EN27 Electricity production by fuel

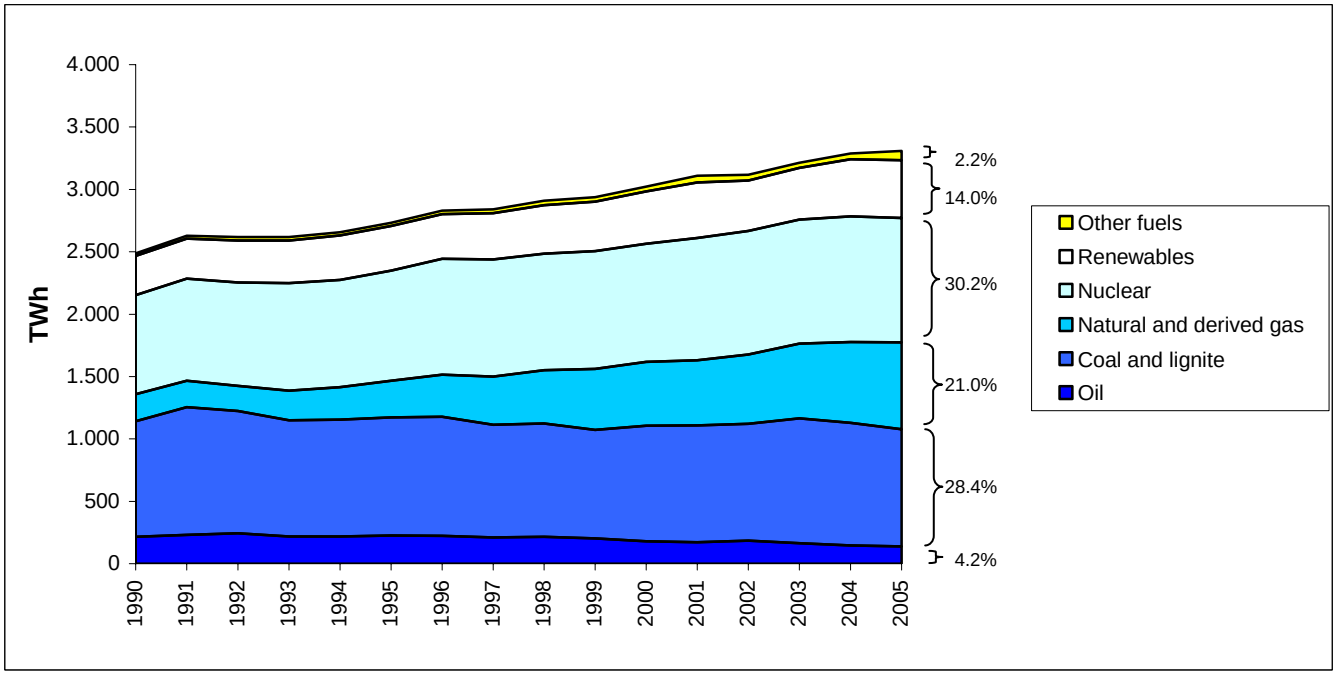
Key message

Fossil fuels and nuclear energy continue to dominate the fuel mix for electricity production despite their risk of environmental impact. This impact was reduced during the 1990s with relatively clean natural gas becoming the main choice of fuel for new plants, in particular at the expense of oil. Production from coal and lignite has increased slightly in recent years. The steep increase in overall electricity production has also counteracted some of the environmental benefits from fuel switching.

Rationale

The trend in electricity production by fuel provides a broad indication of the impacts associated with electricity production. The type and extent of the related environmental pressures depends upon the type and amount of fuels used for electricity generation as well as the use of abatement technologies.

