Overview - Scope of Case Study 2

Objective of the Horizon2020 project plan4res will provide a well-structured and highly modular modelling framework to enable consistent insights into the different needs of future energy system. Three case studies will highlight the potentials of this framework by dealing with different aspects of a future energy systems (compare [1]).

Case study 2 focuses on the Pan-European electric power transmission system within the period from 2020 until 2050 under the presence of various sources of uncertainty.

Overall Objective

The overall objective of the current case study constitutes the identification of the optimal investment decisions that a network planner needs to make over the course of many decades so as to achieve safe electric power system operation under the presence of various sources of uncertainty.

Target Users

The case study is particularly useful to national and European regulatory authorities, transmission system operators (TSOs), electric energy storage investors, entities related to renewable energy development and deployment and distribution system operators (DSOs).

Detailed Description

Case study 2 focuses on the Pan-European electric power transmission system within the period from 2020 until 2050. The following figure displays the topology of the power system, where each circular white node represents a single country and the straight lines connecting the nodes represent the associated electric power transmission corridors.

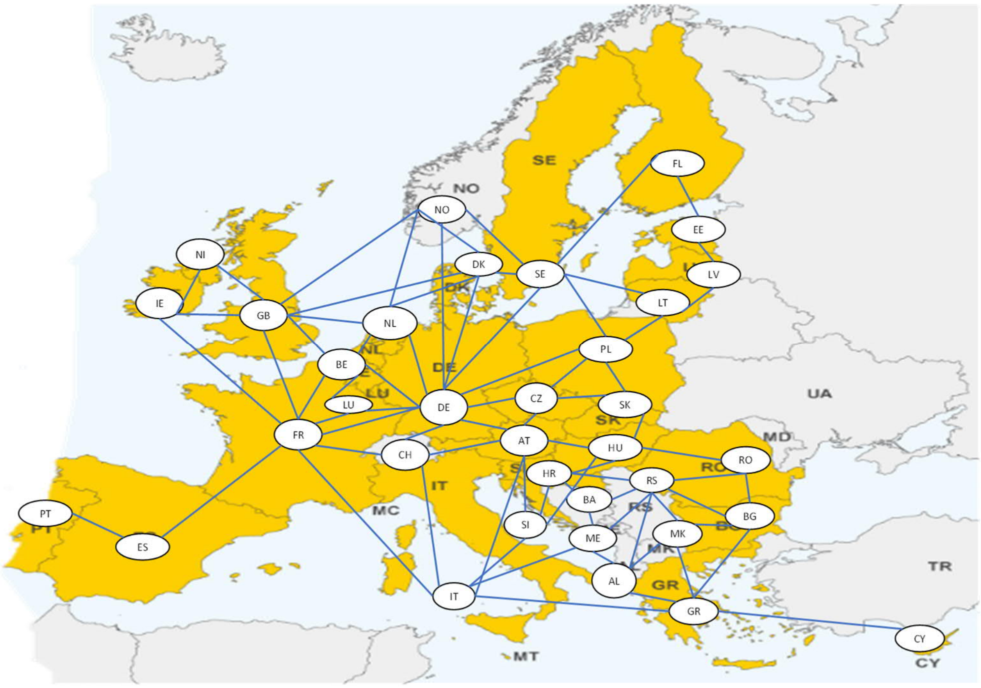

Figure 1. Representation of the Pan-European electricity transmission system in network form.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 773897

The objective of this case study is to assess this plan4res tool's ability to capture:

- The investment and operational cost associated with uncertain integration of solar and wind capacity and uncertain growth in demand. Specifically these costs include:
    - Investment cost associated with the deployment of electric energy storage;
    - Investment cost associated with the upgrade of the thermal capacity of existing corridors;
    - Investment cost associated with the construction of new electric power transmission corridors;
    - Operational cost associated with the generation cost (i.e. fuel cost) of the thermal generating units.
- The option value of different flexibility services/technologies;
- The impact of sources of uncertainty on investment decisions and system economics.

In order to model the uncertainty, a scenario tree needs to be defined. This tree will consist of nodes distributed over a number of scenarios. Each node will contain a particular value of the uncertain parameter (e.g. installed capacity of solar and wind generation, level of demand).

Expected results

The model will yield the following results:

- Optimal investment decisions in terms of timing (i.e. which year the investments will take place), magnitude (I.e. how much investment will be made), location (i.e. which system areas will be equipped with electric energy storage capacity) and type. The latter can be of three different categories:
    - Electric energy storage;
    - Capacity upgrade of existing electric power transmission corridors;
    - Construction of new electric power transmission corridors.

  The results will be displayed in a decision tree, which has a shape identical to the scenario tree given as an input to the optimization problem but additionally displays the resulting investment decisions.

- Value of flexibility (option value) of investing in electric energy storage: This value is associated with the economic benefit that this smart technology brings to the system. This value is called 'option value' because investment in electric energy storage allows for treating the investment in the inflexible and expensive conventional network reinforcement as an option that the network planner will decide to exercise only if it is economically beneficial to the system. The term 'option value' stems from the financial options theory where the holder of an option has the right – but not the obligation – to exercise it when the value from exercising it is greater than the associated cost;
- Operational characteristics of deployed technologies: The analysis will also present the operation of the deployed technologies e.g. how it may affect power flows at selected transmission corridors and how it operates to achieve this. Diagrams will illustrate these findings.

Scope of Technologies

Case study 2 deals with the electricity sector and specifically focuses on the following investment technologies.

- Electric energy storage. The modelling of this technology is done in a technology-neutral manner. This means that the electric energy storage will be modelled by its operation which is to charge with energy at certain periods of the year and discharge it at other periods. This operation is characteristic of energy storage of any type of technology and is performed basically for the purpose of accommodating power flows in a safe and reliable manner. For instance, when the power flows are close to the static thermal rating of a corridor, electric energy storage can discharge and, as a result, feed local loads, thereby alleviating the need for supplying them with power from a distance generating unit. Such operation can help defer conventional network reinforcement;

- Conventional network investment. This investment refers to either upgrading the capacity of an existing corridor or constructing a new one.

Methodology

The methodological approach for conducting case study 2 involves the following formulations:

- Stochastic optimization formulation where both technologies are available for investment: energy storage and conventional network investment.

- Stochastic optimization formulation where only conventional network investment is available for investment;

- Deterministic optimization formulation where both technologies are available for investment.

The evaluation of the option value will be determined by comparing the first two formulations. The effect of using stochastic optimization will be determined by comparing the first and third formulations.

References:

[1] Horizon 2020 project plan4res ,2018, “Deliverable D2.1 Definition and requirements of three case studies”; pdf downloadable at www.plan4res.eu