CONCITO
DENMARK'S GREEN THINK TANK

A way forward for EU energy system modelling

Energy system modelling plays a key role in the development of EU's climate and energy policy. However, the current technology assumptions 1) contain inaccurate data on cost and performance, 2) have several transparency challenges, and 3) are not subject to sufficiently regular review processes to ensure up-to-date data. This brief puts forward a set of recommendations to improve the technology assumptions in the short term and to revise the process of updating input data in the medium term.

CONCITO RECOMMENDS

1. **Update the input data on cost and performance of a range of technologies**
2. **Increase transparency through e.g. full access to input data and model output, clear references to data sources and more complete information on units**
3. **Revise the process of determining the technology assumptions through a yearly review, allocate further resources and introduce the use of sensitivity analyses on the cost of key technologies**

Modelling tools are vital to EU's climate and energy policy

Model-based scenarios are at the core of the impact assessments and policy analysis carried out by the European Commission that constitute the informational bedrock of policy making in the EU. As such, the assumptions behind the models are pivotal as they determine model results on e.g. optimal technology choices and their associated costs. In turn, this shapes the perception of optimal target-setting and the policy options to pursue. The importance of the modelling efforts carried out by the European Commission and external contractors to provide a solid basis for policy making can therefore not be underestimated.

Previous analyses on the EU's energy system modelling (especially the PRIMES model) have revealed data on cost and performance regarding technologies such as heat pumps, electric boilers, batteries etc. that are not commensurate with recent developments.[1]

Although the negotiations of the 'Fit for 55' package are at the final stage, the post-2030 climate targets and policies in the pipeline emphasize the importance of addressing the shortcomings of the current energy system modelling to ensure EU targets and policies that are fit for purpose and based on up-to-date and transparent data.

[1] AGORA Energiewende (2017), Scheuer & Santini (2018), Transport & Environment (2018), Duscha & Lehmann (2018) and the Danish Council on Climate Change (2021).

EU energy system modelling

The European Commission uses various modelling tools to analyze policy options in the area of climate and energy policy. The models are interlinked and represent different systems and sectors (e.g. energy, transport, agricultural activities etc.). The PRIMES model is central as it provides projections of energy demand, supply, prices, and investments in the EU energy system. The model uses macroeconomic and technological input data and is primarily based on behavioral modelling grounded in microeconomic theory. It is developed by E3-Modelling and has been central to the policy analyses carried out by the European Commission for decades. For example, analyses using the PRIMES model was the informational basis behind the European Commission's REPowerEU plan to reduce dependence on Russian fossil fuels.

The Joint Research Centre (JRC) under the European Commission did start and carried out extensive work to develop an in-house energy system model (the so-called POTEnCIA model) based on an open source database. However, the development of the POTEnCIA model seems to have been put on hold in recent years.

This brief will focus on the technology assumptions in the PRIMES model. It aims to exemplify the shortcomings of some of the assumptions, analyze the potential consequences of these flaws (taking into account the lack of transparency regarding model inputs) and offer recommendations on how to remedy that. The brief will not elaborate on other relevant models (for example GAINS, GLOBIOM-G4M, CAPRI, GEM-E3 and POLES-JRC), which are also important modelling tools for the European Commission. Furthermore, the brief will not focus on the macroeconomic and financial input data in the PRIMES modelling – e.g. assumptions on discount and interest rates – which also have significant influence on model outcomes.

