Fundamentals of Energy Statistics

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IEA

Basic concepts in Energy Statistics

- Framework
- Supply & demand breakdown
- Basic conversions
- Calorific values
- The weighted average
- Transformation & energy sector own use
- Main activity producers & autoproducers
- Non-energy use

Where does it all come from?

International Recommendations for Energy Statistics (IRES)

- Internationally agreed definitions (InterEnerStat)
- Comparability across products, flows and countries
- Improved transparency

The 5 Joint Annual Questionnaires

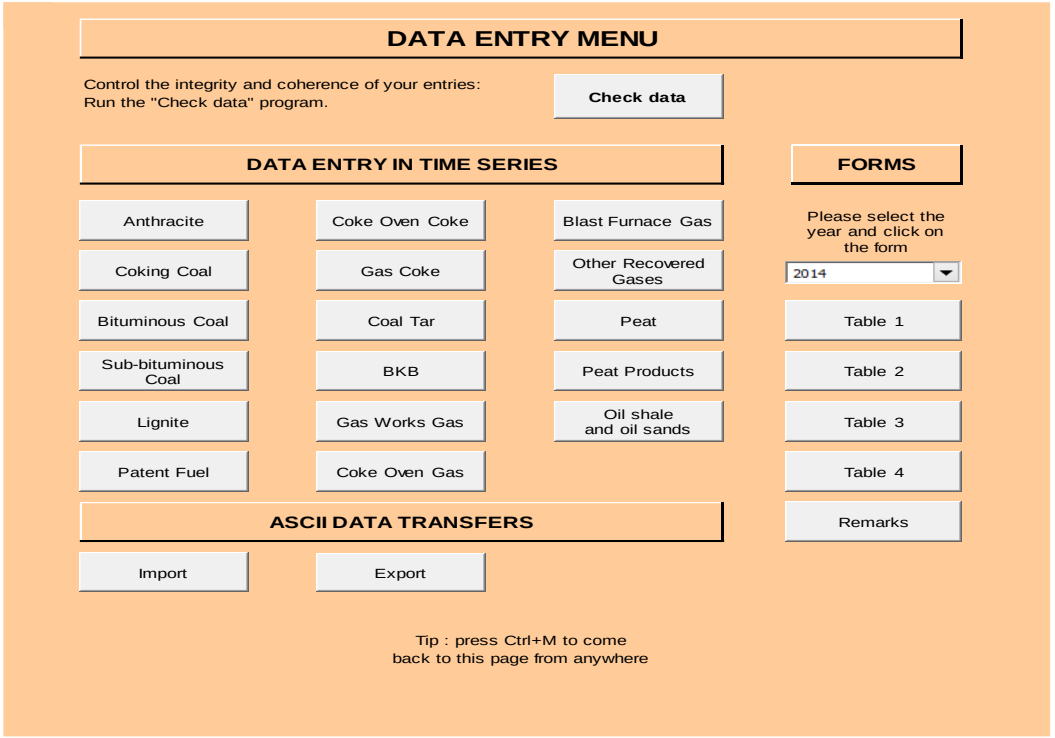
3 organizations

1 set of questionnaires

5 different fuel categories

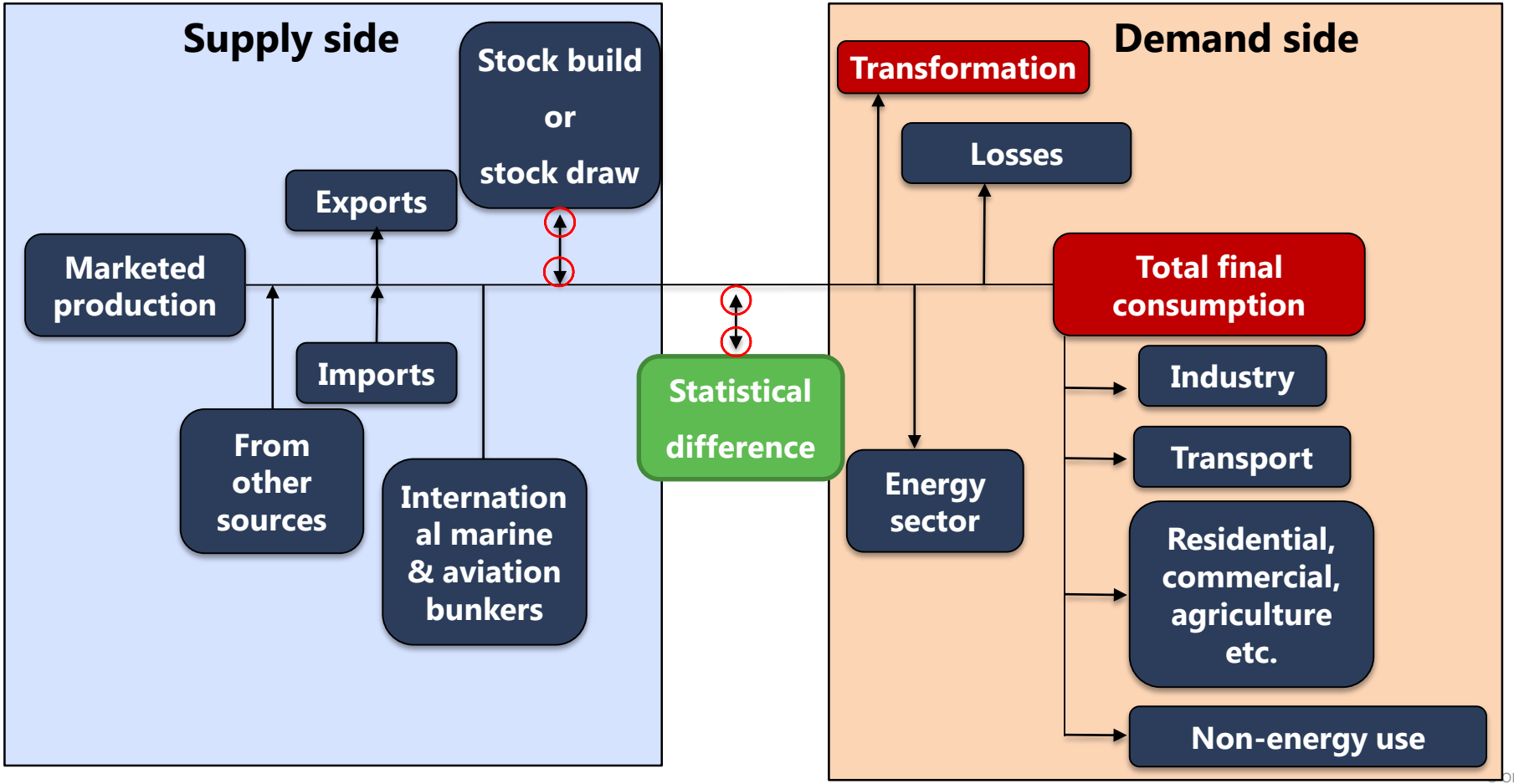
But…many concepts in common

The 5 Joint Annual Questionnaires



Supply & demand breakdown

Supply & demand breakdown



The energy balance

Supply

Demand

Transformation

Final consumption

201· ▼ | Indicators | Balances | Coal and Peat | Electricity and Heat | Natural Gas | Oil | Renewables and Waste

	Coal and peat	Crude oil	Oil products	Natural gas	Nuclear	Hydro	Geothermal, solar, etc.	Biofuels and waste	Electricity	Heat	Total*
Production	33658	173317	0	132349	24390	32309	901	12106	0	0	409029
Imports	5954	34510	12790	25960	0	0	0	759	1287	0	81260
Exports	-20076	-118761	-19053	-76831	0	0	0	-570	-4430	0	-239722
