

End-user GHG emissions from energy

Reallocation of emissions from energy industries to end users 2005–2009

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Summary

The objective of this report ⁽¹⁾ is to help improve the understanding of past greenhouse gas (GHG) emission trends in the energy sector from the demand or end-user side. To do this, the report develops a methodology to redistribute emissions from energy industries to the final users (by sector) of that energy. This reallocation is done on the basis of Eurostat's energy balances and GHG inventories for the energy sector as reported to the United Nations Framework Convention on Climate Change (UNFCCC), for the period 2005–2009.

Background

The European Union (EU), as a party to the United Nations Framework Convention on Climate Change (UNFCCC), reports annually on GHG inventories for the year $t-2$ and within the area covered by its Member States. The European Environment Agency (EEA) is responsible for the compilation of the EU's GHG inventory to UNFCCC. Trends in GHG emissions have traditionally be explained based on the sectorial classification used in UNFCCC reporting. This internationally-agreed reporting system requires Annex I Parties to estimate and report GHG emissions using UNFCCC Guidelines and IPCC methods. Data are reviewed annually and are the basis for assessing progress towards GHG emission targets.

GHG emissions for the energy sector consist of two main blocks: energy combustion and fugitive emissions ⁽²⁾. For reporting purposes, the main combustion categories are: energy industries, manufacturing and construction, residential, commercial and agriculture/fishing/forestry. This means that, for example, emissions from the

transformation of primary fuels in thermal stations to deliver heat and electricity to the residential sector are reported under energy industries, whereas emissions from the burning of coal in a stove by a household would be reported as part of emissions from the residential sector. The official sectoral breakdown based on UNFCCC provides no information on emissions from energy industries by end user.

This report develops a methodology to reallocate emissions from the energy transformation sector to the final users of energy. These end-users are allocated a share of emissions from energy industries. For the purpose of this report, emissions from the energy transformation industries (and fugitives) which are reallocated to end users are termed 'indirect emissions'. This is different from the meaning of 'indirect emissions' in relation to GHG inventories covering CO₂ from the oxidation of CH₄, CO and NMVOC in the atmosphere. Emissions resulting from combustion activities as reported to UNFCCC are termed 'direct emissions'.

In essence, the end-user methodology splits direct and indirect GHG emissions by reallocating all GHG emissions from energy transformation industries to end users using final energy flows. End-use emissions allow a better understanding of the underpinning trends from the demand side by linking final energy use and greenhouse gas emissions. This is useful from a different policy perspective, as for example, policies to improve the insulation of residential buildings could reduce both direct and indirect emissions. Moreover, the method also highlights the relative importance and emission effects of trade in energy flows between EU Member States.

⁽¹⁾ The present summary and the main report published alongside this summary are available from <http://www.eea.europa.eu/publications/end-use-energy-emissions/>.

⁽²⁾ Fugitive emissions are releases of GHG gases from anthropogenic activities that arise from the exploration, production, processing, transmission, distribution and storage of fuels. Combustion emissions are included here if they do not support a productive activity (e.g. flaring of natural gases at oil and gas production facilities).

Box 1 Policy context

The EU Climate and Energy package adopted by the European Council on 6 April 2009 represents the EU's response to limiting the rise in global average temperature to no more than 2 °C above pre industrial levels. European Union leaders also agreed to the so-called '20-20-20' climate and energy targets:

- i A reduction in EU GHG emissions of at least 20% below 1990 levels
- ii 20 % of EU energy consumption to come from renewable resources
- iii 20 % reduction in primary energy use compared with projected levels, to be achieved by improving energy efficiency

All sectors of the economy must contribute to the EU's objective of reducing GHG emissions by 20 % compared to 1990 by 2020. A single EU-wide cap on emission allowances under the EU Emissions Trading Scheme (ETS) will apply from 2013 and the number of allowances will be reduced by 21 % in 2020 compared to 2005. Emissions from sectors not covered by the EU ETS will be governed by the EU Effort Sharing Decision (ESD), where Member States agreed to binding national targets to reduce the EU's overall emissions from non-ETS sectors by 10 % by 2020 compared to 2005. The non-trading sectors represent about 60 % of total GHG emissions in the EU-27 and broadly include 'direct' emissions from households and services, as well as emissions from transport, waste and agriculture. Direct emissions from energy transformation industries are by and large regulated by the EU ETS.

