians.

GDP of the system (economy) can be evaluated on the principle:

- ***Territorial*** **-** production carried out on the territory (home playground).
- ***National*** **-** production is carried out by entities reporting to the territory (it does not matter where it plays whether at home or outdoors).

The measure of material production is then the value of production, which is called the price of production = the price of the product (price ***p [monetary units]***) for a specified period of time (***T = 1 [year]***).

The total product - gross (absolute indicator) can therefore be expressed using:

- ***GDP = gross domestic product***
- ***GNP = gross national product***
-

It is gross because we can never determine the net value precisely – some domestic productions do not go through the records (tax system), the black economy, etc.

We will solve the problem - how to determine at least the gross product?

Determination of GDP:

There are basically three methods:

- ***Product method*** **-** only the value of goods and services in a given year and only once **- *GDP = sum of value added* –** in the monetary expression of the total value of goods and services newly created in a given period in a given territory**.**
- **•*Expenditure method*** - expenditures on final goods and services in a given year are added up, recognizing expenditures on consumption, investment, public expenditure and net exports - ***GDP = aggregate expenditure***.
- ***Pension method*** - the value of pension assets acquired by citizens in a given territory is added up - ***GDP = aggregate expenditures = aggregate pensions, i.e. the sum of pensions:***
  - wages (+ other compensation of employees),
  - rents (income from renting land and real estate),
  - interest (net interest earned by households),
  - profits (profits of companies and pensions of employed persons – self-employed).

Determination of GDP by Production Method:

According to this method, ***GDP*** is defined as the market value of final production achieved in one year, on the territory of a given state. We have to evaluate market production, while the sum of value added is made up of disparate products and services; ***GDP*** is given here by adding the number of products of individual types multiplied by the average market price according to the Eq.4:

GDP = market price multiply amount of A product plus

market price multiple amount of B product [monetary units] ***[4]***

Individual products and services that make up ***GDP*** are categorized into the following areas:

- ***C - final consumption*** - (consumption [currency units]) - household expenditure on the purchase of goods and services, i.e. everything that citizens spend on shops and services,
- ***G – government*** - government purchases of goods and services [currency units], i.e. everything that governments buy,
- ***I – investment*** - gross private domestic investment [currency units], which is mainly investment purchases by companies, both for raw materials and for the expansion and renewal of so-called capital goods (i.e. also damage after the hurricane)**,**
- ***X – exports*** **-** [currency units],
- ***M – imports*** **-** [currency units].

Often the final consumption of production in the domestic territory is combined and the value of C is then:

$$C = C + G \qquad [5]$$

The sum of total domestic consumption and investment prices can be defined as domestic demand or absorption **A**:

$$A = C + I \qquad [6]$$

Thus, ***GDP*** can be defined as domestic demand and supply:

$$GDP = A + (X - M) \qquad [7]$$

How GDP in relevant year can be published:

- ***At current prices of the year***:
  - We take the prices p_i **[*monetary units]*** (for individual years i =1 → n) of a given year („**t**“), i.e. ***the sum of current prices („c.p. or CP“)*** in this relevant year, and multiply it by the number of products in this year q_i. **[number of units].**
    Such ***GDP*** is called ***Nominal GDP -*** or ***GDP in current prices*** $GDP_t^{c.p.}$:

$$\mathrm{GDP}_t = \mathrm{GDP}_t^{c.p.} = \sum_i p_{i,t} * q_{i,t} \quad [\text{monetary units}] \qquad [8]$$

- ***At the average prices of the previous year***:
  - We can have ***GDP*** of the given year in the current prices (average $\bar{p}_i$) of the privies year („t-1“, “PR”), $GDP_t = GDP_t^{CPPR.}$.
    Such ***GDP*** is called ***Reall GDP -*** or ***GDP in APPY***:

$$\mathrm{GDP}_t^{\mathrm{APPY}} = \sum_i \bar{p}_{i,t-1} * q_{i,t} \quad [\text{monetary units}] \qquad [9]$$

Price ratio of two follows years is deflator:

$$\mathrm{def} = d = p_n / p_{n-1} \quad [-] \qquad [10]$$

- ***At the constant prices of the reference year***:
  - We are chaining of data in average prices of the previous year by the corresponding volume index **d**. If we have ,for example, the establish constant at average prices in 2000, than in this year GDP_t is:

$$\mathrm{HDP}_t^{c.p.} = \mathrm{HDP}_t^{r.y.} = \mathrm{HDP}_{2000}^{r.y.} = \sum_i \bar{p}_{i,2000} * q_{i,2000} \quad [\text{monetary units}] \qquad [11]$$

