SIMULATING THE AUSTRIAN DAY-AHEAD MARKET USING THE OPEN AGENT-BASED ELECTRICITY MARKET MODEL AMIRIS

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Motivation

Electricity markets play a key role in order to accomplish the energy transition. It is of high interest to modelers to understand the growing complexity of those markets [1]. Renewable energy technologies increasingly change the price dynamics due to their fluctuating electricity generation. New policies are implemented to lead the way towards net-zero emissions energy systems. Comprehensive tools are necessary in order to understand current and future electricity markets. The method of agent-based modelling promises to account for these challenges by putting the spotlight on agents' behaviour and interactions with their environment [2]. Yet, empirical validation is challenging [3]. In order to validate the state-of-the art electricity market simulation model AMIRIS, we back-test the model's capabilities by simulating Austrian day-ahead market prices and comparing them to historic prices from 2019. We strive for full scientific transparency by providing model code and data at https://gitlab.com/dlr-ve/esy/amiris.

Method

We simulate electricity markets by applying the agent-based model AMIRIS. The model has been extensively and consistently developed for more than a decade at the German Aerospace Center. The model is based on the open framework FAME (https://gitlab.com/fame-framework). FAME gives modelers great flexibility by handling agent messages and parallelization. In AMIRIS, agent types account for different actors in the electricity system. **Fehler! Verweisquelle konnte nicht gefunden werden.** represents a schematic overview of the current agent types and their connections, i.e. energy, money, and information flows.

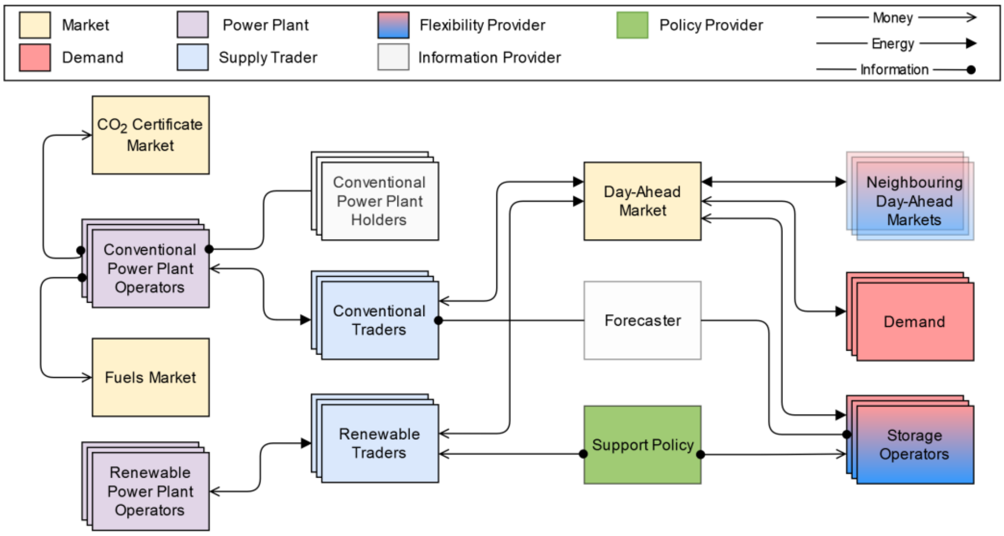

Figure 1: Schematic representation of the AMIRIS model structure.

The centre of the simulation is a representation of the day-ahead electricity market, where an hourly market clearing with uniform pricing is carried out [4]. Traders send their bids to the market once they have collected relevant information such as fuel prices, CO_2 prices, and marginal costs from their associated power plant operators. Neighbouring markets can be added as time series. A dedicated market coupling agent [5] is currently developed. AMIRIS requires inputs regarding power plant capacities, renewable energy generation, electric load, fuel prices, emission allowance prices, and

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remuneration schemes. Results comprise day-ahead electricity prices, power plant dispatch, market values, carbon emissions, and system costs.

This allows several different analyses, such as refinancing of renewable power plants [6], market effects caused by different remuneration schemes [7], economic assessments of individual actors such as battery storage operators [8], effects of cross-border electricity trading during extreme weather events [9], or modelling of demand response [10]. Using open data sources, we parameterize AMIRIS for the Austrian day-ahead electricity market.

Results

The price duration curves of the simulated and historic day-ahead prices are shown in Figure 2. At the lower end, AMIRIS does not reproduce negative prices. This is caused by the yet missing parametrization of run-of-river remuneration policies. Due to the complex Austrian remuneration scheme it is hard to estimate reliable values. However, historic prices below $-10\ \mathrm{EUR/MWh}$ account for less than 24 hours of the full year. At the upper end, simulated prices stay below the historic ones for prices above $80\ \mathrm{EUR/MWh}$. AMIRIS does not contain situational bidding strategies for conventional power plants, yet. Thus, scarcity-induced mark-ups are not considered.

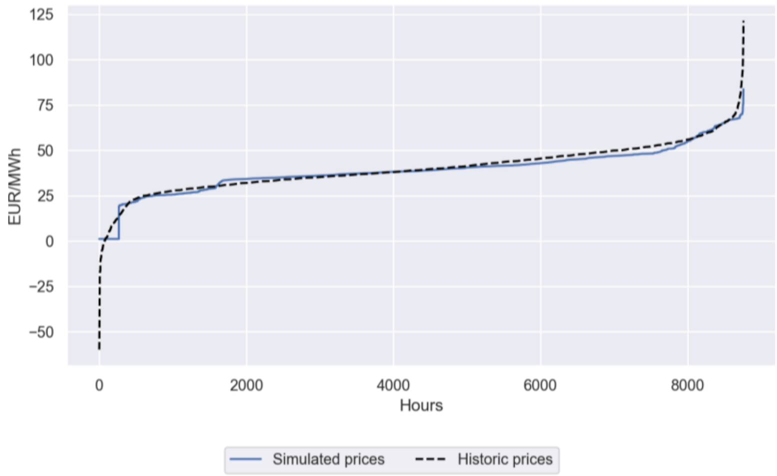

Figure 2: Comparison of simulated and historic day-ahead price-duration curves.

Comparing mean values, we find $39.12\ \mathrm{EUR/MWh}$ in the simulation and $40.06\ \mathrm{EUR/MWh}$ in the historic timeseries with $1.00\ \mathrm{EUR/MWh}$ higher standard deviation in the latter. When parameterized in higher level of detail (e.g. endogenous modelling of neighbouring countries and more comprehensive representation of storage), we estimate to achieve an even better fit. Our fully open modelling approach enables scientists to quickly reproduce these results and easily conduct further research on today's and tomorrow's questions in the field of energy economics.

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