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CapOptix: An options-approach-based framework for capacity market pricing models

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Abstract:

Current capacity market models, fail to provide sufficient financial incentives for renewable generation investments, leading to gaps in cost recovery for capital and operational expenditures. To address this, we introduce *CapOptix*, a reliability-options-based framework that estimates capacity premiums supporting energy expansion regardless of source being renewable or non-renewable.

Our model incorporates uncertainties in future energy prices, applying stochastic processes such as Brownian Motion and Geometric Brownian Motion, with and without jumps, based on supply shortfalls and market trends. We integrate financial option pricing tools including Bachelier's model, Black-Scholes, and Merton's jump Diffusion, treating capacity premiums as option derivatives of wholesale energy prices. These premiums are collected from load-serving-entities 2-3 years before delivery, ensuring peak-power delivery during 10-15 year contract periods.

We compare *CapOptix* with existing capacity remuneration mechanisms in markets such as NewYork and California. Net-Present-Value reveals that current approaches often fail to recover costs or overestimate payouts. By receiving upfront premiums, *CapOptix* empowers developers to manage cash flows at their discretion, reducing financial risks, fostering investor confidence, and promoting cost-effective, reliable infrastructure. Thus, by demonstrating practical financial assessments tied to market dynamics, *CapOptix* aims to strengthen energy projects and promote resilient, reliable sustainable systems.

Keywords: Capacity Market, Reliability Option

Biography:

Millend Roy is a *Ph.D. student in Operations Research at Columbia University*. His research focuses on energy systems, financial modeling, and smart grid optimization. Millend earned his *M.S. in Operations Research from Columbia University* and *B.Tech in Electrical Engineering from the Indian Institute of Technology, Indian School of Mines, Dhanbad*. He has two years of professional experience as a Research Fellow at *Microsoft Research India*, where he contributed to projects on energy management systems for grids and electric vehicles, building optimization frameworks integrating reinforcement learning and other advanced modeling techniques.

Vladimir Pyltsov is a *Ph.D. student in Mechanical Engineering at Columbia University*. He received his *M.S. in Mechanical Engineering at Columbia University* and *B.S. in Mechanical Engineering at Boston University*. His research interests are distributed solar systems and electricity markets with focus on development of optimization frameworks.