## Appendix

# Energy flow, energy demand and $CO_2$ emissions of the world's-regions and of the G-20 countries in 2011

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### **Description of diagrams**

The energy consumption of the world, for the individual regions of the world and for all G-20 countries is illustrated by 6 diagrams A1.....A6, described below (data based on: Energy Statistics from the IEA, International Energy Agency [5])

#### Figure A1: Energy flow in the energy sector

Figure A1 describes the flow of energy in the energy sector from primary energy to gross energy (or gross inland consumption) and to final energy. Primary energy and gross energy are illustrated by the **energy carriers** used. Energy is expressed in Mtoe.

The **primary energy** is the sum of local production and, for regions, net imports minus net exports of energy carriers (for countries, effective imports/exports instead of net imports/net exports per energy carrier).

The **gross energy** follows from the primary energy after subtracting the non-energy use demand (e.g. for the chemical industry) and any stock changes. For the regions of the world, the amounts of energy for the international marine and aviation bunkers are also subtracted, since the corresponding  $CO_2$  emissions are recorded only worldwide.

It is the task of the **energy sector** to provide consumers with energy in the form of **final energy**. In this diagram we distinguish 4 forms of final energy: **electricity**, **district heating**, **motor fuels** and **"heat"**. The latter consists mainly of non-electric heating and process heat (from fossil and renewable energies) and without district heating. Stationary work, of non-electrical origin, can also be included (e.g. stationary gas, petrol or diesel engines and pumps); at least in developed countries, this share is minimal. With the conversion of gross energy into final energy, losses occur, which we refer to as **losses of the energy sector**.

These losses consist of **thermal losses** in power stations (thermodynamic reasons) as well as in combined heat and power plants and heating plants, and additionally **electrical losses** in the transmission and distribution network, including the energy sector's own energy requirement and, finally, of the **remaining losses** in the energy sector (refining, liquefaction and gasification plants, heat transfer losses, in-house use of heat, etc.).

The diagram also shows the  $CO_2$  emissions in Mt associated with the final energy consumption and the losses of the energy sector (together corresponding to the gross inland consumption). Most of the losses of the energy sector are normally associated with the electricity and district heat production, which is why the  $CO_2$  emissions of these three factors are combined. Separation can be done using Figure A4.

#### Figure A2: Shares of energy carriers

Figure A2 shows the shares of energy carriers, in % of total final energy demand, required for obtaining the 4 final energy types, and for covering the losses of the energy sector.

This diagram thus complements diagram A1, with respect to the energy carrier distribution in the final energy area. The energy-carriers-colors are shown in the legend, and also apply to the energy flow diagram A1.

#### Figure A3: Losses of the energy sector

The losses of the energy sector represent a significant part of gross energy demand. Worldwide, in 2011, they were about 54% and in some countries they even exceed 100% of final energy demand. For the  $CO_2$  emissions they are therefore of primary importance.

Figure A3 shows the percentage composition of these losses and the resulting  $CO_2$  emissions. A characteristic parameter and index of the  $CO_2$ -efficiency of the energy sector in the world region or country is the ratio Mt  $CO_2$  relative to Mtoe losses.

#### Figure A4: Energy flow of final energy to the final users

The chart shows the breakdown of the 4 types of final energy over the three end-user categories. Similarly, the  $CO_2$  emissions are allocated to these consumer groups.

The end users are (according to IEA statistics)

- industry,

- residential, services, agriculture, etc.,
- transport.

To obtain the total emissions, the  $CO_2$  emissions of the energy sector (i.-e. of the corresponding losses ) have to be added to this..

#### Figure A5: CO<sub>2</sub> emissions and originating end-energy carriers

The figure gives the total  $CO_2$  emissions in Mt, the emissions per capita and its distribution over the consumer groups, detailed per end-energy carrier.

In addition, the indicator of CO<sub>2</sub> sustainability of the country or region is stated.