International marine bunkers**	0	0	-524	0	0	0	0	0	0	0	-524
International aviation bunkers**	0	0	-1214	0	0	0	0	0	0	0	-1214
Stock changes	66	1064	-206	2092	0	0	0	0	0	0	3016
TPES	19603	90130	-8207	83569	24390	32309	901	12295	-3144	0	251845
Transfers	0	-3781	7993	0	0	0	0	0	0	0	4213
Statistical differences	2329	4585	4579	2410	0	0	0	-1	0	-32	13872
Electricity plants	-17629	0	-1820	-10824	-24390	-32309	-901	-2426	53814	0	-36484
CHP plants	0	0	-41	-2468							047
Heat plants	0	0	0	0							-28
Gas works	0	0	0	0							0
Oil refineries	0	-91737	95461	-849							875
Coal transformation	-1182	0	0	0	0	0	0	0	0	0	-1182
Liquefication plants	0	802	0	-1940	0	0	0	0	0	0	-1138
Other transformation	0	0	0	0	0	0	0	0	0	0	0
Energy industry own use	-4	0	-7956	-13986	0	0	0	-1	-4019	0	-25966
Losses	0	0	0	0	0	0	0	0	-2984	0	-2984
Total final consumption	3117	0	90009	55912	0	0	0	9766	44625	546	203975
Industry	2450	0	6067	23876	0	0	0	5840	17698	545	56476
Transport	0	0	54404	2436	0	0	0	1637	331	0	58808
Other	33	0	8935	26208	0	0	0	2289	26596	0	64062
Residential	33	0	2647	14661							782
Commercial and public services	0	0	3008	10823							464
Agriculture / forestry	0	0	3280	724							316
Fishing	0	0	0	0							0
Non-specified	0	0	0	0	0	0	0	0	0	0	0
Non-energy use	634	0	20603	3392	0	0	0	0	0	0	24629
-of which petrochemical feedstocks	*0*	*0*	*12022*	*3392*	*0*	*0*	*0*	*0*	*0*	*0*	*15415*