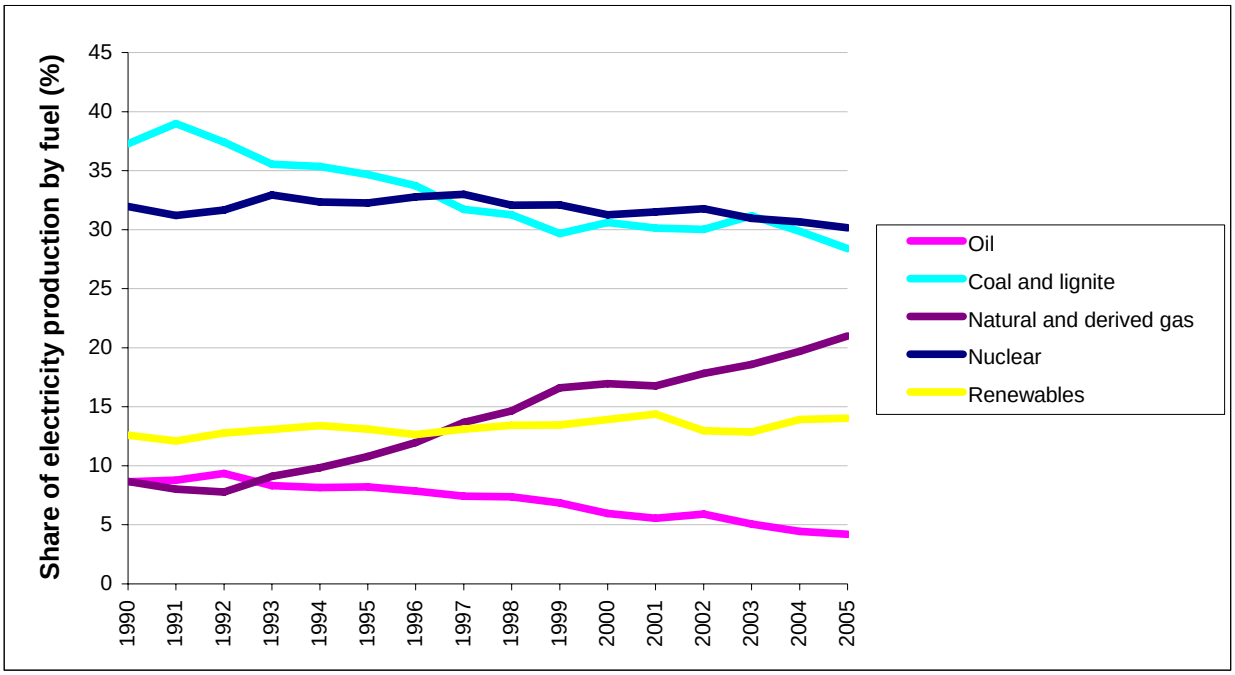
Fig. 1: Gross electricity production by fuel, EU-27



Data Source: Eurostat (Historic data)

Note: Data shown are for gross electricity production and include electricity production from both public and auto-producers. Renewables includes electricity produced from hydro (excluding pumping), biomass, municipal waste, geothermal, wind and solar PV. The share of renewables presented in the chart is that for production and hence does not correspond to the share, for consumption, as required by Directive 2001/77/EC. The difference between both shares is accounted for by the net balance between imports and exports of electricity. The EU-27 value for 1990 includes (former) West Germany only and since 1991 it refers to Germany. More than half of the increase in electricity generation in the EU-27 in 1991 was accounted for by Germany alone, compared to just 10 % over 1991-2005. 'Other fuels' include electricity produced from power plants not accounted for elsewhere, such as those fuelled by certain types of industrial wastes. It also includes the electricity generated as a result of pumping in hydro-power stations.

Fig. 2: Share of electricity production by fuel type, 1990-2005 (%), EU-27



Data source: Eurostat

Note: Data for Germany in 1990 include West Germany only. Electricity produced from pumping in hydro power plants is not considered a renewable source of energy and it is not shown in the chart.

1. Indicator assessment

The contribution of different fuels in electricity production is an important parameter regarding emissions and the security of supply. Decisions concerning the use of nuclear energy are up to Member States: the principle of subsidiarity grants member states broad autonomy in deciding their energy mix subject to some specific targets for the use of renewable energy.

