OPTIMAL REGULATORY INCENTIVES FOR TRANSMISSION SYSTEM OPERATORS UNDER FLOW-BASED MARKET COUPLING

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Overview

Flow-based market coupling is the stipulated method towards an internal electricity market in Europe. It relies on Transmission System Operators to represent the transmission network constraints in a simplified way in the day-ahead electricity market clearing. We investigate welfare implications of the interplay between regulatory incentives and determining the trading domain. Therefore, this paper serves as a guide for policy makers, regulators, TSOs and market participants to tap the full potential of cross-border trade.

Specifically, researchers have extensively discussed that there exists freedom for TSOs to set the flow-based domains and that this impacts the efficiency of the market clearing. Therefore, regulatory intervention (MinRAM criteria) and incentive regulation can be used to push the TSO in the welfare-optimal direction. The latter has not been investigated, but is used in practice, so this paper addresses the question how incentive regulation affects the FBMC outcomes (as a consequence of TSO actions) and whether the full potential of FBMC can be achieved by optimally designing the incentive.

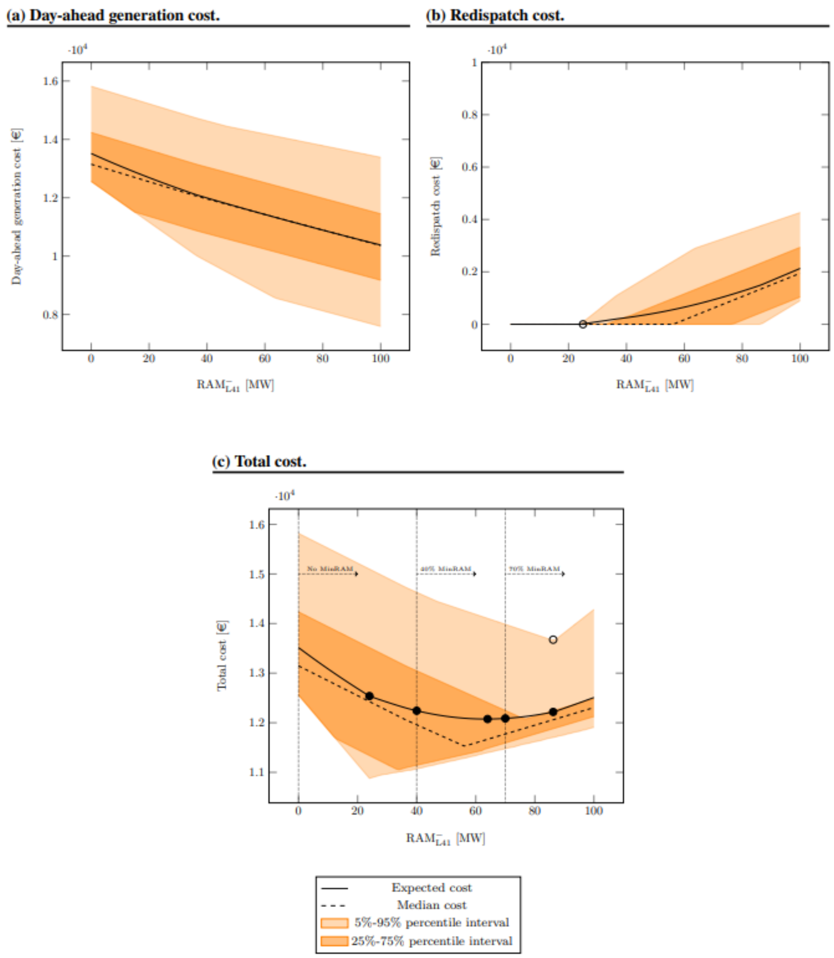
Methods

We set up of a coherent model that captures the three relevant temporal stages (D-2, D-1, D) in a flow-based electricity market. The mathematical model allows to give TSOs adequate incentives. Specifically, at D-2, the TSO determines the transmission capacity for trade by maximising an objective that users can easily adjust in the model. At D-1, the day-ahead coupled market clearing happens using the flow-based methodology. In a final stage, at D, cost-based redispatch adjusts the market schedule to ensure feasible flows.

Results

The figure below visualises the day-ahead, redispatch and total cost with varying RAM on a congested transmission line. Specifically, we display 5%-95% and 25%-75% percentile intervals to account for the uncertain load factors from renewable energy generation. The expected day-ahead generation cost decreases with a less constrained flow-based domain. A higher value for RAM enables more trade, i.e. it allows for a less costly market clearing and more price convergence among zones. However, price convergence comes at the cost of redispatch actions. Greater flow-based domains do not guarantee the feasibility of electrical flows in a constrained network. As a result, redispatch costs increase monotonously with RAM. From a welfare perspective, only the sum of both costs is relevant. The third subfigure shows the total cost with varying RAM. Note that the uncertainty on the total cost is lower than in the day-ahead generation or redispatch cost because both counter eachother.

A minimum in the expected total cost exists, implying the welfare-optimal RAM. Incentive regulation has the potential to provide welfare-optimal stimuli. Our paper lays out a set of conditions to optimally design incentives. Our findings imply a dynamic regulation scheme to anticipate constantly changing (usage of) power systems. Improper regulatory incentives, however, could lead to second-best outcomes that imply a welfare loss.



Conclusions

Flow-based market coupling is prone to cost-efficiency losses compared to its potential as TSOs determine parameters that represent the transmission constraints for the market. The determination of the trading domain can be welfare- (sub)optimal depending on the regulatory framework. The welfare-maximising outcome consists of a careful trade-off between day-ahead generation costs and redispatch costs as a result of the imposed trading domain. Acting as a social planner, TSOs set trading domains in a way that they lead to welfare-optimal outcomes of the day-ahead market and subsequent redispatch actions. However, TSOs could behave according to different incentives, leveraging a second-best outcome that imply a welfare loss. We show that this could lead to overly constrained or oversized trading domains depending on the conditions that implicitly steer the TSO's objective (e.g. minimising redispatch costs solely).

Incentive regulation serves as an instrument to correct for these imperfections, making the second-best outcomes converge to the first-best outcome. We lay out a set of conditions to optimally design an incentive that consists of (i) rewarding higher RAMs on binding network elements, and (ii) penalising excessive redispatch costs. The set of conditions depend on whether the redispatch cost vary with RAMs in a convex or concave way. Our paper implies a dynamic regulation scheme as a response to dynamic power systems with constantly changing parameters. This is opposed to current static approaches to determine (regulatory frameworks for) flow-based domains. This paper serves as a guide for policy makers, regulators, TSOs and market participants to tap the full potential of cross-border trade. Despite that the perspective of our paper is very European, its relevance is not limited to European cases. Specifically, the insights on incentives toward welfare-optimal cross-border trade are also helpful in other regions that strive for highly integrated electricity markets.