REEEM

European Energy System Transition: Regional Energy Security and Grid & Dispatch

Policy Brief

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About this report

This report constitutes the Policy Brief of the WP6 case studies to have a deeper look at certain regions and different modelling approaches for the transition pathways of EU towards to a low carbon society. It includes the main insights obtained in these case studies. Based on the insights, it enlightens key conclusions based on the findings in the case studies.

The report builds on the detailed analyses reported in Deliverable 6.2 –Regional Energy Security Case Study Report, Deliverable 6.3 – Grid and Dispatch Case Study Report which are yet to be published yet.

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About REEEM

REEEM aims to gain a clear and comprehensive understanding of the system-wide implications of energy strategies in support of transitions to a competitive low-carbon EU energy society. This project is developed to address four main objectives: (1) to develop an integrated assessment framework (2) to define pathways towards a low-carbon society and assess their potential implications (3) to bridge the science-policy gap through a clear communication using decision support tools and (4) to ensure transparency in the process.

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According to Paris agreement, the European Union (EU) needs to achieve ambitious GHG reduction targets by 2050 and beyond (European Commission, 2012). In addition, the EU has set, along the years, a strong legislative framework (European Commission, 2019) to secure a safe, resilient and sustainable energy transition while tackling some challenges such as scarce sources, energy needs and climate change.

In the REEEM project, two case studies have been conducted to get a deeper analysis in certain regions on how to optimize the EU energy system according to different modelling approaches. The case studies examine energy systems in different regions with different temporal resolution, additional to EU wide analyses carried with TIMES PanEU.

The first case study focuses on the Baltics and Finland. The idea is to study the regional energy security considering the energy flow, especially with Russia, as a connection point for the flow between Europe. In this case study, the MESSAGE model is used and the results of the TIMES PanEU from Base and HighRES pathways (G. Avgerinopoulos and et al, 2018) are exploited.

The second case study focuses on South Eastern European (SEE) region with 5 countries: Croatia, Bulgaria, Romania, Slovenia and Hungary. This case study verifies the feasibility of dispatch, calculated in TIMES PanEU, and analyses the influence of short-term variability on long-term investments and system configurations using PLEXOS model for five countries in SEE. Again, the results of the Base and HigHRES pathways of TIMES PanEU are also used as inputs to the PLEXOS model.

Case study 1: Energy security in Baltic countries

Energy security is a complex and multidimensional concept that has evolved along the years. It started with the 1970s oil crises and its concerns on the dependency on fossil fuel import and other interdisciplinary issues, such as affordability, social acceptance, and environmental impacts. Energy security is one of the most important priorities of the energy policies in the EU and Baltic States. Energy security is defined as "the ability of the energy system to uninterruptedly supply energy to consumers under acceptable prices and to resist potential disruptions arising due to technical, natural, economic, socio-political and geopolitical threats". To enhance energy security, it is necessary to foresee corresponding measures already at the planning stage of the energy sector development and implement them efficiently on time.

However, the choice of energy security measures is challenging due to the broad variety of threats that need to be addressed. It has to be ensured that the benefits are higher than the costs of security measures for the national economy. Moreover, the implementation of energy security measures is a challenge itself, since some measures require additional policy measures or market mechanisms.

The REEEM project conducted energy security case study, focusing on Estonia, Finland, Latvia, and Lithuania. In this case study, energy security is considered in the context of the development of the energy sector operating under market conditions. This means that market conditions determine the cost-effectiveness of different individual energy generation sources as well as the attractiveness of energy security measures. Environmental restrictions associated with climate change mitigation as well as country specific and EU energy policy requirements are also taken into account. Having this in mind, the case study results show that refurbishment of existing hydro power plants, construction of wind power plants, CHPs running on biomass and municipal waste, CHPs running on natural gas and biogas can be mentioned as economically most attractive electricity generation options in Baltic States and Finland. Additionally, the development of other technologies in the near future is economically less justifiable due to the relatively low electricity market prices and the environmental limitations. Similarly, biomass boilers and heat pumps have the economic preference among technologies analysed for heat production according to results of the study.

Energy security issues in the Baltic States are largely related to the electricity system. Although positive from a diversification point of view, significant share of intermittent electricity generation (in particular wind) creates additional energy security challenges as it requires the power system to maintain sufficient balancing capacities at all time. The lack of balancing power can cause significant imbalances in the power system, which in turn can lead to serious accidents and negatively impact energy security. The spread of large and inflexible generation sources might even worsen the situation. Therefore, flexibility has a key role to play in the “new” energy system.

Based on the results of the case study, the most economically attractive options to balance the generations from solar and wind power plants in the Baltic States and Finland are: a) generation compensation obtained via interconnectors from available sources in neighbouring countries; b) gas turbine CHPs; c) gas turbine power plants and plants with internal combustion engines; d) electricity storages (hydro pumped storage power plant, electric batteries).