Electricity production from fossil fuels continues to dominate total electricity production, with a share of almost 54 % in 2005, despite the recognised environmental impacts such as emissions of greenhouse gases and other pollutants, and resource depletion. Natural gas, which causes less overall pollution than other fossil fuels, was the primary choice for new fossil-fired power plants over the general period 1990-2005 – although this was driven mainly by economic concerns. This fuel switching was one of the factors leading to a decrease in greenhouse gas emissions from public power generation over the period. However, with an increase in natural gas prices relative to coal since 1999 (IEA, 2005) as well as a decrease in hydro electricity production since 2002 due to low rainfall, the use of coal has increased in recent years and hence GHG emissions from public power generation have begun to rise again.

The share of electricity produced from gas has risen by a factor of 3 in the EU-27 between 1990 and 2005. This growth has been influenced by the liberalisation of electricity markets and implementation of environmental legislation, such as the Large Combustion Plant Directive and the requirements for investing in pollution abatement technologies to lower emissions of air pollutants such as SO_2 and NOx (see EN09 for more information). However, the primary factor was economic, with low gas prices for much of the 1990s and the rapid investment in transportation infrastructure for the delivery of gas from within and outside the EU, which has also assisted its progress.

Electricity produced from coal and lignite accounted for 28.4 % of EU-27 electricity production in 2005, falling from 37.3 % in 1990. After a high experienced in 2003, production from coal and lignite decreased between 2003 and 2005. Whether this trend continues into the future will depend upon the long-term cost of gas, which is linked closely to the price of oil and has risen considerably in recent years. It will also depend upon national initiatives and environmental legislation such as the aforementioned LCPD, and in particular the EU greenhouse gas emissions trading scheme (2003/87/EC) which favours a shift to less carbon intensive fuels for electricity generation, such as gas, as well as improvements in generating efficiency.

Electricity produced from nuclear fuels continued to grow in absolute terms from the 1990s through to 2005 in the EU-27, although its share of total production fell slightly to 30.2 % in 2005. This decline is due to the fact that few new nuclear plants have been commissioned in recent years to replace those reaching the end of their lives. However, as outlined in EN 13, in recent years a shift can be seen towards building new Nuclear Power Plants (for instance in the UK, the Baltic States and Sweden, as well as the commissioning of a new reactor in Finland) and the extension of life times of existing NPP's (for

instance in the Netherlands). Furthermore, the European Commission has put forward the importance of nuclear energy as one of the opportunities to combat climate change, and it is one of the main "technology avenues" in the SET Plan.

Total renewable energy sources contributed 14.0 % to gross electricity production in the EU-27 in 2005, and this share has increased by only 1.5 percentage points since 1990. Substantial growth will be required to meet the indicative EU target of a 21% share of renewable electricity in gross electricity consumption by 2010. For a detailed description of past and future trends in renewable technologies, see EN30 and EN29.

The fuel mix for electricity production in the new EU Member States is rather different to the EU-15 due to historic and economic reasons. The traditional electricity industries in the region were originally vertically integrated monopolies controlled by central governments, resulting in a large share of coal/lignite and nuclear in the electricity production.

Overall, fuel switching within electricity production has made a benefit to the environment. However, this trend has slowed in recent years. A significant portion of these benefits has been counteracted by the rapid increase in overall final electricity consumption of about 28.7% from 1990 to 2005 (see EN18) leading to an increase in overall electricity production of about 33 % over the same period.

Projections:

All projections indicate an decrease in Coal and lignite and Oil. The largest relative decrease of Coal and lignite is indicated by the GHG Reduction scenario from Poles and the Alternative Policy scenario's form the IEA. These scenario's also show a large increase in the relative nuclear energy consumption. There where the GHG reduction scenario focus on nuclear and natural gas, the Altenative policy scenario focus on renewables. Notes the the Poles scenario is based on EU-25 and the IEA scenario is based on EU-27

Fig 3: Final Energy Consumption by sector and per capita, 2020 (million TOE)

	(IPTS) POLES		(IEA) WEO	
	Baseline	GHG Reduction	Reference	Alternative Policy
	EU25	EU25	EU27	EU27
Coal and lignite	27.3	18.1	27.6	16.4
Oil	2.1	2.1	2.0	2.2
Natural and deriverd gas	27.0	30.5	26.8	23.4
Nuclear	24.5	34.7	18.7	27.9
Renewables	19.1	14.5	25.0	30.1
Other fuels	0.0	0.0	0.0	0.0
Total gross electricity production (TWh)	4,025,000	3,134,000	3,992,000	3,662,000

Data source: IPTS, IEA

2. Indicator rationale

2.1 Environmental context

The indicator's objective is to analyse the fuel shares of electricity production and the growth in production by fuel type. It identifies whether there is a switch to less polluting fuels to meet the EU's energy needs.

