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Stochastic Programming for Renewable Energy Procurement with Targets

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In recent years, many companies have committed to renewable energy procurement targets, which usually require a certain fraction of the annual demand to be met by renewables. This annual approach overlooks the temporal fluctuations in energy supply and demand, leading to a growing interest in 24/7 targets that aim to match every consumed kilo-watt hour with carbon-free electricity sources at every hour of every day. Since this target is difficult to meet in real life, two relaxations can be defined: (i) hourly target, requiring a minimum fraction of demand to be met by renewables every hour; and (ii) temporal target, ensuring that the demand is fully covered by renewables for a specified fraction of the hours.

In this study we present a two-stage stochastic programming model to optimize procurement decisions to meet a target, using a combination of solar and wind power purchase agreements (PPAs), energy attribute certificates (EACs), and energy storage. In the first stage, decisions on PPA and storage sizes are made; in the second stage, these assets, alongside EACs, are used to meet demand and renewable targets throughout the planning horizon. Future electricity demand, renewable supply, and market prices of electricity and EACs are all uncertain factors that affect procurement decisions.

To tackle this stochastic program, we first demonstrate analytically that no target type between hourly and temporal dominates the other in terms of cost-efficiency. Then, including a discrete set of demand and price scenarios, we solve a two-stage mixed-integer linear programming formulation of our problem both by a commercial solver and scenario decomposition techniques. Preliminary numerical results reveal variations in procurement decisions when we relax the target fraction, distinguishing between hourly and temporal targets. Moreover, by incorporating different demand profiles (i.e., mostly flat, seasonal, and peaky), we highlight the necessity of transitioning from an annual matching framework to a 24/7 one, aiding the companies to set and meet renewable energy targets.

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