  - Therefore, if we want to calculate real ***GDP*** in the nth year compared to the reference year (“***r.y***.”), which is in the time series in the year (t) must apply:

$$\mathrm{HDP}_{t+n}^{r.y.t} = \mathrm{HDP}_t^{c.p.} * \frac{\mathrm{HDP}_{t+1}^{APPR}}{\mathrm{HDPc}_t^{c.p.}} * \ldots * \frac{\mathrm{HDP}_{t+n}^{APPR}}{\mathrm{HDP}_{t+n-1}^{c.p.}} =$$

$$= \left(\sum p_{i,t} * q_{i,t}\right) * \frac{\sum \bar{p}_{i,t} * q_{i,t+1}}{\sum p_{i,t} * q_{i,t}} * \ldots * \frac{\sum \bar{p}_{i,t+n-1} * q_{i,t+n}}{\sum p_{i,t+n-1} * q_{i,t+n-1}} \qquad [12]$$

$$HDP_{t+n}^{r.y.t} = HDP_{t}^{c.p.} * \prod_{k=t}^{t+n-1} \frac{HDP_{k+1}^{APPR}}{HDP_{k}^{c.p.}} \quad \textit{[13]}$$

ACPR – average prices of the privies year.

There is possible to devote **volume index**:

$$HDP_{t+n}^{r.y.t} = HDP_{t}^{c.p.} * d_{t+1} * ... * d_{t+n} \quad \textit{[14]}$$

Similar there is possible vice versa (against the time):

$$HDP_{t-n}^{r.r} = HDP_{t}^{b.c.} * \left(\frac{HDP_{t}^{PCPR}}{HDP_{t-1}^{b.c.}} \right)^{-1} * ... * \left(\frac{HDP_{t-n+1}^{PCPR}}{HDP_{t-n}^{b.c.}} \right)^{-1} \quad \textit{[15]}$$

Comparing the development of ***GDP*** over time is important in order to be able to evaluate the development of the functioning of production chains in the ***GDP*** system. The problem is that in the presented calculation of GDP there is a change in the number of products of material production in individual years, as well as a change in the prices of individual products.

Ex. 1: Deflator Calculation

Let's take a simple example of an economy where nominal GDP (valued at current prices) is $ 5.65 million and real GDP (valued at constant base year 2014 prices) during 2019 is $ 4.50 million. Calculate the GDP deflator against the reference year.

Solution:

*Deflator HDP = (nominal HDP / real HDP) * 100 – Eq. [10]*

*GDP deflator = 5.65 million / 4.50 million USD * 100*

GDP deflator = 125, 56 [%]

Ex. 2: Calculation of GDP and deflator

Calculate the value of nominal and real GDP for individual years 2016-2018, if the year 2016 represents reference year and GDP values of products X and Y. (price, amount) are presented by Tab. 1.

Tab. 1.:

Rok	množství X	cena X	množství Y	cena Y
	q_X [$]	p_X[$]	q_Y[$]	p_Y[$]
2016	100	2	200	1
2017	180	5	250	1.5
208	250	3.5	300	2.5

Solution:

*Nominal GDP = (product amount X * product price X) + (product amount Y * product price Y – Eq [8]).*

*Real HDP = (product amount X * average product price X in the privies year) + (product amount Y * average product price Y in the privies year] – Eq. [9]).*

Year 2016:

*Nominal HDP = $q_X * p_X + q_Y * p_Y$ = (100 * 2, 00 $) + (200 * 1, 00 $)*

Tab. 2:

Year	nominal GDP	real HDP	deflator
	$GDP_t^{c.p.}$ [$]	GDP_t^{APPZ} [$]	d [%]
2016	1 625	400	100
2017	915	610	150
2018	1 625	800	203

Ex. 3: GDP Calculation:

Based on the data in Tab.3 calculate the GDP of the Czech Republic in constant prices of the reference year 1998 (column 4). Then complete column 5 (values and its header) to make the easiest check of the calculation. The values of column 5 will therefore be equal to the values of one of these columns, the data of which must also be calculated.

Tab. 3:

	1 $GDP^{c.p.}$	2 $GDP^{APPY.}$	$d_t = \frac{GDP_t^{APPY}}{GDP_{t-1}^{c.p.}}$	4 $GDP^{r.y.19980.}$	5	$GDP^{r.y.2001}$	$GDP^{r.y.2001}$ (SOPY=100)
1995	1467	1386	x		x	*	x
1996	1661	1528	108,700			*	
1997	1785	*	108,280			*	
1998		*	111,210	1962		*	
1999	2041	*	102,780			*	
2000	2150	*	101,380			*	
2001	2315	2207				*	
2002	2415	2350				*	
2003	2532	2490				*	101,49

Data in the first two years, i.e. GDP in a given year at current prices and GDPs in the average prices of the previous year were entered in the table. GDP data are presented in CZK, S0PY = Same Period of the Previous Year. Arrows at the calculation of r.y.1995 represent multiple (it is forward to 2000), in R.Y.2000 they are also multiples, but with a volume index with the inverted value (1/dt) – we go back.