Electricity generation and public heat together are responsible for 26 % of all EU-27 greenhouse gas emissions and 21 % of all particles emissions (SO_2, NO_X, NH_3 and PM_{10}). The indicator for electricity production by fuel type helps to estimate the environmental impacts of electricity generation. The type and extent of energy-related pressures on the environment depends upon the sources of electricity generation and how the electricity is produced.

Electricity production from fossil fuels (such as crude oil, oil products, hard coal, lignite and natural and derived gas) can therefore provide a proxy indicator of resource depletion, CO_2 and other greenhouse gas emissions and air pollution levels (e.g. SO_2 and NO_X). The degree of environmental impact depends on the relative share of different fossil fuels and the extent to which pollution abatement measures are used. Natural gas, for instance, has approximately 40 % less carbon content than coal per unit of energy content, and 25 % less carbon content than oil, and contains only marginal quantities of sulphur.

The level of nuclear electricity production provides an indication of the trends in the amount of nuclear waste generated and of the risks associated with radioactive leaks and accidents. Increasing consumption of nuclear energy at the expense of fossil fuels would on the other hand contribute to reductions in CO_2 emissions.

Renewable electricity production is a measure of the contribution from technologies that are, in general, more environmentally benign, as they produce no (or very little) net CO_2 and usually significantly lower levels of other pollutants. Renewable electricity can, however, have impacts on landscapes and ecosystems (for example, potential flooding and changed water levels from large hydro power) and the incineration of municipal waste (which is generally made up of both renewable and non-renewable material) may also generate local air pollution.

The efficiency with which electricity is produced also determines the scale of the environmental impacts of electricity production and consumption (see EN19), as it determines the amount of input fuel required to generate a given quantity of electricity.

The impact also depends upon the total amount of electricity demanded and hence the level of electricity production required (see EN18 for more details on electricity consumption). Thus another way of reducing energy-related pressures on the environment includes using less electricity on the demand-side, through improved efficiency, conservation or a combination of the two.

2.2 Policy context

The power generation sector was responsible for 24 % of EU-15 emissions in 2005 (EEA, Greenhouse Gas inventory, 2007. Therefore, the reduction of electricity consumption is also to be seen in the context of reaching the target of an 8 % reduction in greenhouse gas emissions by 2008-2012 from 1990 levels for the EU-15 and individual targets for most new Member-States as agreed in 1997 under the Kyoto Protocol of the United Nations Framework Convention on Climate Change, as well as reaching the target of 20 – 30% reduction of emissions by 2020 as defined in the EU Energy Policy.

The European Commission has put forward a package of legislative proposals regarding energy use and climate change presented on January 23rd 2008 (COM (2008)16, 17, 19). These include an improvement of the EU Emissions Trading Scheme (with a binding target of a 21% emission reduction in 2020 vs. 2005), and binding targets for Member States for emissions outside the EU-ETS. This will encourage a shift to less carbon intensive fuels such as natural gas, although it could also stimulate "clean coal" technology, as the proposals acknowledge that Carbon Capture and Storage is a key means for CO_2-emission reduction.

In the package, the commission also set a proposal for the use of renewable energy sources, with a target of 20% renewables in 2020 (COM(2008)10). These targets are not specified towards electricity-production. However, the EU Directive on the promotion of electricity from renewable energy sources in the internal electricity market (2001/77/EC) did set an indicative target of 22.1 % of gross EU-15 electricity consumption to be supplied by electricity produced from renewable sources by 2010. Targets for the new Member States and a target for the EU-25 of 21.0 % were specified in an amendment to 2001/77/EC contained in the Treaty to Accession of the European Union in 2003.

