Optimal electricity consumption and storage under short-term renewable supply variability*

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Abstract

The expansion of intermittent electricity increases supply variability and requires greater flexibility from consumers. This results in welfare losses for these agents, which can nevertheless be mitigated by energy storage. Our model analyzes these welfare consequences in the context of short-term variability in renewable energy given fixed dispatchable and storage capacities. We explore an optimal control problem that determines a welfare-maximizing electricity consumption path by adjusting dispatchable and stored energy throughout the short-term production cycle of renewables. This optimization problem identifies three regimes (no storage and active storage, with or without capacity constraints) and provides the associated consumer welfare over this cycle. Under all three regimes, a certain degree of consumer flexibility is part of the optimal solution and entails welfare losses. Active storage reduces these losses but cannot eliminate them completely due to the energy conversion losses induced by this activity. However, when storage capacity is constrained, a proactive adjustment of this capacity can offset the losses.

Keywords: intermittent renewable, energy storage, electricity consumption, welfare analysis, optimal control

JEL classification: D61, Q40, Q42

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