SOPR (Spent Output Profit Ratio), SOPR is an indicator which reflects the degree of realised profit and loss for all coins moved on-chain.

It is obvious that the values of the 5th and 7th columns are equal, which represents the control required above. It follows, therefore, that the year-on-year changes in GDP at the prices of any reference year are equal

Solution:

1. For a successful calculation, it is necessary to know the time series of GDP in current prices and in average prices of the previous year. Missing GDP data i.e. we obtain from the time series data GDP r.y. 1998 and GDP r.y.2001, using the relationship: GDP c.p. year "t" is equal to the GDP of year "t" at constant prices of the reference year "t". This relationship is evident in 1998. To obtain data for 2001, we must use column 7. Missing APPY GDP data are obtained using column 2 - GDP deflator (from APPY data).

2. To complete column 4, i.e. the time series of GDP in constant prices of the reference year 1998, we use the following relationships [12]:

Tab. 4:

	$GDP^{c.p.}$	$GDP^{APPY.}$	$d_t = \frac{GDP_t^{APPY}}{GDP_{t-1}^{c.p.}}$	$GDP^{r.y.20000}$	$GDP^{r.y.2000}$ (SOPY=100)	$GDP^{r.y.1995}$	$GDP^{r.y.1995}$ (SOPY=100)
1995	1467	1386	x	2000,5	x	1467	x
1996	1661	1528	1,042	2083,7	104,2	1528	104,2
1997	1785	1649	0,993	2068,5	99,2	1517	99,2
1998	2150	1765	0,989	2044,8	98,9	1499	98,9
1999	2041	1986	1,012	2069,5	101,2	1517	101,2
2000	2150	21207	1,039	2150	102,9	1576	102,9
2001	2315	2207	1,026	2206,7	102,6	1618	102,6
2002	2415	2350	1,015	2239,6	101,5	1642	101,5
2003	2532	2490	1,031	2309,3	103,1	1693	103,1

Comparing of individua countries - Purchasing power parity (PPP)

Source: ČESKÝ STATISTICKÝ ÚŘAD

https://www.czso.cz/csu/czso/evropsky_srovnavaci_program

We can already calculate ***nominal GDP*** and calculate ***real GDP*** in a given area. Now we want to compare individual territories (individual countries) with each other. If they have the same currency, then this should not be a problem and ***GDP*** can be compared using the purchasing power of the population (***PPP***), i.e. how much they pay for spending in their country (P_d) compared to another country (P_f):

$$PPP = P_d / P_f \qquad [11]$$

For example, for one item of expenditure, there is a comparison of purchasing power between Finland (beer costs 5 Euros) and the Czech Republic where the same amount of the same product costs 25 CZK is then parity - ***PPP*** - for this particular product 0.2 Euros to the Czech crown (0.2 = 5/25).
The basis for calculating parities is to compare prices in national currencies for a sufficient number of identical products and services on ***national markets***. This is usually done using the consumer basket method, which expresses the current costs of the household. In the Czech Republic, this comparison is made and the content of the consumer basket is dealt with by the Czech Statistical Office. In macroeconomics, the consumer basket is used to measure the price level, respectively inflation rates. In this case, the consumer basket represents a representative group of goods, which includes expenditure on housing, food, culture. Consumer basket items for 2022 are listed in the file ***spot_kos2022.xlsx***.
The problem is that not all countries pay in the same currency. If countries have different currencies, we could multiply individual ***GDP*** relative to the purchasing power of **GDP*PPP*** at the exchange rate. The conversion rate, the artificial exchange rate, converts one currency into another so that you can still buy the same amount of goods and services.

The effect of the exchange rate on GDP$_{PPP}$

Exchange rates are affected by a number of factors, such as supply and demand in the foreign exchange market. These disruptive elements may not always be directly related to price differences between countries and therefore may not always accurately reflect the real purchasing power of a particular country's currency. Therefore, an artificial currency unit is chosen to express the purchasing power **PPP or Purchasing Power Standard**. The Purchasing Power Standard (***PPS***) is used in international comparisons to express the volume of economic aggregates. It simply states how many currency units (PPS) must be spent on a certain amount of goods and services in each country. We obtain the data from the value expressed in the national currency by dividing by the relevant purchasing power parity.

Purchasing power parities are used not only to analyse ***GDP*** but also to analyse the relative price level in individual countries. For this purpose, Purchasing Power Parities are divided by the current nominal exchange rate to obtain a ***Price Level Index*** (PLI), which expresses a country's price level relative to others. This index is used to compare price levels of individual countries with respect to the European Union average. Price level indices are not intended for strict evaluation of countries and only indicate the magnitude of the price level in one country in relation to other countries. The EU average is calculated as a weighted average of national price level indices weighted by expenditure adjusted for price level differences. If the ***PLI*** is higher than 100, the country concerned is relatively more expensive than the EU average and vice versa.

https://ec.europa.eu/eurostat/web/purchasing-power-parities/data/main-tables

GDP per capita in PPS is also used in the allocation of structural funds within the EU. Regions where GDP per capita in PPS is less than 75% of the EU average (taken over a period of three years) are eligible for support from the structural funds.