Basic conversions

Basic conversions

- Energy statistics involve various units
  - Mass: kg, ton, kt, lb
  - Volume: L, bbl, gal, m^3
  - Energy: TJ, ktoe, ktce, GWh, kcal, BTU

- How to convert from one to another?

- Between the same quantities, we always use a constant!

Basic conversions

Remember!

Kilo-	10^3
Mega-	10^6
Giga-	10^9
Tera-	10^{12}

- 1 kt = 1 000 ton
- 1 ton = 1 000 kg
- 1 kt = 1 000 000 kg

ALWAYS!

- 1 bbl ≈ 159 L
- 1 m^3 = 1000 L
- 1 GWh = 3.6 TJ
- 1 ktoe = 41.868 TJ
- 1 ktce = 0.7 ktoe

http://www.iea.org/statistics/resources/unitconverter/

Basic conversions - example

- Convert 5 ktoe to GWh
  - 1 GWh = 3.6 TJ
  - 1 ktoe = 41.868 TJ

$$5\ ktoe\ \times\ 41.868\frac{TJ}{ktoe} =\ 209.34\ TJ$$

$$209.34\ TJ\ /\ 3.6\ \frac{TJ}{GWh} = 58.15\ GWh$$

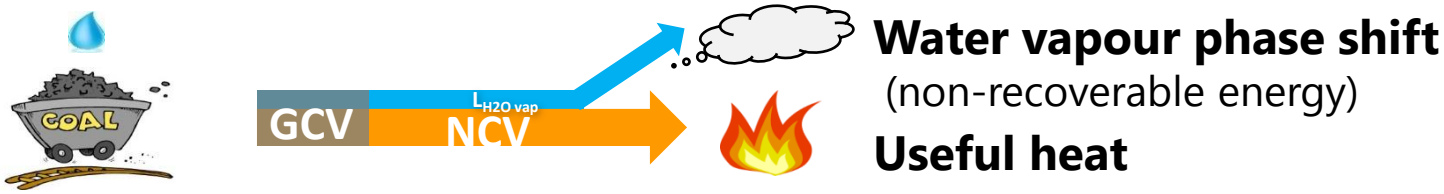
Calorific values

Calorific values

- The heat (energy) obtained from one unit of fuel when burned
- Indicates quality of the fuel
- Should we within expected ranges, but depends on quality
  - Bituminous coal – Kazakhstan: 18581 kJ/kg
  - Bituminous coal – New Zealand: 28201 kJ/kg

Calorific values

- When a fuel is combusted, water vapor is produced, but its energy rarely can be used for energy purposes



- Difference between GCV and NCV approximately:
  - NCV = **90%** of GCV for **natural gas**
  - NCV = **95%** of GCV for **oil**
  - NCV = **95%** of GCV for **coal**

Calorific values - example

- A country produces 2 bcm of Natural Gas
- Its GCV is 38000 kJ/m^3
- What is its gross energy content?
- First, we convert the GCV to more convenient units:

$$38000\,\frac{kJ}{m^3} = 38000\,\frac{10^9 \times kJ}{10^9 \times m^3} = 38000\,\frac{TJ}{bcm}$$

- Then:

$$2\ bcm\ \times 38000\,\frac{TJ}{bcm} = 76000\ TJ \quad \textbf{(gross energy content)}$$

- Or:

$$76000TJ \times 90\% = 68400\ TJ \quad \textbf{(net energy content)}$$

The weighted average

The weighted average

- A country has 2 coal mines, A & B
  - Mine A produced 100 kt with NCV_A = 25000 kJ/kg
  - Mine B produced 100 kt with NCV_B = 20000 kJ/kg
  - NCV_{TOT} = ???