Furthermore, EU governments should reduce emissions in sectors subject to national targets under the ESD, as opposed to sectors where reductions are by and large market driven (EU ETS). As with Kyoto, meeting the 2020 national targets set out in the EU Climate and Energy Package will by and large be determined by how countries reduce emissions in the non-trading sectors. Under the Kyoto Protocol, the EU-15 took on a common commitment to reduce emissions by 8 % between 2008 and 2012 compared to emissions in the base year. When Member States set national emission caps for installations under the EU ETS for the period 2008–2012, they allocated part of their Kyoto emission budget (Kyoto Assigned Amounts) to the EU ETS and fixed the overall contribution of EU ETS sectors towards reaching Kyoto national targets.

The end-user approach provides additional information on the effect of energy demand or sectoral policies on GHG emissions that can be helpful in the context of the ESD. For example, more district heating from combined heat and power (CHP), replacing old stoves in households, or higher demand for electric-powered vehicles, may drive emissions from non-trading sectors (where there are national targets) to trading sectors (governed by carbon prices). Thus, the end-user approach to GHG emissions can also help policy makers target GHG emission reductions more effectively.

It should be noted that the end-user method is not directly linked to monitoring of progress towards targets. It is rather a tool to help understand the links between energy use and emissions at a more disaggregated level, including the emission effects from energy trade between EU Member States.

Main findings

Notwithstanding differences between energy statistics and activity data, the reallocation of emissions from energy transformation to end-users is done on the basis of Eurostat's energy balances and UNFCCC greenhouse gas emissions from the energy sector. One key objective from this exercise is to better analyse the link between GHGs emissions as reported to the UNFCCC and the final energy demand driving the source of emissions.

As explained above, the model to estimate end-use emissions is restricted to the energy sector as defined for reporting purposes under UNFCCC (i.e. energy combustion and fugitive emissions). Much of the sector is regulated by the EU ETS (e.g. combustion installations). The 'energy' subsectors which are outside the scope of the EU ETS broadly include direct combustion emissions from residential and commercial buildings, as well as transportation (excluding electric trains). Thus, while direct emissions from households, for example, are generally excluded from the EU ETS the indirect emissions from the electricity and heat supplied to households fall within the scope of the EU ETS.

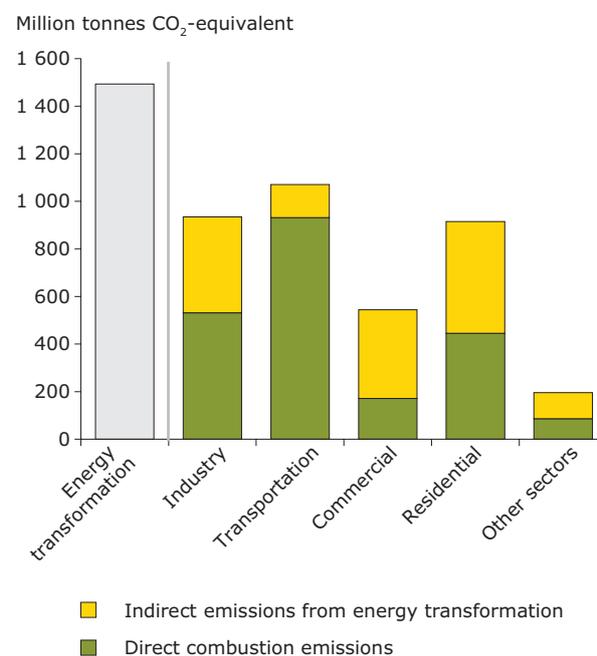
Results by end use for 2009

Figure ES.1 shows the indirect emissions from energy transformation and the direct combustion emissions by main energy-consuming sector in million tonnes of CO₂-equivalent. The heights of the bars depict the total end-use GHG emissions in that sector. Energy transformation on the left side of the chart is shown in white colour to reflect all emissions (including fugitives) are allocated to the end-use sectors.

Figure ES.2 presents the same information in an alternative way, and in relation to total energy-related greenhouse gas emissions in 2009. The height of the line in each sector (in red) is the sum of direct and indirect greenhouse gas emissions in that sector.

