EVALUATING DESIGN OPTIONS FOR IMPROVED INTEGRATION OF PV AND BESS INTO THE AUSTRIAN POWER SYSTEM AND BEYOND

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Abstract

Introduction

Solar photovoltaic (PV) generation has become a central pillar of Europe's decarbonisation strategy. In recent years, Austria has seen a rapid expansion of PV capacity, driven by the ambition to supply 21 TWh of electricity from solar power by 2030 [1]—an essential milestone for achieving the national target of 100% renewable electricity as defined in the NECP [2].

However, the accelerating growth of PV is creating challenges for both the Austrian power system and the wider Continental European synchronous area. Increasingly frequent PV feed-in peaks are contributing to congestion in distribution and transmission networks, leading to higher redispatch volumes and rising balancing costs [3]. Simultaneously, extreme positive and negative price peaks are placing additional pressure on market participants [4]. With current grid expansion plans falling short of projected PV growth [5], these tensions are expected to intensify.

Battery energy storage systems (BESS) are regarded as a key lever to mitigate these challenges. According to [6], Austria will require roughly 5.1 GW of BESS capacity by 2030 to manage weather-dependent fluctuations, relieve network congestion, and support system stability through ancillary services. At the same time, the recent surge in grid connection requests driven by falling battery cell prices and renewable-induced wholesale price spreads has raised concerns among system operators about how to effectively integrate BESS into future power system planning [6].

Against this backdrop, a systematic implementation of regulatory and market design options for both PV and BESS integration is essential to support a secure and economically efficient energy transition. Although Austria's current legislation has begun to introduce various design options, their actual contribution to system-friendliness, overall efficiency, and broader system impacts remains insufficiently understood. A thorough assessment is therefore needed to determine how effectively these measures can address emerging challenges in the evolving power system.

Research Questions

The research questions formulated in this context are:

- Which regulatory and market design options can support a **system-friendly** integration of photovoltaic (PV) generation and battery energy storage system (BESS) operation into the Austrian power system?
- How do these design options perform with respect to other key indicators such as **economic viability**, **renewable curtailment**, and other system-and household-level metrics?

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Method

To address these research questions, an extensive literature review is conducted with the goal of identifying relevant design options within the current Austrian legislative framework (e.g. Elektrizitätswirtschaftsgesetz (ElWG) [7]) as well as in international contexts. The insights derived from the literature are subsequently validated using a simplified analytical model that enables the assessment and comparison of different system design options.

The model represents Austria's PV and BESS potential as a single-node system, in which regulatory and market design options (RTP vs. fixed feed-in tariff, static peak shaving, capacity-based tariffs) determine the utilization of photovoltaic generation and battery storage. It allows for differentiation between household-level and system-level perspectives and incorporates varying degrees of flexibility, including demand-side and sector-coupling options.

Within this framework, a set of KPIs is generated and compared, capturing economic viability, renewable curtailment, maximum injections and withdrawals, and overall system friendliness of each design option. Based on the KPI results and the accompanying graphical analyses, design recommendations are derived for key stakeholders — including the Austrian transmission system operator APG, which serves as the technical advisor for this work.

Preliminary Results

The preliminary analysis has focused on research questions 1 and 3, examining several design options for PV integration including real-time pricing (RTP) as a PV remuneration scheme, static peak shaving, and capacity-based tariffs for PV feed-in. The results indicate that RTP improves economic viability but leads to higher curtailment and increases in maximum feed-in. Static peak shaving reduces curtailment but results in economic losses, while capacity-based tariffs cause even higher losses, albeit offering the strongest reduction in peak injections.

A comparison of key performance indicators (KPIs) related to PV integration further shows that the introduction of flexibility options improves outcomes across all scenarios while it is associated with higher upfront investment expenditures. Overall, a combination of system design measures appears most effective, enabling system-friendly utilization of PV while maintaining economic feasibility and reducing curtailment.

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