Decisions at the Grid's Edge: An Improved Spatial PV Expansion in Swiss Residences

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Abstract

The rapid expansion of residential photovoltaic (PV) installations is a central pillar of the transition toward a renewable energy production. However, increasing PV penetration is beginning to create congestion in low-voltage distribution grids, risking damage to network components, production losses and constraints on further PV deployment. Using a newly developed spatial expansion model for a Swiss subregion, this paper quantifies the timing and magnitude of grid-related losses in the near future. The results further illustrate how a small adjustment to existing subsidy schemes can delay binding grid constraints by one to two years and reduce congestion-related losses by up to 6.02 percent. While such a subsidy design does not represent a first-best economic solution, it offers a practical and readily implementable approach, addressing the coordination challenges associated with decentralized residential PV adoption.

1 Introduction

The global debate about the energy transition has been accelerated in recent years both due to more political attention to climate change and a surge in fossil fuel prices. Policymakers at all levels are increasing their efforts to decarbonize their energy production. Photovoltaic (PV) electricity production is playing a decisive role in this transition and is predicted to surpass coal in 2027 with 2350 GW or 22 percent of global cumulative power production capacity (IEA, 2022).

Because the decision of adaptation of residential PV is with individual investors, their installations' impacts on low-voltage grid network capacities are not taken into consideration. A coordination mechanism steering decentralized behavior and avoiding negative effects is still absent. Consequently, grid component overloading has already been observed, requiring costly grid updates or the curtailment of production which in turn slows down the further expansion of renewable energy (REN21, 2023).