Energy industries and fugitive emissions accounted for 41 % of energy-related GHG emissions in the EU-27 in 2009. In the commercial and residential sectors indirect emissions from heat and electricity generation in thermal stations are larger than the direct (inventory) combustion emissions attributed to these sectors. This is by and large because of the electricity supplied by thermal stations to these two sectors. The remaining difference is accounted for by distributed heat from district heating and combined

Figure ES.1 End-use greenhouse gas emissions from energy use in EU-27 in 2009



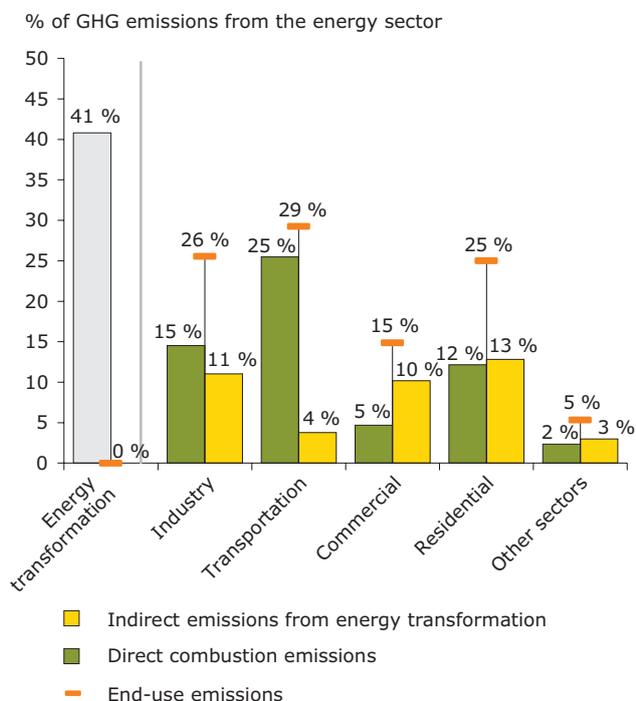
Note: The sum of direct and indirect emissions equals end-use emissions. The total indirect emissions allocated to end-users in a country can be smaller than the direct emissions from fuel transformation in that country if some of the indirect emissions are allocated to exports and international bunkers. The indirect emissions allocated to end users including exports and bunkers equals the direct emissions from fuel transformation plus the indirect emissions associated with energy imported from other countries. The indirect emissions arising from energy supplied from countries outside the EU are assumed to be zero. 'Other sectors' include emissions from agriculture, forestry and fishing as well as the net (indirect) emissions from energy trade. The emissions shown in the chart are only representative of the EU as a whole. Country-specific data are available in the main report.

Source: EEA, 2011.

heat and power plants. In transport, particularly, direct emissions account for the bulk of emissions in the sector, with a significantly lower share of indirect emissions from petroleum refining and electricity for railways, for example. 'Other sectors' include the indirect emissions from imports and exports of energy between countries (e.g. electricity trade). For some EU member states there is a larger effect, which highlights the relative importance of trade in energy flows in these countries. These effects can also vary significantly from year to year.

Figures ES.1 and ES.2 portray the emission's shares across sectors from the final demand side in one point in time, i.e. 2009. It should be stressed these shares only apply to the EU as a whole and very

Figure ES.2 End-use greenhouse gas emissions from energy use in EU-27 in 2009



Note: The sum of direct and indirect emissions equals end-use emissions. The total indirect emissions allocated to end users in a country can be smaller than the direct emissions from fuel transformation in that country if some of the indirect emissions are allocated to exports and international bunkers. The indirect emissions allocated to end users including exports and bunkers equals the direct emissions from fuel transformation plus the indirect emissions associated with energy imported from other countries. The indirect emissions arising from energy supplied from countries outside the EU are assumed to be zero. 'Other sectors' include emissions from agriculture, forestry and fishing as well as the net (indirect) emissions from energy trade. The shares shown in the chart are only representative of the EU as a whole. Country-specific data are available in the main report.

Source: EEA, 2011.

different pictures emerge for different countries. This shows for example that the vast majority of transport emissions (with the exception of electric railways) are by and large direct emissions which are covered by the ESD.

The dynamics of how end-use emissions evolve over time are even more relevant. The progressive development of electric vehicles should result in a redistribution of the emission shares in transport across the EU ETS and the ESD. GHG emission savings will depend on whether transport demand continues growing, outpacing any environmental benefits, and whether the fuel mix for electricity generation is more carbon friendly than combustion

engines using mainly diesel and/or gasoline. Improvements in the efficiency of electricity transformation should also contribute to further emissions reductions.