In addition to these targets EU Energy Policy (COM(2006) 545) also aims at reaching the target of a 20% reduction of energy-use by 2020. The Action Plan for Energy Efficiency sets 10 priority actions. Some of these will primarily affect the use of electricity. One important action will be the labelling and setting of minimum energy performance standards for appliances and other energy-using equipment. This will be done by implementing Directives for 14 priority product groups by 2008. These include computers, televisions, standby-equipment, cooling and street lighting. Other priority actions include building performance requirements, facilitating financing of energy investments and raising energy efficiency awareness. Furthermore, it expands on measures to introduce more efficient electricity generation and transmission in order to reduce environmental pressures.

Finally, the Large Combustion Plant Directive (2001/80/EC), which aims to control emissions of SO_2, NO_x and particulate matter from large combustion plants (> 50 MW), also has a sizeable effect on the shares of electricity generation by fuel type, as it effectively favours the use of higher efficiency gas plant as opposed to coal plant. Various EU directives and voluntary agreements are also in place which aim to reduce European electricity demand (see factsheet EN18)

Fig. 4: Share of electricity production by fuel type in 2005

	Coal and lignite	Oil	Natural and derived gas	Nuclear	Renewables	Other fuels	Total gross electricity production (TWh)
EEA	26.7	3.9	20.9	27.8	18.5	2.1	3,676
EU-27	28.4	4.2	21.0	30.2	14.0	2.2	3,309
EU-15	23.9	4.4	22.9	31.6	14.7	2.5	2,847
World	40.3	6.6	19.7	15.2	18.2	n/a	18,235
MENA	8.5	40.7	47.3	0.0	3.4	n/a	600
United States	50.5	3.3	18.3	19.0	8.9	n/a	4,268
China	78.7	2.4	1.0	2.1	15.8	n/a	2,536
Russia	17.4	2.2	46.2	15.7	18.5	n/a	951
Belgium	9.4	2.0	28.9	54.7	3.0	2.0	87.0
Bulgaria	40.6	1.5	5.2	42.0	9.8	0.9	44.4
Czech Republic	59.2	0.4	5.8	29.9	3.8	0.8	82.6
Denmark	42.6	3.8	24.3	0.0	29.3	0.0	36.3
Germany	43.6	1.7	12.4	26.3	10.4	5.6	619.0
Estonia	91.2	0.3	7.4	0.0	1.0	0.1	10.2
Ireland	34.9	13.2	43.2	0.0	7.4	1.4	25.4
Greece	59.2	15.3	13.6	0.0	10.7	1.2	60.0
Spain	27.0	8.3	27.0	19.7	15.0	2.9	292.5
France	4.8	1.3	4.5	78.5	10.1	0.8	575.4
Italy	14.4	15.5	51.1	0.0	16.4	2.7	303.7
Cyprus	0.0	100.0	0.0	0.0	0.0	0.0	4.4
Latvia	0.0	0.1	30.3	0.0	69.6	0.0	4.9
Lithuania	0.0	2.7	20.4	69.9	3.1	3.8	14.8
Luxembourg	0.0	0.0	75.6	0.0	5.8	18.6	4.1
Hungary	19.6	1.3	35.0	38.7	5.4	0.0	35.8
Malta	0.0	100.0	0.0	0.0	0.0	0.0	2.2
Netherlands	23.5	2.3	61.2	4.0	8.9	0.2	100.2
Austria	10.9	2.5	21.8	0.0	60.2	4.5	65.7
Poland	91.4	1.5	3.2	0.0	2.7	1.3	156.9
Portugal	32.7	18.9	29.2	0.0	18.4	0.9	46.6
Romania	36.9	3.2	16.6	9.3	34.0	0.0	59.4
Slovenia	34.9	0.3	2.2	38.9	23.6	0.0	15.1
Slovakia	17.6	2.4	8.4	56.4	14.8	0.6	31.5
Finland	15.6	0.7	16.9	33.0	33.4	0.4	70.5
Sweden	0.4	0.9	0.8	45.7	51.8	0.4	158.4
United Kingdom	33.7	1.4	38.7	20.4	4.4	1.5	400.5
Turkey	26.1	3.4	46.0	0.0	24.5	0.1	162.0
Iceland	0.0	0.1	0.0	0.0	99.9	0.0	8.7
Norway	0.0	0.0	0.3	0.0	99.0	0.7	138.1
Switzerland	0.0	0.3	1.5	39.2	52.4	6.6	59.6