- But what if:
  - Mine A produced 400 kt with NCV_A = 25000 kJ/kg
  - Mine B produced 100 kt with NCV_B = 20000 kJ/kg
  - NCV_{TOT} = ???

The weighted average

- Most of the coal is of the higher-quality mine
  - This has to be reflected in the average NCV

Mine A:	**400 kt**	**25000 kJ/kg**
Mine B:	**100 kt**	**20000 kJ/kg**

- $NCV_{TOT} = \frac{NCV_A \times PROD_A + NCV_B \times PROD_B}{PROD_A + PROD_B}$
- $NCV_{TOT} = \frac{25000\frac{kJ}{kg} \times 400kt + 20000\frac{kJ}{kg} \times 100kt}{400kt + 100kt} = 24000\frac{kJ}{kg}$
- Generic formula: $CV_{TOT} = \frac{\sum_i (CVi \times Quantityi)}{\sum_i (Quantityi)}$

Transformation & energy sector own use

Transformation & energy sector own use

Table 2a - Consumption

Menu

Country

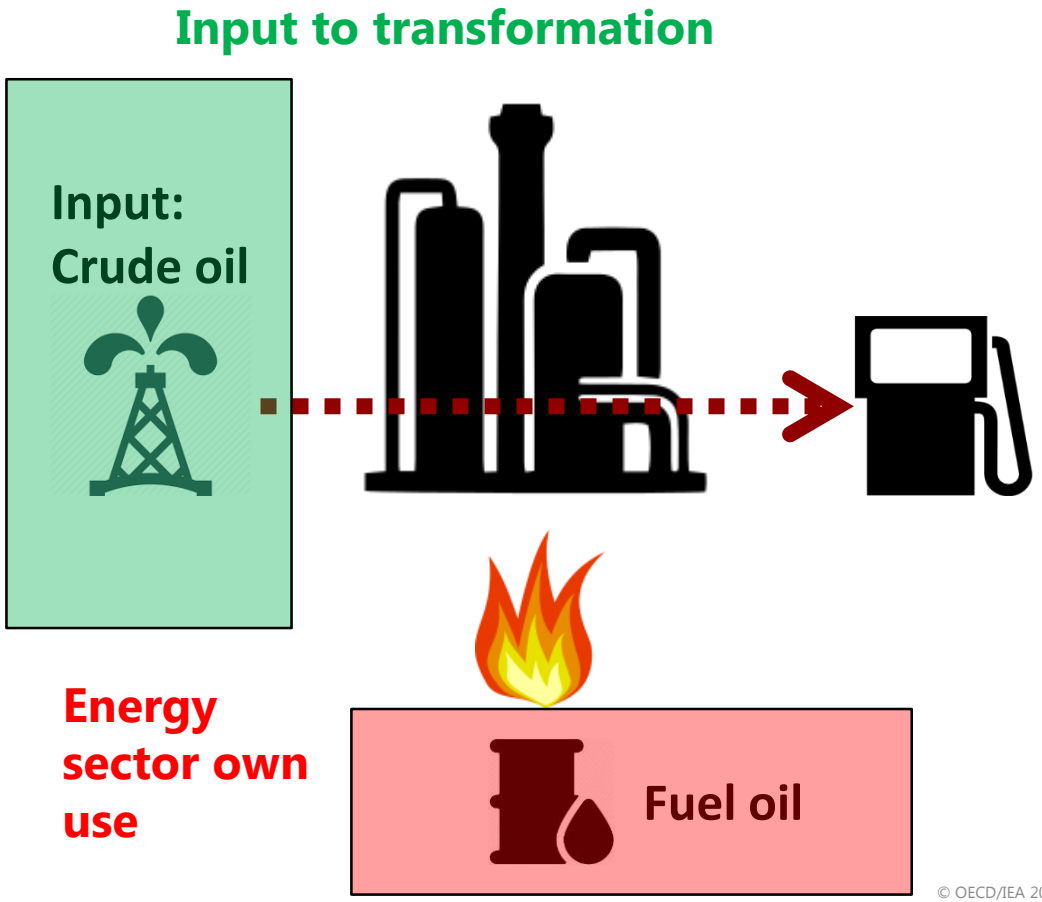
Terajoules	1990	1991	1992
Inland demand (Total consumption)	0	0	0
Transformation sector	0	0	0
Main activity producer electricity plants			
Autoproducer electricity plants			
Main activity producer CHP plants			
Autoproducer CHP plants			
Main activity producer heat plants			
Autoproducer heat plants			
Gas works (Transformation)			
Coke ovens (Transformation)			
Blast furnaces (Transformation)			
Gas-to-liquids (GTL) plants (Transformation)			
Not elsewhere specified (Transformation)			
Energy sector	0	0	0
Coal mines			
Oil and gas extraction			
Oil refineries			
Coke ovens (Energy)			
Blast furnaces (Energy)			
Gas works (Energy)			
Electricity, CHP and heat plants			
Liquefaction (LNG) / regasification plants			
Gas-to-Liquids (GTL) plants (Energy)			
Not elsewhere specified			
Distribution losses			
Total final consumption (2ii+2iii)	0	0	0