How have end-use emissions changed between 2005 and 2009?

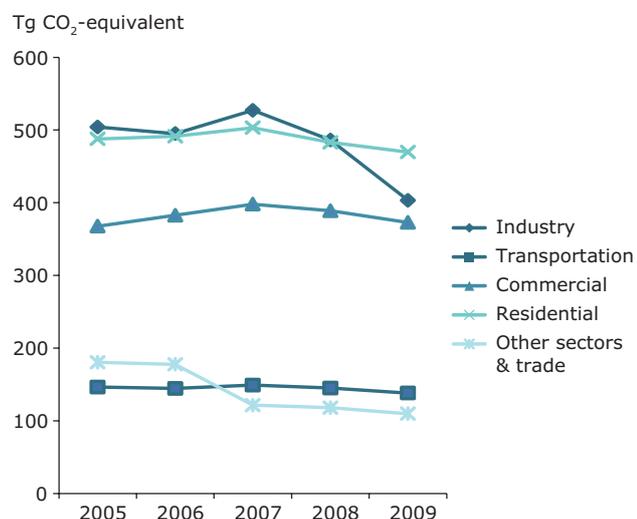
Figure ES.3 (top) shows the evolution of indirect GHG emissions, estimated by reallocating GHG emissions from energy industries and fugitives. Figure ES.3 (middle) shows the trends in direct GHG emissions as reported to UNFCCC, while excluding emissions from the energy transformation sector. Figure ES.3 (bottom) shows total energy-related GHG emissions, including both indirect and direct emissions from the charts above.

All the main sectors reduced their GHG emissions in 2009 (Figure ES.3). Clearly, GHG emissions fell in the transformation sector (energy industries, including fugitives). On an end-use basis, GHG emission reductions in industry accounted for two thirds (30 % indirect and 36 % direct) of all energy-related GHG emission reductions in 2009. Emissions for sectors which are part of the EU ETS declined more than the so-called non-trading sectors. Most of the biggest industrial installations are part of the EU ETS and the stark contraction in gross value added in industry during 2009 appears to have led to a sharp reduction in final energy demand and emissions in the sector (combustion, but also process-related). Emissions fell particularly for manufacturing industries and construction, as well as for key industrial processes, such as iron and steel and cement production. The 2009 energy balances and the verified 2009 emissions from the EU ETS published last year also confirm significantly lower energy use and lower emissions in all industrial sectors. There was also a marked decline in real energy and carbon prices which has to be seen in the context of lower final energy demand and the 2009 economic recession.

After industry, transport was the sector contributing most to the reduction in GHG emissions in 2009, particularly road transport. Gasoline emissions continued their downward trend, whereas diesel emissions fell for the second time since 1990. Along with the start of economic recession in the second half of 2008 and the whole of 2009, this could have triggered a fall in freight transport demand. Part of this reduction in emissions on an end-use basis was accounted for by lower (electric) rail transport demand and lower emissions from refining of oil products in 2009.

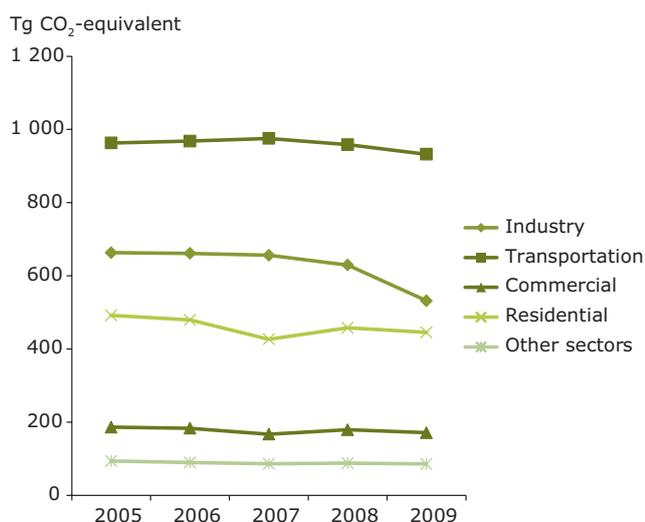
Figure ES.3 Trends in direct and indirect GHG emissions by end-use sector in EU-27, 2005-2009