CONCITO RECOMMENDS

1. Update the input data on cost and performance of a range of technologies

It is crucial for the validity of model results that the assumptions on cost and performance of technologies are up-to-date and reflect the best estimate of how these evolve in the future. The technology assumptions in the PRIMES model are based on both publicly available and restricted-access sources (including databases and surveys). Although the input data on cost and performance of some technologies has undergone some positive changes (e.g. more accurate costs and multiple subcategories for wind and solar technologies), the current technology assumptions continue to contain data on cost and performance that diverge significantly from other sources such as the Danish Energy Agency's Technology Data Catalogues (DATC).[2]

For example, the cost of electric boilers is listed to be more than 10 times higher than in the DATC. As a consequence the PRIMES model potentially favor fossil fuel technologies like gas boilers over electric boilers as shown in Box 1. The efficiency assumption for heat pumps also seems too low for both district heating and residential heating, while the efficiency of residential gas boilers is too high.[3] These discrepancies are an indication that several technology assumptions might be inaccurate which potentially leads to model results that discourage cost-effective climate solutions. As shown below, the lack of transparency regarding the input data (e.g. on units) makes it difficult to assess the scale of the problem.

[2] The DATC contains well-documented data on cost and performance for a wide range of technologies with a specific focus on the energy system in Denmark. Therefore, it can be a useful public source to identify differences in the technology assumptions.
[3] In PRIMES, the efficiency of heat pumps is 2.5 for district heating and 1.98 for residential air heat pumps in Nordic countries in 2020. However, in DATC the efficiency of district heating heat pumps is 3.8 and 4.85 for residential heating in 2020. The assumed efficiency of gas boilers at 1.08 is only theoretically obtainable. Such a value would require extremely low boiler inlet temperature.

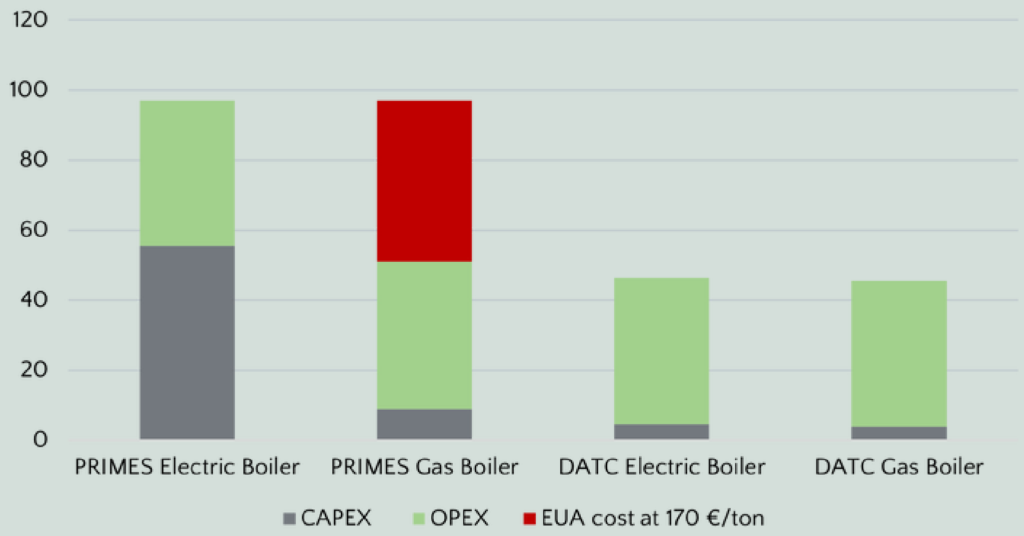
In the short term, the European Commission and external contractors are recommended to carry out a thorough review to adjust the technology assumptions. This could be done by comparing current assumptions to other data sources that are regularly updated, such as the DATC.

Box 1 – Cost of electric boilers in the PRIMES model

Electric boilers allow for flexibly utilizing wind and solar power for heat production at times of high output and low power prices. This both helps displacing fuels and creating value of variable renewable energy.

The assumed cost of electric boilers in the PRIMES model makes gas boilers cheaper than electric boilers for heating, unless the price of emissions allowances (EUA) in the Emissions Trading System (ETS) increases to around 170 €/ton as shown in Figure 1. Using the DATC data, the two boilers cost approximately the same and the total costs are comparable even without a carbon price.[4]

Figure 1 – Cost of heat production using electric or gas boilers (€/MWh)



2. Increase transparency through e.g. full access to input data and model output, clear references to data sources and more complete information on units

The general lack of access to the PRIMES code due to its private ownership has been criticized by several stakeholders.[5] As shown above, some of the technology assumptions in the model are available, but there continues to be restricted access to the input data, e.g. lifetime extension costs and losses in district heating units,[6] as well as model output.[7] The effects of input data on the modelling results are likely much greater than the coding itself.