The causes of the  $CO_2$  emissions of the end energy carriers electricity and district heat can be taken from the diagrams A2 and A6.

#### Figure A6: Electricity production and consumption

The large, often decisive importance of electricity consumption and of its generation for the amount of  $CO_2$  emissions is clear from the flow charts A1 and A4, and also from A5. The share of the losses of the energy sector (mostly coupled with the electricity production) is also to be taken into account.

Diagram A6 shows in detail the percentage composition of the energy sources used for the production of electricity.

Similarly, imports and exports are given in % of final consumption.

The final consumption follows after deduction of losses (network losses and the energy sector's own use).



Color of the energy carriers as in A2 and A5 (petroleum dark brown, oil products light brown)



A2. World: : Shares of energy carriers for obtaining the final energies ("heat", motor fuels, electricity, district heating) and to cover the losses of the energy sector











#### OECD-34



A1. OECD-34: Energy flow in the energy sector from primary to final energy and total CO<sub>2</sub> emissions. Color of the energy carriers as in A2 and A5 (petroleum dark brown, oil products light brown)



A2. OECD-34: Shares of energy carriers for obtaining the final energies ("heat", motor fuels, electricity, district heating) and to cover the losses of the energy sector















A1. EU-27: Energy flow in the energy sector from primary to final energy and total CO<sub>2</sub> emissions. Color of the energy carriers as in A2 and A5 (petroleum dark brown, oil products light brown)



heating) and to cover the losses of the energy sector



![](_page_8_Figure_1.jpeg)

![](_page_8_Figure_2.jpeg)

![](_page_8_Figure_3.jpeg)

#### Middle East

![](_page_9_Figure_1.jpeg)

![](_page_9_Figure_2.jpeg)

![](_page_9_Figure_3.jpeg)

![](_page_10_Figure_1.jpeg)

![](_page_10_Figure_2.jpeg)

![](_page_10_Figure_3.jpeg)

#### Eurasia+

![](_page_11_Figure_1.jpeg)

Color of the energy carriers as in A2 and A5 (petroleum dark brown, oil products light brown)

![](_page_11_Figure_3.jpeg)

A2. Eurasia+: Shares of energy carriers for obtaining the final energies ("heat", motor fuels, electricity, district heating) and to cover the losses of the energy sector

![](_page_11_Figure_5.jpeg)

#### Eurasia+

![](_page_12_Figure_1.jpeg)

![](_page_12_Figure_2.jpeg)

![](_page_12_Figure_3.jpeg)

![](_page_12_Figure_4.jpeg)

#### Rest-Asia/Oceania

![](_page_13_Figure_1.jpeg)

A1. Rest-Asia/Oceania: Energy flow in the energy sector from primary to final energy and total CO<sub>2</sub> emissions. Color of the energy carriers as in A2 and A5 (petroleum dark brown, oil products light brown)

![](_page_13_Figure_3.jpeg)

A2. Rest-Asia/Oceania: Shares of energy carriers for obtaining the final energies ("heat", motor fuels, electricity, district heating) and to cover the losses of the energy sector

![](_page_13_Figure_5.jpeg)

#### **Rest-Asia/Oceania**

![](_page_14_Figure_1.jpeg)

![](_page_14_Figure_2.jpeg)

(for electricity see also A2 or A6 and for district heating also A2)

![](_page_14_Figure_4.jpeg)

#### **Non-OECD** America

![](_page_15_Figure_1.jpeg)

![](_page_15_Figure_2.jpeg)

A2. Non-OECD America: Shares of energy carriers for obtaining the final energies ("heat", motor fuels, electricity, district heating) and to cover the losses of the energy sector

![](_page_15_Figure_4.jpeg)

![](_page_16_Figure_1.jpeg)

![](_page_16_Figure_2.jpeg)

(for electricity see also A2 or A6 and for district heating also A2)

![](_page_16_Figure_4.jpeg)

#### Africa

![](_page_17_Figure_1.jpeg)

