Supply side indicators in Odyssee

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Acknowledgements

The methodology has been set up using inputs from and discussions with Piet Boonekamp (ECN), Matthias Reuter (Fraunhofer ISI), Lea Gynther (Motiva) and Wouter Wetzels (ECN).

The goal of including supply side indicators

The main goal of adding supply side indicators to the Odyssee database is to be able to determine savings from cogeneration of heat and power (CHP) which are currently not available in the Odyssee database. An additional goal is to enable extension of the decomposition analysis of the power sector and possibly other transformations. Improving the decomposition is not part of the supply side indicator task though.

The way electricity generation was handled in Odyssee until 2017

Odyssee follows the Eurostat approach, which means that all energy carriers delivered to end use sectors are considered to be used for final consumption. All electricity generation, whether it is centralized or owned by final consumers (called 'autoproducers' by Eurostat), is combined in a single transformation sector. Odyssee does already provide a decomposition of primary energy consumption and of electricity generation into different factors: the volume effect (a combination of the change of final consumption, the share of electricity in final consumption and the share of imported electricity), the structural effect (changes in generation types, among which fuel switch) and efficiency effects of thermal power plants. The existing decomposition is based on the Eurostat sector classification (without any electricity generation in the end-use sectors), and thus does not include the energy savings from cogeneration in the different end-use sectors. In addition, Odyssee currently does not use Eurostat data on electricity production per fuel type, as all thermal generation is seen as a single generation type.

The method for improving the estimate of energy savings in the power sector in Odyssee

The supply side indicators will be limited to electricity and (combined) heat generation. The availability of Eurostat data from the main database limits what can be achieved. The problem lies in the information about CHP that Eurostat provides in the main database. The first problem is that the main Eurostat database does not provide data about heat produced by CHP that is not sold to third party heat consumers. This means the information is not sufficient to calculate the total efficiency of CHP generation by all so-called autoproducers combined (CHP owners in end-use sectors). The second problem is that information about ownership of CHP facilities in different sectors is missing, which means that CHP savings cannot be calculated for individual end-use sectors. The amount of unsold heat (i.e. heat used by the CHP owners themselves) can either be acquired by making use of separate data from Eurostat on CHP[1], or by estimating the heat-to-power production ratio and the total efficiency of CHP heat by fuel and generation type. Despite the fact that the separate Eurostat

[1] See http://ec.europa.eu/eurostat/web/energy/data at the end of the page, below 'Combined heat and power generation (CHP)'.

CHP data are inconsistent with the main Eurostat database, due to different definitions according to Eurostat itself, the first option has been chosen. This is in accordance with a recent article on decomposition of primary energy consumption that makes use of both the main Eurostat database and the separate Eurostat CHP data [Reuter et al., 2017]. In a later stage, national teams might be able to provide CHP ownership data in different sectors, which is lacking from Eurostat. The approach for now however is to follow the Eurostat methodology and to treat autoproducer CHP as part of a single electricity and heat generation sector, also because the Energy Efficiency Directive[2] targets savings on final energy consumption and on CHP separately in articles 7 and 14 respectively. This approach means that savings on electricity and heat generation by CHP owners cannot be attributed to the individual end-use sectors with CHP. However, it will be possible to provide more detail than available before in Odyssee about the shares and efficiency of electricity and heat generation by fuel type, as Eurostat provides data about this (fuel input for transformation from the energy balance (nrg_110a), electricity and heat generation from separate tables on supply, transformation and consumption of electricity and heat (nrg_105a and nrg_106a)). With these additional data it will be possible to calculate more detailed efficiency indices for the electricity and heat generation sector. The focus will be on the gross electricity production and efficiency developments in thermal electricity and heat generation. The more detailed efficiency indices can be used for a more detailed decomposition of the primary energy consumption in the power sector. The effects of the import and export of electricity, distribution losses and use for pumped storage are related to the decomposition of the total primary energy consumption and are not part of the task described in this paper.

The calculation of energy savings by electricity-only and CHP generation

What follows are the choices made for calculating the supply side indicators.