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[4] Figure 1 assumes boilers that operate 2000 hours a year, and that flexible operation allows buying electricity, which on average costs the same as gas in those hours. All four installations are assumed to have a lifetime of 20 years with a discount rate of 7,5% which was used for regulated monopolies and grids in PRIMES when making the EU Reference Scenario 2016. The price of natural gas is assumed to be 50 €/MWh based on low heating value and the price of electricity 50 €/MWh. The remaining costs can be found in either the DATC or the technology assumptions in the PRIMES model. For the natural gas boiler based on PRIMES' input data, it is assumed that all costs are based on heat output, and the heat efficiency is based on the high heating value of natural gas.

[5] See for example Scheuer & Santini (2018) and Duscha & Lehmann (2018). A model description of the PRIMES model from 2018 is public.

[6] As noted by the Danish Council on Climate Change assumptions regarding losses in district heating units may put all district heating at a significant disadvantage in the PRIMES model.

[7] Only selected model outputs are made publicly available. Published outputs are defined by the European Commission and are project-specific.

Therefore, CONCITO recommends full access to input data as well as model output to increase transparency and facilitate review efforts. Ideally, the data could be shared in a user friendly interface allowing the public to get more insights into the basis of the policy discussions.

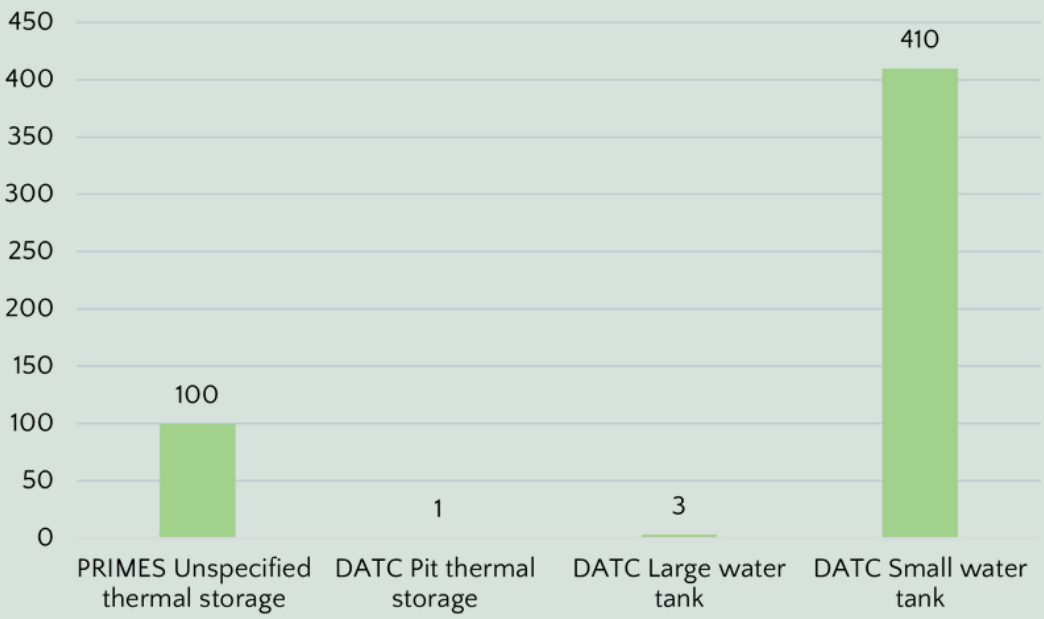
The current dataset on the technology assumptions should also contain clear references to data sources and more complete information on units. Although an overall summary of the data sources is official,[8] the dataset itself does not contain references to data sources. The dataset also contains irregularities and lacks comprehensive information regarding units and assumptions as exemplified in Box 2.[9] Without this information it is hard to assess whether the technology assumptions used in the PRIMES model adequately reflect reality.