Color of the energy carriers as in A2 and A5 (petroleum dark brown, oil products light brown)

![](_page_17_Figure_3.jpeg)

![](_page_17_Figure_4.jpeg)

![](_page_18_Figure_0.jpeg)

![](_page_18_Figure_1.jpeg)

![](_page_18_Figure_2.jpeg)

![](_page_18_Figure_3.jpeg)

![](_page_18_Figure_4.jpeg)

![](_page_19_Figure_0.jpeg)

![](_page_19_Figure_1.jpeg)

Color of the energy carriers as in A2 and A5 (petroleum dark brown, oil products light brown)

![](_page_19_Figure_3.jpeg)

A2. G-20: Shares of energy carriers for obtaining the final energies ("heat", motor fuels, electricity, district heating) and to cover the losses of the energy sector

![](_page_19_Figure_5.jpeg)

![](_page_20_Figure_0.jpeg)

![](_page_20_Figure_1.jpeg)

![](_page_20_Figure_2.jpeg)

![](_page_20_Figure_3.jpeg)

#### Argentina

![](_page_21_Figure_1.jpeg)

![](_page_21_Figure_2.jpeg)

![](_page_21_Figure_3.jpeg)

A2. Argentina: Shares of energy carriers for obtaining the final energies ("heat", motor fuels, electricity, district heating) and to cover the losses of the energy sector

![](_page_21_Figure_5.jpeg)

#### Argentina

![](_page_22_Figure_1.jpeg)

![](_page_22_Figure_2.jpeg)

![](_page_22_Figure_3.jpeg)

![](_page_22_Figure_4.jpeg)

#### Australia

![](_page_23_Figure_1.jpeg)

Color of the energy carriers as in A2 and A5 (petroleum dark brown, oil products light brown)

![](_page_23_Figure_3.jpeg)

A2. Australia: Shares of energy carriers for obtaining the final energies ("heat", motor fuels, electricity, district heating) and to cover the losses of the energy sector

![](_page_23_Figure_5.jpeg)

#### Australia

![](_page_24_Figure_1.jpeg)

![](_page_24_Figure_2.jpeg)

![](_page_24_Figure_3.jpeg)

![](_page_24_Figure_4.jpeg)

![](_page_25_Figure_1.jpeg)

![](_page_25_Figure_2.jpeg)

![](_page_25_Figure_3.jpeg)

A2. Brazil: Shares of energy carriers for obtaining the final energies ("heat", motor fuels, electricity, district heating) and to cover the losses of the energy sector

![](_page_25_Figure_5.jpeg)

![](_page_26_Figure_0.jpeg)

![](_page_26_Figure_1.jpeg)

![](_page_26_Figure_2.jpeg)

![](_page_26_Figure_3.jpeg)

#### Canada

![](_page_27_Figure_1.jpeg)

Color of the energy carriers as in A2 and A5 (petroleum dark brown, oil products light brown)

![](_page_27_Figure_3.jpeg)

A2. Canada: Shares of energy carriers for obtaining the final energies ("heat", motor fuels, electricity, district heating) and to cover the losses of the energy sector

![](_page_27_Figure_5.jpeg)

#### Canada

![](_page_28_Figure_1.jpeg)

![](_page_28_Figure_2.jpeg)

![](_page_28_Figure_3.jpeg)

## China (with Hongkong)

![](_page_29_Figure_1.jpeg)

![](_page_29_Figure_2.jpeg)

![](_page_29_Figure_3.jpeg)

heating) and to cover the losses of the energy sector

![](_page_29_Figure_5.jpeg)

![](_page_30_Figure_1.jpeg)

![](_page_30_Figure_2.jpeg)

![](_page_30_Figure_3.jpeg)

![](_page_31_Figure_1.jpeg)

![](_page_31_Figure_2.jpeg)

![](_page_31_Figure_3.jpeg)

A2. France: Shares of energy carriers for obtaining the final energies ("heat", motor fuels, electricity, district heating) and to cover the losses of the energy sector