- Similar flows - what is the difference?
- Transformation:
  - Inputs to transformation processes – from one form of energy to another
  - E.g. coal to electricity
- Energy sector own use:
  - Fuel used to support energy industry activities

Transformation & energy sector own use

- Oil refineries:
  - Crude oil gets transformed into secondary oil products that we can use

- Fuel is needed to keep the refinery running!
  - Fuel oil, refinery gas, etc.



Main activity producers & autoproducers

Many activities producers & autoproducers

Table 2a - Consumption

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Main activity producer CHP plants			
Autoproducer CHP plants			
Main activity producer heat plants			
Autoproducer heat plants			
Gas works (Transformation)			
Coke ovens (Transformation)			

- Main activity producer plants
  - Facility generating electricity and/or heat for sale to third parties as their primary activity
- Autoproducers
  - Facility generating electricity and/or heat wholly or partially for their own use as support to their primary activity

Many activities producers & autoproducers

- Main activity producer plants
  - Regardless of whether they are state or privately owned
  - In practice, any plant called a "power plant" or "heat plant"!

- Autoproducers
  - Regardless of whether they are state or privately owned
  - E.g.: Steel mill, paper mill, waste recycling facilities, etc…

Non-energy use of energy products

Non-energy use of energy products

- Fuels used as raw materials and not consumed as a fuel or transformed into another fuel (e.g. asphalt, plastics, fertilizers)

- For biomass commodities:
  - only the amounts specifically used for energy purposes are included in the energy statistics
  - Non-energy use of biomass is not taken into consideration and the quantities are null by definition

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Exercises- Supply and Demand

Multiple choice exercise on supply/demand flows.

Please work in couples, answering one block of questions each!

	Is this supply or demand?	Choose answer from dropdown menu
Question 1	Production of natural gas	
Question 2	Final consumption in households	
Question 3	Final consumption in industries	
Question 4	Transformation of coal into electricity	
Question 5	Stock changes	
Question 6	Statistical differences	
Question 7	Exports	
Question 8	Losses	
Question 9	International marine bunkers	
Question 10	Non-energy use	

	Is this supply or demand?	Choose answer from dropdown menu
Question 1	Transportation sector	
Question 2	Own use in energy sector	
Question 3	Installed solar power capacity	
Question 4	Imports	
Question 5	Final consumption in commercial sector	
Question 6	From other sources	
Question 7	Stock build	
Question 8	Production of crude oil	
Question 9	International aviation bunkers	
Question 10	Non-energy use	

Exercises- conversions

Using the conversion factors in the green box, please fill in the blank cells. The cells will turn green if the result is correct.

2	Gt of coal is equal to		kt of coal
5000	kt of coal is equal to		kg of coal
3500	bbl of oil is equal to		L of oil
3500	L of oil is equal to		bbl of oil
65000	GWh is equal to		TJ
65000	GWh is equal to		ktoe
65000	GWh is equal to		Mtce
5	kbd of oil production for a year equals		bbl
5	kbd of oil production for a year equals		L

1 Tera- =	1000	Giga-
1 Giga- =	1000	Mega-
1 Mega- =	1000	Kilo-
1 Kilo- =	1000	-
1 ton =	1000	kg
1 bbl =	159	L
1 GWh =	3.6	TJ
1 ktoe =	41.868	TJ
1 ktce =	0.7	ktoe
1 year =	365	days

Exercises- calorific values

Using the information in the green box, please fill in the blank cells. The cells will turn green if the result is correct.