Box 2 – Cost of thermal storages in the PRIMES model

Thermal storages are an important source of balancing in energy systems with a high share of variable renewable energy. Thermal storages cover many different technologies ranging from hot water storage in a house to utility scale high temperature storage in molten salt.

The dataset on the technology assumptions provides a value for "thermal storage" with no detail regarding what technology is assumed or at what scale. Figure 2 compares the PRIMES value to three types of water storages in the DATC.[10] The figure illustrates the fact that the lack of information in the dataset makes it difficult for external stakeholders to check the validity of the technology assumptions.

Figure 2 – Cost of thermal storages (€/kWh)



[8] For example, there is a short summary in the impact assessment on Renewable Energy Directive (page 91).
[9] For example, it is unclear, if capacities are based on high heating value or low heating value for the technologies, e.g. gas boilers, in several of the sheets provided. Furthermore, heat efficiency should be listed in addition to electrical efficiency. For some technologies like gas boilers heating efficiency is shown as electrical efficiency, which adds to the confusion. It is also unclear if cost data is given per kilowatt input or output, e.g. electrical input or heat output for heat pumps. The way electrical efficiency is calculated doesn't seem to be consistent between geothermal technologies and heat pumps.
[10] The first two are for district heating and the latter for a house.

3. Revise the process of determining the technology assumptions through a yearly review, allocate further resources and introduce the use of sensitivity analyses on the cost of key technologies

The review process of the technology assumptions in the PRIMES model is formally carried out in the preparation of the EU Reference Scenario, which is the key baseline scenario on which the European Commission can assess new policy proposals. In recent years, a EU Reference Scenario for 2016 and 2020 have been compiled. In the preparation of the latest reference scenario, input on the technological assumptions were given by national experts from Member States (e.g. an expert group was set up) and by stakeholders from industry and non-governmental organizations through a consultation process and one workshop.[11] This review resulted in some changes to the technology assumptions, but did not ensure the necessary updates of all assumptions as shown above.

The cost and performance of several clean technologies (including batteries and solar PV) is improving very fast. Therefore, the current review process is not fit for purpose in terms of ensuring up-to-date and well-documented technology assumptions. Furthermore, the future review process of the assumptions is currently unclear, including the involvement of stakeholders.

On this basis the European Commission is recommended to revise the process to determine, update, and document technology assumptions. The following steps would ensure a higher degree of accuracy:

- A yearly review of the technology assumptions. A yearly review will ensure a regular and ongoing update of relevant technology assumptions. The review must be carried out with clear stakeholder involvement from both Member States and external stakeholders. The process of the DATC can be used as inspiration. This review process should be an integral part of future modelling tenders or spun out as a separate task.

- Allocation of resources. A relatively small group of consultants are tasked to derive assumptions and process the vast amount of inputs from stakeholders. The European Commission should consider allocating more resources to ensure the provision of well-documented and transparent technology assumptions.[12] Any potential reboot of the work on the POTEnCIA model and the open source database behind it needs to address the same shortcomings on input data and transparency as underlined above.

- Sensitivity analyses on technology costs. Currently the sensitivity analyses in the impact assessments have been carried out on policy (e.g. the policy scenarios in the 'Fit for 55' package) or macroeconomic developments (e.g. sensitivity scenarios related to COVID-19 pandemic recovery) rather than on technology developments. However, the cost of e.g. renewable energy has evolved very differently than expected. In this light, sensitivity analyses on cost of key technologies should be considered.

[11] The process is further elaborated in the EU Reference Scenario report (page 9-10). The technological assumptions was also reviewed in an ASSET study in 2018 commissioned by the European Commission.
[12] The European Commission clearly states that it does not guarantee the accuracy of the data included in e.g. the technology assumptions.