Indirect GHG emissions by sector, 2005-2009



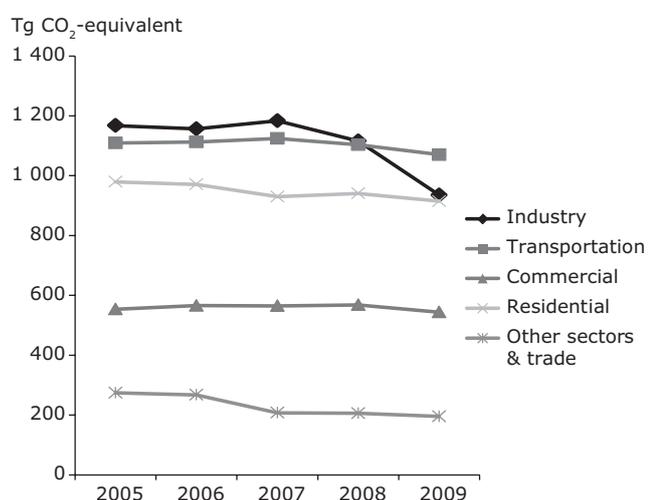
Sector	Contribution to the total reduction in energy-related emissions, 2008/2009
Indirect emissions	
Industry	30.3 %
Transportation	2.5 %
Commercial	5.9 %
Residential	4.9 %
Other sectors & trade	3.0 %
Indirect emissions (all sectors)	46.5 %

Direct GHG emissions by sector, 2005-2009



Sector	Contribution to the total reduction in energy-related emissions, 2008/2009
Direct emissions	
Industry	35.5 %
Transportation	9.6 %
Commercial	3.0 %
Residential	4.6 %
Other sectors	0.8 %
Direct emissions (all sectors)	53.5 %

Total (direct + indirect) GHG emissions by sector, 2005-2009



Sector	% of the total absolute reduction in energy-related emissions, 2008/2009
Total emissions	
Industry	65.8 %
Transportation	12.1 %
Commercial	8.9 %
Residential	9.4 %
Other sectors & trade	3.8 %
Total direct and indirect emissions (all sectors) in Tg CO₂-equivalents	- 274

The year 2009 also saw GHG emission reductions in households (and services) despite the colder winter. There was an increase in the number of 'heating degree days' in most European countries (an indicator of household demand for heating) compared to 2008. Eurostat's energy balances confirm a significant increase in derived heat (and also in electricity demand) in EU-27 households during 2009. However, this increase has been more than offset by lower use of fuel in non-distributed heat in the residential sector, particularly liquid fuels. As a result, household emissions fell in 2009 even though the winter was on average colder than 2008.

While tracking indirect emissions from energy transformation industries is not directly suited to monitoring overall GHG emission targets, the method to reallocate indirect emissions to the end users can help increase the transparency of how reductions in energy use in households and other sectors affect overall emissions reductions at the level of that sector (direct and indirect). In this way, Member States could better assess which additional policies/measures may be needed to reduce emissions in these sectors to meet their overall emission targets. These additional measures could for example include specific sectoral policies as well as overall improvements in energy efficiency, carbon intensity and higher shares of renewables, to mention but a few.

How were end-use emissions calculated?

There is no perfect match between the sectoral classification used in GHG inventories submitted to UNFCCC and the energy balances because of different reporting requirements. Energy industries (CRF 1A1) and fugitive emissions (CRF 1B) could be thought of as the equivalent of the transformation sector in the energy balances. However, the GHG inventory does not allocate emissions from energy industries to the end users of the final energy (households, transport,

agriculture, industry and services). In the energy balances, primary energy is transformed (combustion or by mechanical means) to useful energy (e.g. heat, electricity and gasoline/diesel) which is then allocated to these sectors. Thus, one should not compare GHG inventory emissions directly with final energy consumption from the energy balances ⁽³⁾.

The conceptual model to reallocate emissions from energy transformation industries to the end users is based on the *UK end-user model* ⁽⁴⁾. The model reallocates emissions from the energy transformation industries (power stations, refineries, coal mining, solid smokeless fuel production, gas production and town gas production) to the end users.