The most frequently asked for indicators from the PPP program are included in the following main tables:

Ex. 4: Calculation of Intensity indicators

On the base of statistic CZ data for year 2020 calculate ES CZ indicators and compare them with others EU countries.

Solution:

*An example of CZ energy balance in the tabular for in toe*10^3 (oil equivalent) is presented in* ***Tab. 5:****– source EIA.*

(toe = energy density 41,868 GJ

Tab. 5:

SUPPLY and CONSUMPTION	Coal and Peat	Crude Oil	Petroleum Products	Gas	Nuclear	Hydro	Geothermal, Solar, etc.	Combustible Renewables and Waste	Electricity	Heat	Total*
Production	23725	405	0	147	6813	219	7	2089	0	12	33419
Imports	2027	7850	2917	8006	0	0	0		986	0	21824
Exports	-5427	-42	-1152	-101	0	0	0	-263	-2072	-3	-9061
International Marine Bunkers**	0	0	0	0	0	0	0	0	0	0	0
Stock Changes	502	-132	-11	-485	0	0	0	-3	0	0	-128
TPES	**20827**	**8082**	**1754**	**7567**	**6813**	**219**	**7**	**1861**	**-1086**	**9**	**46054**
Transfers	0	28	-10	0	0	0	0	0	0	0	18
Statistical Differences	-649	0	37	0	0	0	0	0	0	0	-612
Electricity Plants	-8363	0	-22	-40	-6788	-219	-4	-86	5457	-5	-10069
CHP Plants	-5535	0	-80	-910	-26	0	0	-163	1737	2403	-2572
Heat Plants	-207	0	-70	-570	0	0	0	-53	0	720	-180
Gas Works	-576	0	0	323	0	0	0	0	0	0	-253
Petroleum Refineries	0	-8176	8294	0	0	0	0	0	0	0	117
Coal Transformation	-1084	0	0	0	0	0	0	0	0	0	-1084
Liquefaction Plants	0	0	0	0	0	0	0	0	0	0	0
Other Transformation	0	66	-66	0	0	0	0	0	0	0	0
Own Use	-416	0	-288	-122	0	0	0	0	-784	-365	-1975
Distribution Losses	-121	0	0	-102	0	0	0	0	-420	-449	-1092
TFC	**3877**	**0**	**9549**	**6146**	**0**	**0**	**3**	**1559**	**4903**	**2314**	**28351**
Industry sector	**2529**	**0**	**341**	**2460**	**0**	**0**	**0**	**503**	**2031**	**705**	**8570**
Transport sector	**1**	**0**	**6083**	**44**	**0**	**0**	**0**	**19**	**189**	**0**	**6335**
Other sectors	**934**	**0**	**415**	**3642**	**0**	**0**	**3**	**1037**	**2683**	**1609**	**10323**
Residential	820	0	33	2275	0	0	2	958	1307	1113	6508
Commercial and Public Services	93	0	17	1221	0	0	1	55	1116	484	2987
Agriculture / Forestry	22	0	335	65	0	0	0	23	105	12	561
Fishing	0	0	0	0	0	0	0	0	1	0	1
Non-Specified	0	0	30	81	0	0	0	0	154	0	266
Non-Energy Use	**413**	**0**	**2710**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**3123**
- of which Petrochemical	*0*	*0*	*1802*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1802*

Intensity CZ indicators 2006:
Tab. 6:

Key Indicators		Compound Indicators	
Population (million)	10.27	**TPES/Population** (toe/capita)	4.49
GDP (billion 2000 US$)	72.50	**TPES/GDP** (toe/thousand 2000 US$)	0.64
GDP (PPP) (billion 2000 US$)	196.69	**TPES/GDP (PPP)** (toe/thousand 2000 US$ PPP)	0.23
Energy Production (Mtoe)	33.42	**Electricity Consumption / Population** (kWh/capita)	6511
Net Imports (Mtoe)	12.76	**CO_2/TPES** (t CO_2/toe)	2.63
TPES (Mtoe)	46.05	**CO_2/Population** (t CO_2/capita)	11.78
Electricity Consumption* (TWh)	66.85	**CO_2/GDP** (kg CO_2/2000 US$)	1.67
CO_2 Emissions ** (Mt of CO_2)	120.97	**CO_2/GDP (PPP)** (kg CO_2/2000 US$ PPP)	0.62

Key indicators = absolute values for Intensity indicators calculation.
Compound indicators = comparison indicators – relative – intensive.