Title: **Electricity Market Models for the Future Power Grid: A US-European Review**

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Topline Research Focus:
Power systems in the United States and Europe are undergoing a rapid transformation in the resource mix, driven by technology progress, corresponding cost declines, and policy drivers. A large expansion of low marginal cost generation with variable and uncertain resource availability impacts electricity prices and the need for grid services (e.g. operating reserves, frequency and voltage control) to maintain system reliability. There are intense debates about the ability of current electricity markets to provide cost-efficient system solutions, adequate incentives for individual market participants, and whether the ongoing grid transformation require new electricity market designs. The future value of hydropower in evolving electricity markets was also the main topic that emerged from the breakout session on hydropower optimization at the Hydro Summit in Trondheim, Norway, in February 2020. A key question is whether hydropower and other flexible storage technologies are adequately compensated for the full range of services they provide to the grid.

In order to analyze these complex questions it is of utmost importance to have adequate market optimization and simulation tools that reflect individual resources and system constraints with sufficient detail. A particular modeling challenge is the representation of hydropower, which has strong inter-temporal ties through water reservoirs and also are subject to uncertainty in future inflows. Other flexible technologies, such as batteries and demand response are characterized by similar inter-temporal constraints, but at different time scales. However, many of the tools that are currently used for electricity market analysis were developed for a conventional resource mix. Moreover, hydropower and other flexible resources are oftentimes represented in a simplistic manner. The purpose of this project is to evaluate and compare existing models for electricity market analysis that are commonly used in the United States and Europe. We will focus on 1) the ability to represent the dynamics of future power systems, as described above, 2) to what extent existing tools can provide robust estimates of prices for energy and other grid services, 3) to what extent these tools can be used to assess the economic viability of hydropower and other flexible resources in the future power grid, considering the full range of grid services, markets, and revenue streams.

The research will be conducted by reviewing existing literature on electricity market models in the US and Europe. Initially, we will focus on tools developed by the national labs in the United States and by NTNU and SINTEF Energy Research in Norway. However, the review will also consider other research and commercial tools with sufficient documentation in the public domain. An intermediate step will be the classification of the selected models by main application area (e.g. production cost simulation, generation expansion, hydro-thermal coordination, price forecasting). The final deliverable will be a paper documenting the findings of the study along with recommendations for the development of improved tools for analysis of future electricity markets and valuation of hydropower and other flexible technologies. The research will be conducted in close collaboration with SINTEF Energy Research, the Norwegian University of Science and Technology (NTNU), and the HydroCen project, with Dr. Michael Belsnes (SINTEF/HydroCen) and Prof. Magnus Korpås (NTNU) as the main POCs.

Timeline:
Working paper ready for journal/conference submission: October 30, 2020