![](_page_31_Figure_5.jpeg)

![](_page_32_Figure_0.jpeg)

![](_page_32_Figure_1.jpeg)

![](_page_32_Figure_2.jpeg)

(for electricity see also A2 or A6 and for district heating also A2)

![](_page_32_Figure_4.jpeg)

#### Germany

![](_page_33_Figure_1.jpeg)

A1. Germany: Energy flow in the energy sector from primary to final energy and total CO<sub>2</sub> emission: Color of the energy carriers as in A2 and A5 (petroleum dark brown, oil products light brown)

![](_page_33_Figure_3.jpeg)

A2. Germany: Shares of energy carriers for obtaining the final energies ("heat", motor fuels, electricity, district heating) and to cover the losses of the energy sector

![](_page_33_Figure_5.jpeg)

#### Germany

![](_page_34_Figure_1.jpeg)

![](_page_34_Figure_2.jpeg)

![](_page_34_Figure_3.jpeg)

![](_page_35_Figure_0.jpeg)

![](_page_35_Figure_1.jpeg)

A1. India: Energy flow in the energy sector from primary to final energy and total  $CO_2$  emissions Color of the energy carriers as in A2 and A5 (petroleum dark brown, oil products light brown)

![](_page_35_Figure_3.jpeg)

A2. India: Shares of energy carriers for obtaining the final energies ("heat", motor fuels, electricity, district heating) and to cover the losses of the energy sector

![](_page_35_Figure_5.jpeg)

![](_page_36_Figure_0.jpeg)

![](_page_36_Figure_1.jpeg)

![](_page_36_Figure_2.jpeg)

![](_page_36_Figure_3.jpeg)

#### Indonesia

![](_page_37_Figure_1.jpeg)

![](_page_37_Figure_2.jpeg)

![](_page_37_Figure_3.jpeg)

A3. Indonesia: Percentage distribution of losses in the energy sector; contributors to  $CO_2$  emissions include thermal losses of fossil-fuel plants, the electrical losses and the residual losses

#### Indonesia

![](_page_38_Figure_1.jpeg)

![](_page_38_Figure_2.jpeg)

![](_page_38_Figure_3.jpeg)

225

![](_page_39_Figure_0.jpeg)

![](_page_39_Figure_1.jpeg)

![](_page_39_Figure_2.jpeg)

![](_page_39_Figure_3.jpeg)

heating) and to cover the losses of the energy sector

![](_page_39_Figure_5.jpeg)

![](_page_40_Figure_0.jpeg)

![](_page_40_Figure_1.jpeg)

![](_page_40_Figure_2.jpeg)

![](_page_40_Figure_3.jpeg)

![](_page_41_Figure_1.jpeg)

![](_page_41_Figure_2.jpeg)

A2. Japan: Shares of energy carriers for obtaining the final energies ("heat", motor fuels, electricity, district heating) and to cover the losses of the energy sector

![](_page_41_Figure_4.jpeg)

![](_page_42_Figure_0.jpeg)

![](_page_42_Figure_1.jpeg)

![](_page_42_Figure_2.jpeg)

![](_page_42_Figure_3.jpeg)

#### **Mexico**

![](_page_43_Figure_1.jpeg)

A1. Mexico: Energy flow in the energy sector from primary to final energy and total CO<sub>2</sub> emissions. Color of the energy carriers as in A2 and A5 (petroleum dark brown, oil products light brown)

![](_page_43_Figure_3.jpeg)

A2. Mexico: Shares of energy carriers for obtaining the final energies ("heat", motor fuels, electricity, district heating) and to cover the losses of the energy sector

![](_page_43_Figure_5.jpeg)

#### **Mexico**

![](_page_44_Figure_1.jpeg)

![](_page_44_Figure_2.jpeg)

![](_page_44_Figure_3.jpeg)

#### Russia

![](_page_45_Figure_1.jpeg)