Significant energy security issues are related to the substantial amount of electricity imports from third countries to Baltic countries and possible malfunctions of individual elements (lines or generators) of the electricity system. The Baltic States have powerful electrical connections in terms of their capacities and their load with neighbouring power systems. Therefore, the capacity of a separate power line may exceed 30-50% of the country's total power demand. In the energy security case study, the need for different types of reserves (frequency containment reserve, frequency restoration reserve, replacement reserve) are modelled in details by employing the methodology developed at LEI. The total requirement for all types of reserves over a given time period is approximately three times the maximum potential interference power in that specific time period. Thus, in theory, the power system should not have any serious disruptions. However, in practice, certain elements ensuring the provisions of reservation services may not be implemented or their functioning may not correspond to the real threats of the failure of such a line. Therefore, the disruption of the operation of such a line may cause a major disturbance on the entire power system, especially in the case throughput capacity of interconnectors could be reduced. Looking at the current situation, the main problems are related to the provision of frequency containment and replacement reserves.

The results of the case study suggest that the number of interconnectors and their throughput capacities, used for electricity trade between countries as well as for providing balancing and reservation services, should be maintained or even extended. The higher electricity market integration and diversification of supply chains increases the overall energy security. Also, existing fossil fuel power plants, currently not competitive in the electricity market might, can still be a cost-effective option to provide reserve services and ensure energy security. The changing role (for example, from electricity generation to provision of reservation services) of existing technologies can be considered as an important aspect of flexibility to secure energy efficiency. Such cost-effective solutions may accelerate a real energy transition by ensuring energy security at a lower cost.

The energy security study also reveals a certain lack of cross-border cooperation, preventing closer system integration and common operation. In this context it is possible to mention the bottleneck problem in electricity transmission grid between Estonia and Latvia, the long-term processes with synchronization of electricity system with the power system of Continental Europe, construction and operation of liquefied natural gas import terminal and others. For example, the recently constructed LNG terminal in Klaipėda improves the energy security of the whole region but its maintenance costs are only carried by Lithuania, due to a "no agreement" on the construction of the regional terminal.

Among other existing or potential issues related to energy security, it is also possible to mention the significant growth of biofuel use, especially in heat production. In some district heating systems, share of this fuel already reaches 100%. On one hand, this could mean the beginning of dominance of one type of renewable fuel, however this is not a good phenomenon in terms of energy security. Besides of growing particulate emissions in towns, this may have an impact on the competition between fuel types and supplies and lead to fuel price growth. On the other hand, this can cause unsustainable processes in forestry if insufficient attention is paid to reforestation, cultivation and forest care.

It can be concluded that ensuring energy security in changing situation is a permanent challenge. Energy security is a multidimensional phenomenon, not always considered in all its aspects. According to the probabilistic analysis results of this study, if probabilities of certain events are known, it helps to reveal the influence of such factors that cannot be directly assessed in the models of energy development analysis.

Case study 2: Grid and Dispatch in SEE

In this case study, PLEXOS Simulation Software is used to develop model of power systems in five EU member states: Bulgaria, Croatia, Hungary, Romania and Slovenia. It focuses on a single year at a higher temporal resolution (hourly) than what could be possible in the long-term IEM. IEM works with the 12 time slices in a year in the modelling horizon between 2015 and 2050, split into 5-year time steps. 2030 is chosen as a year in the middle of IEM time horizon to model in PLEXOS as a single year. The PLEXOS Simulation Software is a simulation software designed for energy market analysis with the possibility to analyse a shorter time horizon in electricity market using more operational details (e.g., ramp rates, forced outages, stochastic behaviour of renewables, operating reserves) compared to long-term models. In this case study PLEXOS is used to model power systems, i.e. electricity markets in five SEE countries.

According to the outline of the REEEM project, several EU transition pathways are developed (G. Avgerinopoulos and et al, 2018). Results of TIMES PanEU from Base and HighRES pathways are used as inputs to PLEXOS. During the development of the PLEXOS model for SEE region, several iterations have been made between TIMES PanEU and PLEXOS to calibrate both of the models.

Figure 1 shows the main input and output data used in PLEXOS model.

