

IMPACTS OF THE DISTRIBUTION GRID ON THE EUROPEAN ENERGY SYSTEM PROSPECTIVE SCENARIOS

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Overview

To achieve decarbonization of the energy sector, the analysis of the power grid behavior under a high share of renewable energies is fundamental. However, in its current state, the electrical grid is not adapted to such a scenario due to volatile/uncertain profiles and limited hosting capacities in “weak” grid areas. Energy models and long-term prospective studies are needed to adapt the power grid to new paradigms and to reshape the grid and the electricity mix jointly considering the economic, technical, and environmental constraints.

Methods

Several energy system models already exist and are usually used for capacity and investment planning over the transmission network. Depending on what they are meant to do, those models cover different geographical scales, from worldwide or continental models to provide trends to more country-specific ones to better represent behaviors. These models, however, are rarely combined to create a coupling between long-term and operational planning results. The lack of technical details of continental models, notably at the scale of distribution networks should be better covered with the help of more specific modeling tools. In this context, this research aims at linking energy system models (build with a top-down approach in mind) and operational ones that cover the distribution network (where the majority of renewable energies are installed) to capture the constraints on distribution grids. Two models have been coupled: POLES and Backbone. POLES is a partial equilibrium economic model used for prospective scenarios at the country level and long-term scale (up to a hundred years). Backbone is a multi-energy and multi-market unit commitment model using stochastic optimization. It has been upgraded to integrate transmission and distribution grid models, i.e. load flow for the local and short-term scale at a fine space/temporal granularity. These two models are soft linked to perform analysis capturing the global and local, short- and long-term aspects together.

POLES presents a country-size granularity, but generation units and energy demand are unevenly located inside a country. An allocation strategy has been developed to dispatch national resources at an appropriate level for Backbone which is the scope of this paper. There are mainly three types of resources to distribute on local grids: energy consumption, energy production, or flexibility. The distribution strategy is built in three steps. First, output data from POLES at the country scale are obtained, then these data are dispatched regionally, and finally, resources are allocated to distribution grid nodes. To cover as well international and local scales, simplifications are proposed to reduce the number of variables, notably acting on the modeling variables to accelerate the optimization process and thus reduce the computational burden.

Results

The paper will propose a set of interesting results on both the national dispatch of resources and preliminary prospective scenarios. For instance, even if rural grids are spread over the most space available, the number of photovoltaic plants per distribution grid is higher in semi-urban grids. This highlights the relevance to install distributed energy sources closer to the points of consumption, while appropriately sizing them to avoid any local excess of energy that would incur reverse flow or additional losses in the grid.

Three types of distribution grids have been considered: urban, semi-urban, and rural for simulations. Those grids will be spread over the French territory. The main simplification hypothesis will be presented in the final paper, notably on the generation side and how some actions did decrease the computational time in function of the increased modeling error. The reached compromise will be justified.

Conclusions

Allocation strategies for three typical distribution grids allow taking into consideration the local scale of energy generation and consumption but particularly the role of different options of flexibilities in a bigger picture. The coupling of local models and partial equilibrium models, typically at the EU scale will allow in terms to be more precise while building large-scale prospective scenarios.

References

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