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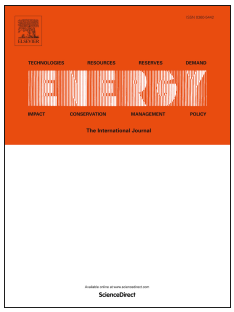

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Impact of model resolution on scenario outcomes for electricity sector system expansion

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Abstract

Power sector capacity expansion models (CEMs) explore least-cost infrastructure trends under alternate techno-economic and policy scenarios. To maintain computational tractability when considering investment decisions over multiple decades, CEMs typically rely on a compact representation of annual hourly grid operations. Even as CEMs are being used to explore the role of variable renewable energy (RE) sources in the transition to a low-carbon grid, the required temporal resolution and operational detail in a CEM to adequately capture the fundamental economics of RE sources remains an open question. Here, we investigate the impact of embedding additional operational and temporal detail in a CEM framework on the resulting projections for generation capacity additions and their utilization. Our approach is based on systematically comparing the outputs from a "chronological" CEM (C-CEM), which models annual grid operations using up to 12 representative days (288 hours), with outputs from a commonly used "time slice" CEM (TS-CEM), using seasonally-averaged time blocks. The CEMs mainly differ in their representation of operational flexibility of thermal generators as well as the temporal resolution of load and RE generation. Studying the Texas grid over a range of hypothetical RE penetration scenarios, we find that, more often than not, the TS-CEM estimates higher solar capacity and lesser wind and natural gas capacity relative to the C-CEM, with 35% higher solar capacity projected by the TS-CEM in one scenario. We also test capacity projections of both CEMs through an hourly grid operations model to explore operational metrics, such as the ability to meet demand subject to intra and inter-annual variations in load and RE generation. This experiment reveals that C-CEM projections consistently lead to lower unmet demand compared to the TS-CEM capacity projections. These findings imply the need for sufficient temporal resolution and chronology or validated parameterizations that yield similar behavior to be included in power sector CEMs and multi-sector energy-economic models using a time slice representation.

Keywords: power system modeling, multi-scale modeling, renewables integration, generation expansion planning, temporal resolution