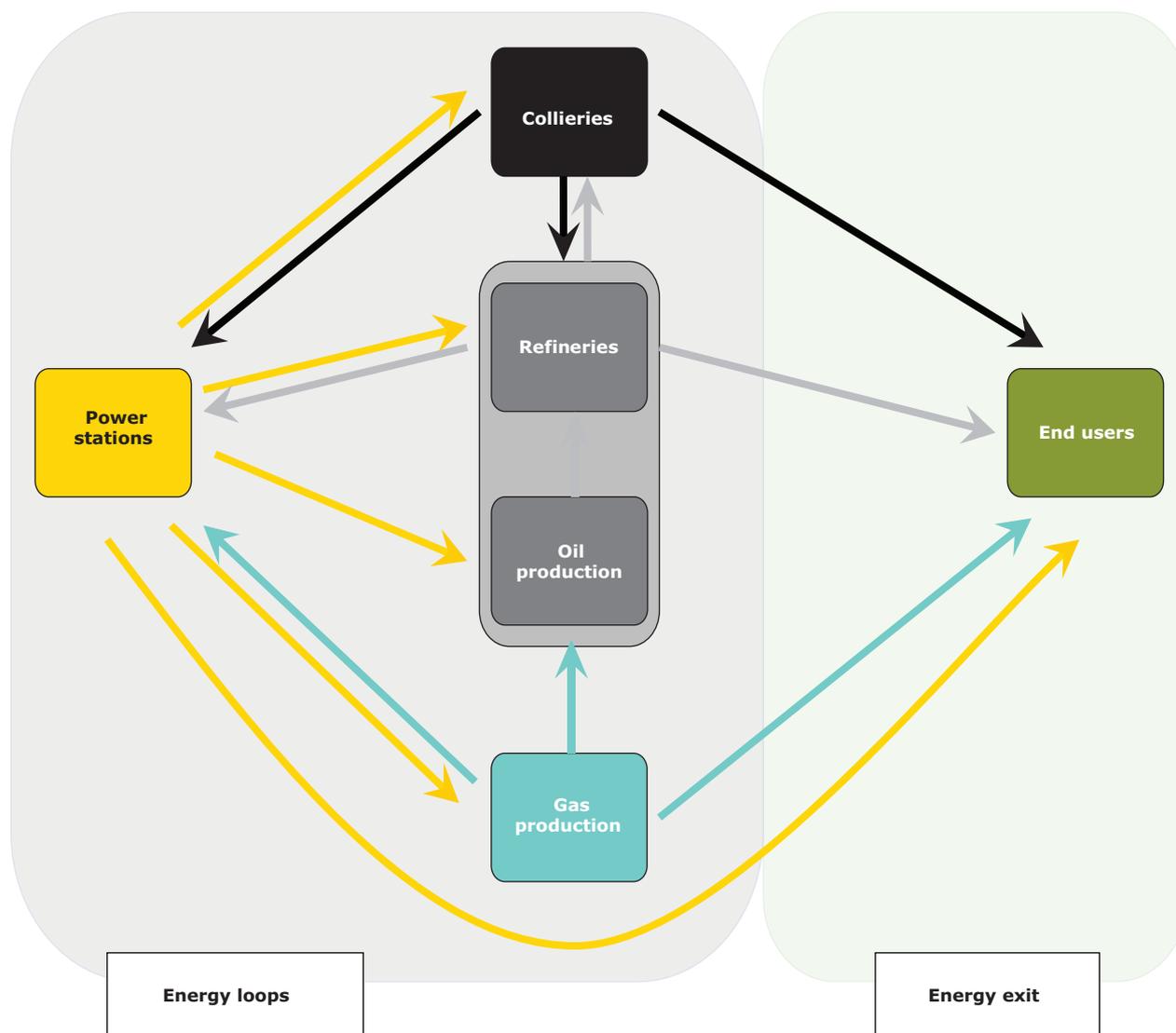
Refineries, the coal industry and the gas production industry are supplied with a small part of the public electricity produced. The refineries supply oil to the power stations and the coal industry. The coal industry supplies coal to the power stations. The gas industry supplies gas to the power stations. Carbon dioxide and other greenhouse gases are emitted by each of these source categories. Each of the source sectors thus produces both direct and indirect emissions. It is not possible to allocate emissions directly from all producers to their end users, and the reallocation of emissions thus requires the development of a conceptual model that takes account of feedback loops between energy producers. In this way, all the emissions from the energy producers, including heat production are reallocated. These feedback loops are illustrated in Figure ES.4.