Data Source: EEA, Eurostat, IEA

Notes: The share of renewables above refers to production and therefore it does not necessarily match exactly the share, for consumption, as required by Directive 2001/77/EC. The difference between both shares is accounted for by the net balance between imports and exports of electricity. 'Other fuels' include electricity produced from power plants not accounted for elsewhere, such as those fuelled by certain types of industrial wastes. It also includes the electricity generated as a result of pumping in hydro-power stations.

MENA refers to Middle East and North Afica

References

COM(2006)545 final Action Plan for Energy Efficiency - Realising the potential analysis of the action plan for energy efficiency - Realising the potential {SEC(2006)1174} {SEC(2006)1175}

COM(2008) 16 Proposal for a Directive amending Directive 2003/87/EC (EU ETS)

COM(2008) 17 Proposal for a Decision on the effort of Member States to reduce their greenhouse gas emissions

COM(2008) 19 Proposal for a Directive on the promotion of the use of renewable energy sources

Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market.

Directive 2001/80/EC on the limitation of emissions of certain pollutants into the air from large combustion plants

EEA (2005) Climate change and a European low-carbon energy system, European Environment Agency report No 1/2005.

EEA (2007) Greenhouse Gas inventory

IEA (2005): Electricity information 2004 – IEA statistics.

UN (1998): Kyoto Protocol to the United Nations Framework Convention on Climate Change; adopted at COP3 in Kyoto, Japan, on 11 December 1997

Treaty of Accession to the European Union, Annex II, Part 12, page 588, which amends Directive 2001/77/EC in order to set targets for new Member States on the contribution of renewable energy to electricity generation.

Meta data

Technical information

1. Data source:
   Electricity production by fuel and total gross electricity generation: Eurostat (historical data): http://europa.eu.int/comm/eurostat/
   Energy balances: Electricty output in GWh: IEA http://data.iea.org/IEASTORE/DEFAULT.ASP

2. Description of data/Indicator definition:
   Total gross electricity generation covers gross electricity generation in all types of power plants. The gross electricity generation at the plant level is defined as the electricity measured at the outlet of the main transformers, i.e. the consumption of electricity in the plant auxiliaries and in transformers is included.
   Electricity production by fuel is the gross electricity generation from plants utilising the following fuels: coal and lignite, oil, nuclear, natural and derived gas, renewables (wind, hydro, biomass and waste, solar PV and geothermal) and other fuels. The latter include electricity produced from power plants not accounted for elsewhere, such as those fuelled by certain types of industrial wastes which are not classed as renewable. Other fuels also include the electricity produced as a result of pumping in hydro power stations.
   The share of each fuel in electricity production is taken as the ratio of electricity production from the relevant category against total gross electricity generation. It should be noted that the share of renewable electricity in this indicator, based on production, is not directly comparable with the share required under Directive 2001/77/EC which is based upon the share of renewables in electricity consumption. The difference between both shares is accounted for by the net balance between imports and exports of electricity and by how much domestic electricity generation is increased or reduced as a result.
   Units: Electricity generation is measured in either GWh or TWh (1000 GWh)
   Projections are for 2020 from the POLES (IPTS) Baseline and GHG Reduction Scenario and from the WEO 2007 (IEA) Reference and Alternative Policy Scenario.

3. Geographical coverage:
   The Agency had 32 member countries at the time of writing of this fact sheet. These are the 27 European Union Member States and Turkey, plus the EFTA4 countries (Iceland, Switzerland and Norway). There are 20 MENA (Middle East and North Africa) countries.
   No energy data is available for Switzerland, Djibouti, Iran and Palestinian territories.

