Transmission Network Investment in a Time of Transition

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Motivation

Because of unparalleled level of uncertainty in the electricity industry associated to the energy transition toward renewables, the problem of transmission planning is more complex than ever. Transmission investment remains fundamentally important, as a key facilitator of investment in new sources of generation. In this paper we review the literature on transmission network investment and regulation. We start with a review of the transmission planning task as carried out by a welfare-maximising planner and address the issues that arise in liberalised electricity sectors from the separation of generation and network investment. We further review the design of efficient financial incentives for a transmission planner, as well as the scope for merchant transmission investment and forms of competitive procurement. We also analyze the future challenges for transmission network investment in a time of energy transition, and even propose in an appendix a simple general stylized model for transmission planning.

Research Performed

In modern power systems the transmission network investment task is usually solved through an explicit optimisation algorithm. The algorithm takes as input the supply curve of every generator, the demand curve of each load, and the physical capability of the transmission network, and finds a combination of production and consumption for each generator and load which maximises the total economic welfare. The resulting locational marginal prices (LMPs) from this process send efficient signals for small-scale investment and dis-investment decisions at each location on the transmission network. However, even in sophisticated power systems, this optimal-dispatch process only operates every few minutes. On timescales shorter than the dispatch interval, it is common to rely instead on ad hoc or heuristic processes. Of course, there are many practical issues with the transmission planning task that make it more complex, such as computational intensity in the planning process, the handling of uncertainty and risk, and inefficiencies in the market and regulatory frameworks.

One of key question asked in the literature is whether it is possible to design a financial mechanism which provides incentives to the transmission company (TransCo) to both operate and invest in the network efficiently. In a market with LMPs, the TransCo will normally be the recipient of a merchandising (or congestion) surplus. In principle, the TransCo will face the correct incentives for the operation of, and investment in, the transmission network if it is granted a revenue stream equal to the total economic surplus received by the customers of the network (generators and loads). This idea can be seen reflected in the proposals of Léautier (2020) and Vogelsang (2020).

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In the proposal by Léautier, the TransCo is made liable for the difference between the total economic welfare created by the transmission network in two scenarios: (a) the case where there are no transmission binding constraints; and (b) the case where there are binding transmission constraints. Léautier claims that, under this mechanism, the TransCo will have the correct incentives to expand the grid. However, there are concerns with Léautier's proposal, such as: in the presence of inter-temporal constraints, the concept of unconstrained dispatch is not clearly defined.

The H-R-G-V proposal described in Vogelsang (2020) alternatively proposes a two-part tariff for the TransCo. The variable part of the two-part tariff is the merchandising surplus, while the fixed part is restricted to be less than or equal to the total consumers' surplus. The H-R-G-V mechanism has various desirable properties, such as immediate convergence to social optimal investment in expanding a transmission network. However, there are also some concerns with this proposal, such as: how the TransCo obtains complete information on the supply and demand curves for all existing and future generation and load assets?

Given the hurdles of incentive financial mechanisms, can a merchant mechanism be created under which private entrepreneurs have an incentive to pay for upgrades to the transmission network? Several researchers have asked the question whether it is possible to link incentives for investment with the sale of Financial Transmission Rights (FTRs). Biggar and Hesamzadeh (2020) emphasise that generators with an upward-sloping supply curve (or loads with a downward-sloping demand curve) would like to construct a portfolio with a volume that varies with the supply curve (or demand curve), such as so-called 'Cap' or 'Floor' contracts. They point out that a financial intermediary could provide hedge contracts to market participants and to the system operator.

Conclusion and Future Challenges

A wide range of transmission investment issues, which also represent a list of challenges for policy makers and researchers, are likely to arise in a time of energy transition, including:

- The need to explicitly value flexibility through the real options framework;
- A deeper understanding of the appropriate handling of risk;
- The need to pay closer attention to the identity of the beneficiaries of transmission investment;
- The need to be clearer about the handling of the costs of stranded assets, and
- Resolving the role of market forces in wholesale power system operation and its impact on investment.