A1. Russia: Energy flow in the energy sector from primary to final energy and total  $CO_2$  emissions Color of the energy carriers as in A2 and A5 (petroleum dark brown, oil products light brown)

![](_page_45_Figure_3.jpeg)

A2. Russia: Shares of energy carriers for obtaining the final energies ("heat", motor fuels, electricity, district heating) and to cover the losses of the energy sector

![](_page_45_Figure_5.jpeg)

#### Russia

![](_page_46_Figure_1.jpeg)

![](_page_46_Figure_2.jpeg)

![](_page_46_Figure_3.jpeg)

#### Saudi Arabia

![](_page_47_Figure_1.jpeg)

A1. Saudi Arabia: Energy flow in the energy sector from primary to final energy and total  $CO_2$  emissions. Color of the energy carriers as in A2 and A5 (petroleum dark brown, oil products light brown)

![](_page_47_Figure_3.jpeg)

district heating) and to cover the losses of the energy sector

![](_page_47_Figure_5.jpeg)

![](_page_48_Figure_1.jpeg)

![](_page_48_Figure_2.jpeg)

![](_page_48_Figure_3.jpeg)

#### **South Africa**

![](_page_49_Figure_1.jpeg)

A1. South Africa: Energy flow in the energy sector from primary to final energy and total CO<sub>2</sub> emissions. Color of the energy carriers as in A2 and A5 (petroleum dark brown, oil products light brown)

![](_page_49_Figure_3.jpeg)

A2. South Africa: Shares of energy carriers for obtaining the final energies ("heat", motor fuels, electricity, district heating) and to cover the losses of the energy sector

![](_page_49_Figure_5.jpeg)

#### **South Africa**

![](_page_50_Figure_1.jpeg)

![](_page_50_Figure_2.jpeg)

![](_page_50_Figure_3.jpeg)

#### South Korea

![](_page_51_Figure_1.jpeg)

A1. South Korea: Energy flow in the energy sector from primary to final energy and total CO<sub>2</sub> emissions. Color of the energy carriers as in A2 and A5 (petroleum dark brown, oil products light brown)

![](_page_51_Figure_3.jpeg)

district heating) and to cover the losses of the energy sector

![](_page_51_Figure_5.jpeg)

#### South Korea

![](_page_52_Figure_1.jpeg)

![](_page_52_Figure_2.jpeg)

![](_page_52_Figure_3.jpeg)

![](_page_52_Figure_4.jpeg)

#### Turkey

![](_page_53_Figure_1.jpeg)

![](_page_53_Figure_2.jpeg)

![](_page_53_Figure_3.jpeg)

![](_page_53_Figure_4.jpeg)

![](_page_54_Figure_0.jpeg)

![](_page_54_Figure_1.jpeg)

![](_page_54_Figure_2.jpeg)

![](_page_54_Figure_3.jpeg)

#### **United Kingdom**

![](_page_55_Figure_1.jpeg)

Color of the energy carriers as in A2 and A5 (petroleum dark brown, oil products light brown)

![](_page_55_Figure_3.jpeg)

A2. U.K: Shares of energy carriers for obtaining the final energies ("heat", motor fuels, electricity, district heating) and to cover the losses of the energy sector

![](_page_55_Figure_5.jpeg)

#### **United Kingdom**

![](_page_56_Figure_1.jpeg)

![](_page_56_Figure_2.jpeg)

![](_page_56_Figure_3.jpeg)

#### **United States of America**

![](_page_57_Figure_1.jpeg)

Color of the energy carriers as in A2 and A5 (petroleum dark brown, oil products light brown)

![](_page_57_Figure_3.jpeg)

A2. USA: Shares of energy carriers for obtaining the final energies ("heat", motor fuels, electricity, district heating) and to cover the losses of the energy sector

![](_page_57_Figure_5.jpeg)

![](_page_58_Figure_1.jpeg)

![](_page_58_Figure_2.jpeg)

![](_page_58_Figure_3.jpeg)