4. Temporal coverage: 1990-2005, projections 2020

5. Methodology and frequency of data collection: Data collected annually.
   Eurostat definitions for energy statistics http://forum.europa.eu.int/irc/dsis/coded/info/data/coded/en/Theme9.htm
   Eurostat metadata for energy statistics http://europa.eu.int/estatref/info/sdds/en/sirene/energy_base.htm

6. Methodology of data manipulation:
   Average annual rate of growth calculated using: [(last year/base year) ^ (1/number of years) –1]*100
   Share of electricity production by fuel calculated as ratio of electricity production by fuel type to total gross electricity generation.
   The coding (used in the Eurostat database) and specific components of the indicator are:
   - Coal and lignite: gross electricity generation coal fired power stations 107006 + gross electricity generation lignite fired power stations 107007
   - Oil: gross electricity generation oil fired power stations 107008
   - Natural and derived gas: gross electricity generation natural fired power stations 107009 + gross electricity generation derived-gas fired power stations 107010

- Nuclear: gross electricity generation nuclear power plants 107003
- Renewables: gross electricity generation biomass fired power stations 107011 + gross electricity generation geothermal power plants 107002 + primary production 100100 hydro power 5510 + gross production from photovoltaic systems 107023 + gross electricity generation wind turbines 107005
- Other fuels: gross electricity generation other power stations 107012 + pumping in hydro power stations (calculated as gross electricity generation hydro power plants 107001 Electrical energy 6000 - primary production 100100 hydro power 5510)

It should be noted that in the Eurostat database 'Other fuels – 107012' also includes 'gross production from photovoltaic systems - 107023' and although almost negligible in overall terms it has been subtracted from 107012 in the calculation of the indicator.
For the denominator, where required: total gross electricity generation 107000
The coding (used in the IEA database) and specific components of the indicator are:
• Coal and lignite: electricity output in GWh Coal and coal products
• Oil: electricity output in GWh Crude, NGL and Feedstocks + electricity output in GWh Petroleum products
• Natural and derived gas: electricity output in GWh Natural Gas
• Nuclear: electricity output in GWh Nuclear
• Renewables: electricity output in GWh Hydro + electricity output in GWh Geothermal + electricity output in GWh Solar/Wind/Other + electricity output in GWh Combustable Renewables and Waste + electricity output in GWh Heat Production from non-specified comb.fuels + electricity output in GWh Heat
• Other fuels: n/a
POLES: Net electricity generation (TWh)
WEO 2007: Total generation (TWh)

Qualitative information

7. Strengths and weaknesses (at data level)
   Data have been traditionally compiled by Eurostat through the annual Joint Questionnaires, shared by Eurostat and the International Energy Agency, following a well established and harmonised methodology. Methodological information on the annual Joint Questionnaires and data compilation can be found in Eurostat's web page for metadata on energy statistics.
   http://europa.eu.int/estatref/info/sdds/en/sirene/energy_sm1.htm

8. Reliability, accuracy, robustness, uncertainty (at data level):
   Indicator uncertainty (historic data):
   Biomass and wastes, as defined by Eurostat, cover organic, non-fossil material of biological origin, which may be used for heat production or electricity generation. They comprise wood and wood waste, biogas, municipal solid waste (MSW) and biofuels. MSW comprises biodegradable and non-biodegradable wastes produced by different sectors. Non-biodegradable municipal and solid wastes are not considered to be renewable, but current data availability does not allow the non-biodegradable content of wastes to be identified separately, except for that from industry.
   Also, electricity data (unlike that for overall energy consumption) for 1990 refers to the western part of Germany only.
   Electricity consumption within the national territory includes imports of electricity from neighbouring countries. It also excludes the electricity produced nationally but exported abroad. In some countries the contribution of electricity trade to total electricity consumption and the changes observed from year to year need to be looked at carefully when analysing trends in electricity production by fuel. Impacts on the (national) environment are also affected since emissions are accounted where the electricity is produced whereas consumption is accounted where the electricity is consumed.

9. Overall scoring – historic data (1 = no major problems, 3 = major reservations):
   Relevance: 1
   Accuracy: 1
   Comparability over time: 1
   Comparability over space: 1