There are two streams of data used in the allocation of energy-related greenhouse gas emissions to the end users. The first one is the greenhouse gas inventory of the European Union — an annual submission of national greenhouse gas inventories of Annex I Parties under the UNFCCC and the Kyoto Protocol, which the EEA compiles on behalf of the European Commission. The second data

⁽³⁾ To give one example: the electricity and heat used by households and services which is reported as final energy consumption in the energy balances also include the energy supplied/distributed from conventional thermal stations. Under UNFCCC reporting, GHG emissions from households and services are estimated from direct combustion activities and exclude indirect emissions from energy transformation industries. The same is true for other energy-consuming sectors such as industry, agriculture and transportation. Emissions arising from the transformation of primary fuels in thermal power stations to produce heat and electricity for the final users of energy (e.g. households, services, transportation, industry and agriculture) are reported under public electricity and heat production. Other energy transformation industries include petroleum refining, coal mining, and oil and gas extraction. Fugitive emissions are also linked to the production, processing, transmission, storage and use of fuels (e.g. flaring of natural gases at oil and gas production).

⁽⁴⁾ The UK end-user model has been used by policy makers in the United Kingdom to understand the interactions between the energy transformation industries and their effect on GHG emissions in the United Kingdom. In addition, the model has been used to improve the analysis of energy efficiency and GHG emissions in the Devolved Administrations of the United Kingdom by taking account of electricity transfers between the Devolved Administrations.

Figure ES.4 Energy flows in the end-user model



source is the annual energy balances reported to Eurostat under the Energy Statistics Regulation. In both cases there are well established QA/QC processes to ensure the highest possible quality of the emissions and energy estimates, respectively. Differences remain between both sets of data: between fuel/activity data in GHG inventories and energy data in the energy balances, for example. Under the Energy Statistics Regulation, EU Member States are expected to ensure a high degree of consistency between the energy balances reported to Eurostat and the activity data reported under the UNFCCC. The main mismatch occurs at a more detailed sectoral level due to different reporting requirements and/or practices. The treatment of

non-energy use, particularly in industrial sectors, can be a source of inconsistencies between the energy balances and national GHG inventories.

The end-user approach is internally consistent at EU level as all emissions from energy producing industries are reallocated to the final users using the energy balances as the distributing tool. The starting point is the emissions (EEA GHG data viewer) which are then reallocated using energy flows in the energy balance (Eurostat). The allocation of indirect emissions depends on the fuel mix in the energy balance. This means emission factors are not an input to the model but can be derived from the model.

The end-user model also takes into account energy trade flows between EU Member States to allocate emissions to the final users. This is because electricity, oil products, natural gas and solid fuels produced in one country may be exported to other countries. Thus, the net exported indirect emissions by Member State may be different from zero for countries with significant energy trade flows with other countries. The indirect emissions allocated to end users including exports and bunkers equals the direct emissions from fuel transformation plus the indirect emissions associated with energy imported from other countries.

A country can both import and export fuels and the implied emissions factors for imports and exports are not generally the same because of different fuel mixes across countries. To guarantee the internal consistency in the model, the redistribution of indirect emissions across EU Member States is based on the fuel mix of the exporting country. For example, if country A exports electricity to country B, then country B is allocated a fraction of country A's emissions based on the fuel mix in country A. Also, indirect emissions from refining oil products in one country would be allocated to end users in other countries in proportion to the energy content of the fuel supplied. Thus, the derived emission factors for the allocation of indirect emission to the end users in the importing country are based on the exporting country fuel mix and transformation efficiency. See Chapter 2 and 3 in the main report for more information.

Planned improvements and additional information

An update of this EEA technical report is planned for 2012. The report will include a refined description of GHG emission trends from the demand side as well as a number of flow charts to map primary energy flows by fuel on the one hand and GHG emissions on the other.

The geographical scope will also be extended to cover all EEA member countries including Iceland, Liechtenstein, Norway, Switzerland and Turkey.

Finally, the same allocation principles applied to CO₂ will be tested for NO_x and SO_x emissions.

For more information:

Annual EU greenhouse gas inventory 1990–2009 and inventory report 2011

<http://www.eea.europa.eu/publications/european-union-greenhouse-gas-inventory-2011/>

EEA GHG data viewer

<http://dataservice.eea.europa.eu/PivotApp/pivot.aspx?pivotid=475>

EEA Climate publications

<http://www.eea.europa.eu/themes/climate/publications>

Eurostat energy balances

<http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/data/database>.

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