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RESEARCH BRIEF

Modeling Unit Commitment in Political Context: Case of China's Partially Restructured Electricity Sector

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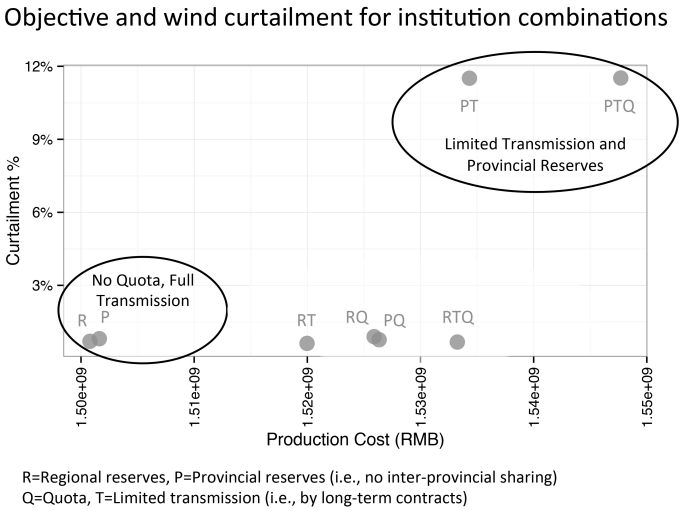
Electricity sector restructuring processes can undergo long, protracted transition periods that are not well-captured in typical power systems operation models. We create a tractable dispatch optimization with important political considerations for a region of China, demonstrating interactions among institutions relevant for ongoing power sector reforms.

A wide range of countries have chosen to introduce competition into one or several segments of the traditional vertically-integrated utility (VIU) model of electricity supply. Due to differences in institutional histories, resource endowments, regulatory philosophies, and macro-economic conditions, these transitions have been often protracted and incomplete (Jamasb, 2006; Correlje & de Vries, 2008). Calculating efficiency penalties of macro market design issues, such as the choice of zonal price zones over locational marginal pricing, is an important and growing area of research (Aravena & Papavasiliou, 2017). However, the effects on outcomes of the range of observed institutional combinations are not well explored in the literature.

China is currently undergoing a decades-long transition toward competitive electricity markets--most recently reinvigorated in 2015--while maintaining dispatch priorities that preserve quotas for coal generators and create non-physical barriers to trade. This paper develops a unit commitment (UC) optimization for the northeast region of China which minimizes production cost subject to both technical constraints and political priorities. We focus on the northeast grid, which is known for its inflexible must-run cogeneration, coal overcapacity, and persistent wind curtailment (Zhao et al., 2012).

Our findings show that while the quota and must-run cogeneration in winter contribute to increased system costs, they alone do not explain the region's poor wind integration. When inter-provincial trade is constrained in both the short- and long-term--i.e., reserves cannot be shared across provincial borders and transmission is limited by long-term contractual agreements--wind integration increases several-fold (see figure). Importantly, just one of these two sources

of inflexibility alone is insufficient to significantly increase wind curtailment.



R=Regional reserves, P=Provincial reserves (i.e., no inter-provincial sharing)
Q=Quota, T=Limited transmission (i.e., by long-term contracts)

A unit clustering technique is implemented (with acceptable aggregation errors in the objective of 0.02%) to deal with the long-term coupling quota constraints and to run sensitivities across uncertain policy parameters. Furthermore, our results are robust to changing the level of must-run cogeneration.

This unified model of technical and political constraints can provide guidance for reforms under consideration, in order to achieve near-efficient outcomes and other policy priorities such as renewable energy integration. For example, popular reforms of reducing the quota through long-term bilateral contracts without addressing inter-provincial trade barriers may not yield all desired benefits. Indeed, as quotas are reduced, the efficiency losses from limited transmission are enhanced.

The modeling framework presents additional opportunities for capturing realism of operating under political context. Future work could expand to other network and generator configurations, and explore more detailed dispatch heuristics and agent coordination mechanisms to understand additional observed inflexibilities.

References

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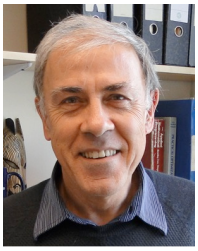
Michael R. Davidson is a Ph.D. candidate in engineering systems at the MIT Institute for Data, Systems, and Society. Michael studies the engineering implications and institutional conflicts inherent in deploying renewable energy at scale, particularly in systems with emerging electricity markets.



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