	NCV	GCV
Natural Gas (kJ/m3)		38000
Other Bituminous Coal	25800	
Motor Gasoline		47158

Natural Gas:	**NCV =**	**90% of GCV**			
Coal:	**NCV =**	**95% of GCV**			
Oil:	**NCV =**	**95% of GCV**			

				Net energy content (TJ)	Gross energy content (TJ)
3.4	bcm of Natural Gas with a GCV of	38000	kJ/m3 equal to:		
150	kt of coal with a GCV of	27000	kJ/kg equal to:		
1700	kt of motor gasoline with a GCV of		kJ/kg equal to:		76160
550	kt of motor gasoline with a GCV of		kJ/kg equal to:	23408	
	kt of coal with a GCV of	28000	kJ/kg equal to:		84000
	kt of coal with a GCV of	31000	kJ/kg equal to:	35340	

Exercises- weighted average

Generic formula: $CV_{TOT} = \frac{\sum_i (CV_i \times Quantity_i)}{\sum_i (Quantity_i)}$

1. Country A has two gas wells with the following calorific values:

Well A: production is	1875	MCM with a GCV of	38420	kJ/m³
Well B: production is	1750	MCM with a GCV of	37780	kJ/m³
Total production is		MCM with a GCV of		kJ/m³

2: Country A imports gas from four different countries. Calculate the calorific value of the gas imported from each country.

Austria:	530	MCM equivalent to	21021	TJ (gross).	GCV=	kJ/m³
Germany:	27	MCM equivalent to	1038	TJ (gross).	GCV=	kJ/m³
Hungary:	501	MCM equivalent to	19523	TJ (gross).	GCV=	kJ/m³
Slovenia:	51	MCM equivalent to	1960	TJ (gross).	GCV=	kJ/m³

Exercises- own use vs transformation

Distinguish between transformation and energy sector own use.

Question 1.

A coal mine used 3 kt of diesel oil to run the machinery in the mine and 2 GWh for the conveyer belt.

How would you classify the following:

Use of 3kt of diesel:	
Use of 2 GWh of electricity:	

Question 2.

A coal-fired electricity plant uses 28 kt of coal to produce 60 GWh of electricity in a given period. The plant uses 3 GWh for its own purposes (processes and lights).

How would you classify the following:

Use of 28kt of coal:	
Use of 3 GWh of electricity:	

Question 3.

A refinery, which is also an autoproducer of electricity, uses 1000kt of crude oil as input to the refinery, 10kt of refinery gas for its energy needs, 5kt of fuel oil to produce electricity, and 1GWh of electricity for its own lighting needs.

How would you classify the following:

Use of 1000kt of crude oil:	
Use of 10kt of refinery gas:	
Use of 5kt of fuel oil:	
Use of 1 GWh of electricity:	

Exercises- main activity or autoproducer

Distinguish between main activity and autoproducers.

Question 4.	A publicly owned nuclear power plant produces electricity that send to the grid. Is this a main activity producer or an autoproducer?	
Question 2.	A farmer has a large greenhouse where he grows tomatoes. The greenhouse needs to be heated. He uses natural gas to heat the greenhouse but he realised that he might as well produce electricity and reuse the heat for the greenhouse. Is this a main activity producer or an autoproducer?	
Question 3.	A waste recycling facility uses waste to produce 45GWh of electricity, as well as some heat. Is this a main activity producer or an autoproducer?	
Question 4.	A power plant is owned and run by a privatized company producing electricity and heat. The electricity is sold to the grid and the heat is used for district heating in households. Is this a main activity producer or an autoproducer?	

Exercises- non energy use

Distinguish between energy and non-energy use

Question 1. A petrochemical factory used 3kt of naphthta as a feedstock for the production of plastics and for this purpose consumed also 2kt of diesel.

How would you classify the following:

Use of 3kt of naphtha:	
Use of 2 kt of diesel:	

Question 2. For the construction of a new road, 1kt of diesel was used for the machinery and 2kt of bitumen were used for paving.

How would you classify the following:

Use of 1kt of diesel:	
Use of 2kt of bitumen:	

Question 3.

An industry used 2kt of lubricants for their lubricating qualities in engines, 3kt of fuel oil to fuel a furnace, 1kt of white spirit as a solvant and another 4kt of diesel to power the engines.

How would you classify the following:

Use of 2kt of lubricants:	
Use of 3kt of fuel oil:	
Use of 1kt of white spirit:	
Use of 4kt diesel:	