Considerations

- It is known that information about CHP generation in the regular Eurostat database is not consistent with the separate Eurostat data on CHP, and national CHP data can again be different. Still, a generic methodology has been selected that makes use of data from Eurostat as much as possible and minimises the need for estimates. The separate CHP data are seen as more reliable, as a detailed submission instructions are provided, and unsold heat is included. The impression is that an exaggerated share of generation has been labelled as CHP generation in the main Eurostat database. The instructions for the separate CHP reporting include detailed instructions on what part of the fuel input and electricity generated should be labelled CHP fuel input and CHP electricity. A method that make use of both the main Eurostat database and the separate CHP data from Eurostat has also been used by [Reuter et al., 2017].
- Another option would be to use only data from the generic Eurostat database, but this would have required estimates for the amount of unsold CHP heat. This involves the application of multiple estimated parameters, like for the ratio of electricity and heat produced by CHP installations per fuel type and installation type and the efficiency of the production of the unsold heat. Because of the need of multiple estimates, this method has been discarded.

[2] https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive

General approach (for all fuels combined)

- Supply side indicators are derived for six fuel groups: solid fuels; oil products; residual gases; natural gas; biofuels and renewable waste; non-renewable waste and other. The methodology will first be described for all fuels combined for the sake of clarity.
- For a complete decomposition of primary energy consumption into volume, structure and efficiency effects in electricity-only and CHP generation, data on electricity and heat production by combustible fuels, by nuclear and by renewable energy are needed. As the generation efficiencies of non-combustible renewables and of nuclear power plants are fixed at 100% and 33.3% respectively, the focus is on thermal power and CHP generation. Indicators for combustible fuels are developed for electricity-only and CHP generation separately.
- For the total input of combustible fuels for conventional thermal electricity production (and heat production in case of CHP) by main activity and autoproducers [1], the main Eurostat database is used.
- For the total volume of electricity produced by thermal power generation by main activity and autoproducers [2], the total gross electricity production by combustible fuels from the main Eurostat database is used.
- For the amounts of fuel input in CHP [3] and the volumes of electricity [4] and heat [5] produced in CHP, the separate Eurostat CHP data are used. Main activity and autoproducer CHP are combined in a single CHP section.
- The amount of electricity produced in electricity-only plants [6] is calculated by subtracting CHP electricity [4] from total gross electricity from combustible fuels as found in the main database [2].
- The amount of fuel input in electricity-only plants [7] is calculated by subtracting CHP fuel input [3] from the total fuel input as found in the main database [1]. A known possible error is that the fuel input used for unsold CHP heat should have been excluded from the main database, which will result in an underestimation of fuel input for electricity-only generation after subtraction.
- The fuel input attribution to CHP electricity [8] and heat [9] production can be done in many ways, no single 'true' method exists. A straightforward option is attribution by weighing according to output of electricity and heat measured in energy content, which was applied in the method described by the Energy Efficiency article [Reuter et al., 2017]. A different method was chosen for the Odyssee supply side indicators: it calculates the energy saved by CHP by comparing the fuel input to the fuel input that would have been used in the case of separate generation of electricity and heat, and then sharing the saved energy weighed by electricity and heat production (see annex for the calculation). This is a variant of the Finnish method[3]. The reference efficiency used for heat is 90%, the reference for electricity production is the efficiency of electricity-only generation with the same fuel, which is in accordance with the CHP Directive[4]. Using this methodology, CHP electricity and heat

[3] See for example http://era17.fi/wp-content/uploads/2012/02/Report-Nordic-CHP-Allocation_Energy-AN-Consulting_2010-9-7.pdf
[4] http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32004L0008

efficiencies will both be a bit higher than electricity-only generation or stand-alone boiler efficiency respectively. It will often result in heat efficiencies that are above 100%.

- To be able to calculate effects starting in 2000, the CHP data are linearly extrapolated from 2005 back in time towards 2000, as data before 2005 are missing.
- If member states have submitted data to the main Eurostat database and for the CHP data according to the instructions, then this method will *not* deliver completely accurate results. There will be differences in fuel input for unsold heat and the unsold part of the total heat production. This is due to the fact that the fuel input for unsold CHP heat *should not* be included in the main database, but it *should* be included in the CHP data. This means that using the method described above can lead to a too low fuel input for electricity only generation, as this input is calculated as the total fuel input from the main database (that excludes input for unsold heat) minus the fuel input for CHP (that does include fuel input for unsold heat). The error will become clear if the effect is significant, because the efficiencies for electricity-only generation will be higher than expected. In the case of inaccurate results, member states will have the option to provide corrected data in the Odyssee country data sheet. Results from the generic methodology that can be overruled in the Odyssee datasheets are: fuel input for electricity and fuel input for heat, amounts of heat and electricity produced for electricity-only and for CHP; all of these for six different fuel categories. It should be clearly indicated in the on line Odyssee interface if generic Eurostat data or improved national data have been used to calculate the supply side indicators.