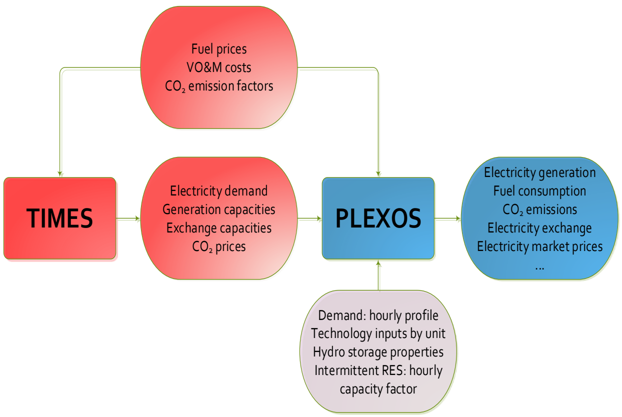

Figure 1. Main input and output data to PLEXOS model of SEE region

Since TIMES PanEU is a long-term energy system planning model, most of the input/output data are available with lower temporal resolution. In this case study PLEXOS is used for short-term analysis and some of the input data are required with higher temporal resolution or higher disaggregation level compared to TIMES PanEU data. Thus, required input data which are not available from TIMES PanEU are obtained from other relevant sources, such as TYNDP 2018 (ENTSO-E, 2018) and ENTSO-E (ENTSO-E) Pan-European Market Model Database (PEMMDB) used for creation of TYNDP 2018 (TYNPD, 2019).

Installed capacities by fuel/technology based on TIMES PanEU are used as inputs to PLEXOS in each scenario. Two EU transition pathways, Base & HighRES, are diversified regarding cross-border exchange to be modelled in PLEXOS: 1) Integrated SEE region with cross-border exchange between modelled SEE region and neighbouring countries, 2) Isolated SEE region without cross-border exchange between modelled SEE region and neighbouring countries, which means that only between countries in SEE region the exchange is allowed. These scenarios with integrated SEE region are diversified regarding constraints on electricity generation as well according to following structure: 1) Integrated SEE region with fixed electricity generation – minimum level of yearly electricity generation in PLEXOS is set to yearly values according to TIMES PanEU results by different fuels/technologies to confirm that the results from TIMES PanEU are also possible with hourly optimization, 2) Integrated SEE region without fixed electricity generation – complete optimization of electricity generation by generation units in PLEXOS.

With the additional diversification in the pathways, six different scenarios are modelled in PLEXOS:

- Base pathway – Integrated SEE region – fixed generation,
- Base pathway – Integrated SEE region – generation optimization,
- Base pathway – Isolated SEE region,
- HighRES pathway – Integrated SEE region – fixed generation,
- HighRES pathway – Integrated SEE region – generation optimization,
- HighRES pathway – Isolated SEE region.

Listed scenarios are modelled with PLEXOS for the year 2030. Feasibility of TIMES PanEU electricity balances is tested in PLEXOS on an hourly level for the countries of SEE region.

PLEXOS modelling results in scenarios with fixed yearly electricity generation by fuels/technologies based on TIMES PanEU data show that:

- power system in SEE region in 2030 can be dispatched on the hourly level, i.e. projected generation capacities in SEE based on TIMES PanEU can ensure to cover projected electricity demand and projected cross-border exchange with neighbouring countries.

PLEXOS modelling results in scenarios with generation optimization show that:

- short-term optimization of power system with objective to minimize total operational costs results in different generation mix by fuels/technologies compared to long-term optimization of entire energy system with objective to minimize discounted system costs (including investment costs),

- short-term optimization of power system in PLEXOS is determined based on hourly electricity demand and generation costs of available generation units to meet the demand, while long-term optimization of the energy system in TIMES PanEU is also affected by heat demand (which is not considered in PLEXOS model of SEE region).

PLEXOS modelling results in scenarios with isolated SEE region show that:

- power system in SEE region in 2030 can be dispatched on the hourly level, i.e. projected generation capacities in SEE based on TIMES PanEU can ensure to cover projected electricity demand in isolated SEE region without cross-border exchange with neighbouring countries.

PLEXOS modelling results in all analysed scenarios show that:

- hourly balancing of intermittent renewable energy sources is possible with projected generation capacities in SEE based on TIMES PanEU results in 2030,
- cross-border electricity exchange (sum of electricity import and export) between modelled countries of SEE region in 2030 is higher compared to TIMES PanEU results (from 48 to 57 TWh depending on the scenario),
- due to significant share of thermal power plants on fossil fuels in SEE region in 2030 resulted from TIMES PanEU and the fact that short-term optimization is affected by fuel prices and CO_2 emission prices, in PLEXOS generating units on coal and lignite have preference over gas-fired units. It should be pointed out that different assumptions on fuel and CO_2 emission prices (given as an input to PLEXOS based on TIMES PanEU results) would result in different PLEXOS optimization results.

Aside from the conclusions on grid and dispatch for all analysed PLEXOS scenarios, there are messages that can be extracted regarding feasibility and influence of Base and HighRES pathways on power systems of SEE region. HighRES pathway results show higher electricity generation and consequently higher CO_2 emissions, but lower resulting wholesale electricity market prices compared to Base pathway. However, **both pathways are achievable and feasible in terms of grid and dispatch on an hourly level, so there are no obstacles in implementation of either of them in SEE region.**

It can be concluded that in the long-term planning of power system development, it is necessary also to consider short-term issues, especially in terms of growing development of intermittent renewable energy sources and challenges that their integration represents for grid and dispatch of powers systems on an hourly level.

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