VARIABLE RENEWABLE ENERGIES AND STORAGE DEVELOPMENT IN LONG TERM ENERGY MODELING TOOLS

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Overview

Europe and many other countries aim at reducing the CO_2 emissions from their electricity production. In order to evaluate the trajectory of their energy systems, they use energy scenarios produced by long term energy modeling tools. More and more Variable Renewable Energies (VRE) like wind or solar are deployed, so the energy models have to take into account the variability and relative unpredictability of these non dispatchable energies. A review of long term energy models is conducted to understand how they represent the specific constraints of VRE on the rest of the power system. For this, a new typology is proposed for comparing both long term energy models and power sector models. It includes new criteria focusing on the representation of VRE and of the power sector components helping the integration of VRE, such as electricity storage. This brings out several options for representing the VRE integration challenges. However, among the long-term energy models, none represents the variability of VRE and its effects on the power sector. For example, there is no real representation of the electricity storage operation. Therefore we develop a new power sector module for POLES (Prospective Outlook on Long-term Energy Systems), one of the most technology-detailed long term energy models. We present the first results of this new detailed electricity module.

Method

The typology of technical and economical modeling tools for the energy system and the power sector shows different methodologies, particularly concerning the specific constraints imposed by VRE. The main categories of this typology are the following. First, the objectives of the models are described with five criteria (represented energies, evolution over time or not, computation logic, centralized or decentralized approach, and the choice of dynamics in the model). Then, temporal characteristics are compared, with time step and time horizon of the model. Finally, the following components are studied in further detail, both on the technical precision and the economical mechanisms: conventional productions, renewable productions, electricity storage, electricity demand, and electric grid.

This categorization clearly shows that up to now energy modelling tools and power system tools respond to separate objectives and do not combine their advantages. A new optimization model is thus developed and connected to the broader long term energy model POLES. This module, DisNat (Dispatch of the National electricity generation), dispatches all technologies optimally, including storage technologies. It represents the electricity dispatch module of POLES, and is linked to POLES year-after-year. The rest of the electricity mechanisms, in particular capacity planning, and the other energies are still managed within POLES.

Results

The typology developed applies to any kind of energy modelling tool; we present some of them, in particular those focusing on the power sector. It highlights the differences in objectives and precision of representation of long-term energy system and power sector tools. Power sector tools have a good description of the technical constraints; their sequential dispatch can incorporate storage options, thanks to inter-temporal constraints. On the other hand, long term energy models can represent broader economic assumptions and provide economic scenarios. Combining benefits is possible, for the first time, thanks to the direct coupling between DisNat and POLES. The economic dispatch is now precisely represented in the long term model, including ramping constraints and electricity storage. The main storage option considered is hydro pumping, while hydrogen and electric vehicle are work in progress. Thanks to the split of hydro power plants, we see how the hydro storage option is used in accordance with the development of VRE. Hydro reservoirs of lakes also contribute a lot to the overall flexibility of the power system and VRE integration.

Conclusions

VRE and storage are becoming more and more important in the power system, and should therefore appear in long term energy modeling tools. The new typology of technical and economical models allows a comparison of the representations of VRE and their challenges. The complexity of the VRE integration challenges is too high for long term models, but specific power sector tools can take it into account. The technical and economical characteristics of each component are crucial to capture the interactions between conventional productions, storage, demand and grid. We use a coupling of the long term energy model POLES with a dispatch module, DisNat, in order to shed light on some integration challenges and the role of storage. A representation in POLES of the competition between the different integration solutions (storage, demand side or grid interconnection) is a work in progress.

The insights gained from this work into the impacts of VRE will improve the understanding of the effects of sustainable energy policies. Renewable development and VRE integration challenges will be assessed and flexibility options compared.

References

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