Effects per fuel

The regular Eurostat database has data on many different fuels for fuel input, electricity generation and heat generation in conventional thermal power generation (database tables nrg_110a, nrg_105a and nrg_106a). This makes it possible to calculate indicators for six different fuel groups, and to estimate generation efficiencies per fuel group for CHP. The fuels have been grouped into solid fuels, oil products, residual gases, natural gas, biofuels & renewable waste and non-renewable waste & other. Data on CHP electricity and heat efficiencies by fuel type from the main Eurostat database will be used as estimates for attribution of CHP electricity and heat production to the input fuel categories. This is necessary because the separate Eurostat CHP data do contain different fuel categories for input, but all generated electricity and heat are combined and are not split according to the fuel used.

Information on CHP ownership per end-use sector not available

Autoproducer CHP data are not split among end-use sectors as this information is not available from Eurostat. As an option, we could ask countries to provide data about CHP ownership by end-use sector, but this would require substantial additional development work while the benefits would probably be limited to results for just a few countries. Therefore, this feature will not be implemented in this stage.

Improvements for a decomposition of the power sector

With the CHP data completed and by distinguishing between fuel types, it will be possible to construct a more detailed decomposition into structural and efficiency effects as described below.

- Structural effects
    - The share of renewable electricity production except bio fuels
    - The share of electricity production of nuclear
    - The shares of electricity and heat produced by combustible fuels including bio fuels, split into electricity-only and CHP
    - Changes in the amount of CHP heat
    - The share of final use of electricity from net import
    - The effect on primary energy consumption of net export of electricity
- Saving effects
    - Efficiencies for electricity and heat generation for electricity-only and for electricity from CHP (main activity CHP and auto producer CHP combined)
    - Savings for nuclear will be assumed to be zero, as the efficiency is 33,3% by default
    - Savings for non-combustible renewables will be assumed to be zero, as a fixed conversion efficiency of 100% is assumed.
    - Own consumption of the transformation sector as a separate savings effect is not taken into account
- Heat generation and savings
    - It would be possible to also include heat only generation as a separate subsector of the transformation sector, but this is not implemented because heat only generation is small in comparison to electricity only and CHP generation. The effects of changes in heat only generation can be put in 'other transformations' in a decomposition of primary energy consumption.

Indicators for inclusion in the Odyssee database

Electricity and CHP heat production shares

- Share of nuclear electricity production
- Share of non-combustible electricity production
- Shares of electricity-only electricity production for six fuel types
- Shares of CHP electricity production for six fuel types
- Shares of CHP heat production for six fuel types

Electricity and CHP heat efficiencies

- Efficiencies of electricity-only electricity production for six fuel types
- Efficiencies of CHP electricity production for six fuel types
- Efficiencies of CHP heat production for six fuel types

Annex – calculation details

Reference efficiencies, energy savings and fuel attribution for CHP electricity and heat

Energy savings for CHP are calculated for application in the attribution of fuel input to CHP electricity and heat. The saved energy is calculated by comparing the total fuel input for CHP to a situation in which electricity and heat would be generated separately. The reference for heat production is a boiler with an assumed efficiency of 90% for all fuels. The reference for electricity is electricity-only production with the same fuel as the CHP installation, with country specific values based on the main Eurostat database. Using electricity production with the same fuel as a reference for CHP savings is in accordance with the CHP directive (Annex III/f/1)[5]. The saved energy is split according to the volume of heat and electricity produced by CHP. The resulting efficiencies are calculated by correcting the fuel input that would have been used in the reference situation by the respective shares of the CHP savings.

With 40% as an example electricity-only efficiency, the fuel attribution calculations for CHP are as follows:

Reference fuel input for electricity = CHP electricity/0.4

Reference fuel input for heat = CHP heat/0.9

CHP savings = Reference fuel input for elec + Reference fuel input for heat - actual CHP fuel input

Weighed CHP elec savings = CHP savings * CHP electricity/(CHP electricity + CHP heat)

Weighed CHP heat savings = CHP savings * CHP heat/(CHP electricity + CHP heat)

CHP electricity efficiency = CHP electricity/(reference fuel input for elec – weighed CHP elec savings)

CHP heat efficiency = CHP heat/(reference fuel input for heat – weighed CHP heat savings).

[5] http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32004L0008

References

Reuter et al., 2017: Applying ex-post index decomposition analysis to primary energy consumption for evaluating progress towards European energy efficiency targets, Matthias Reuter, Martin K. Patel, Wolfgang Eichhammer, Energy Efficiency 28 April 2017, DOI 10.1007/s12053-017-9527-2