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A massively parallel approach to forecasting electricity prices

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Background

With the ongoing energy crisis in Europe, accurate forecasting of electricity price levels and volatility is essential to planning grid operations and protecting consumers from extreme prices.

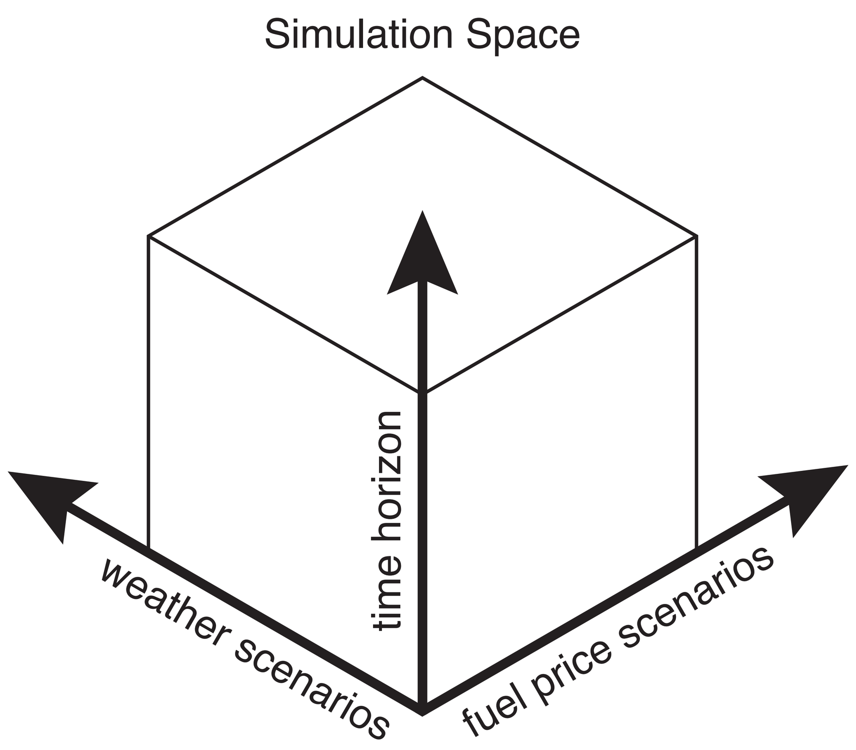


Fig. 2 - Weather scenarios are combined with fuel price scenarios to form simulation set. On a typical trading day, ~135k scenarios are simulated at a cost of ~6k CPU hours per day.

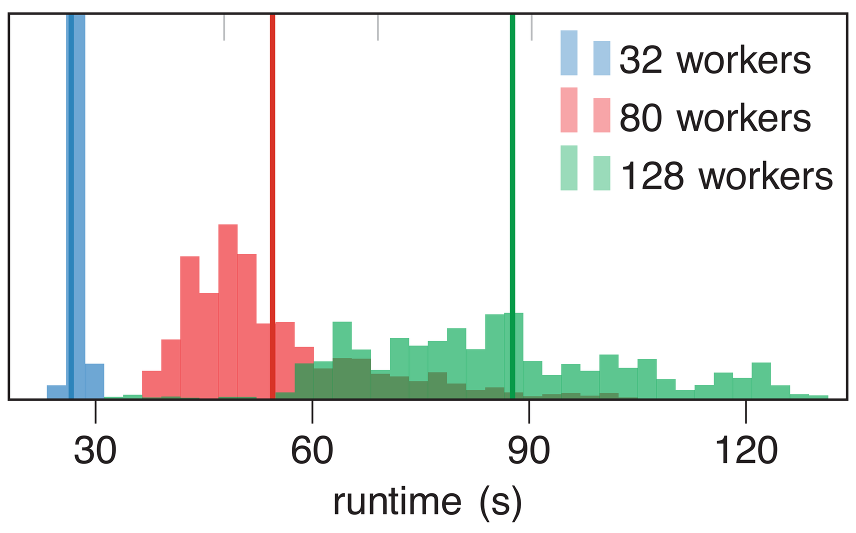
Massively parallel stochastic optimal power flow (OPF) models deployed on computational clusters efficiently forecast grid configurations in real time. The grid is represented with the Economic OPF Model visualized in Fig. 1. Fig. 2 shows the huge batches of input variable scenarios that are prepared and then run through the model to estimate the price distributions shown in Fig. 3.

Parallel deployment

Given the independent nature of individual simulations, single-level parallelization is conceptually simple, although deployment in a production environment on modern clusters with many-core architectures presents challenges. Fig. 4 shows how increasing single-node parallelism causes congestion that greatly impedes throughput.

This impedance varies not only with the level of parallelism, but also size of the simulations, underlying model type, and solution algorithm used. Numerical experiments presented in SEST 21 and SEGAN 2022 papers (see QR codes below), show that deployment using optimized levels of parallelism can increase simulation throughput by 63%.

Fig. 4 - Histogram: runtime vs. parallelism. Scenarios are processed on a single AMD Zen 3 128-core compute node. As number of concurrent simulations increases, mean (vertical lines) and variance of runtime increase considerably.



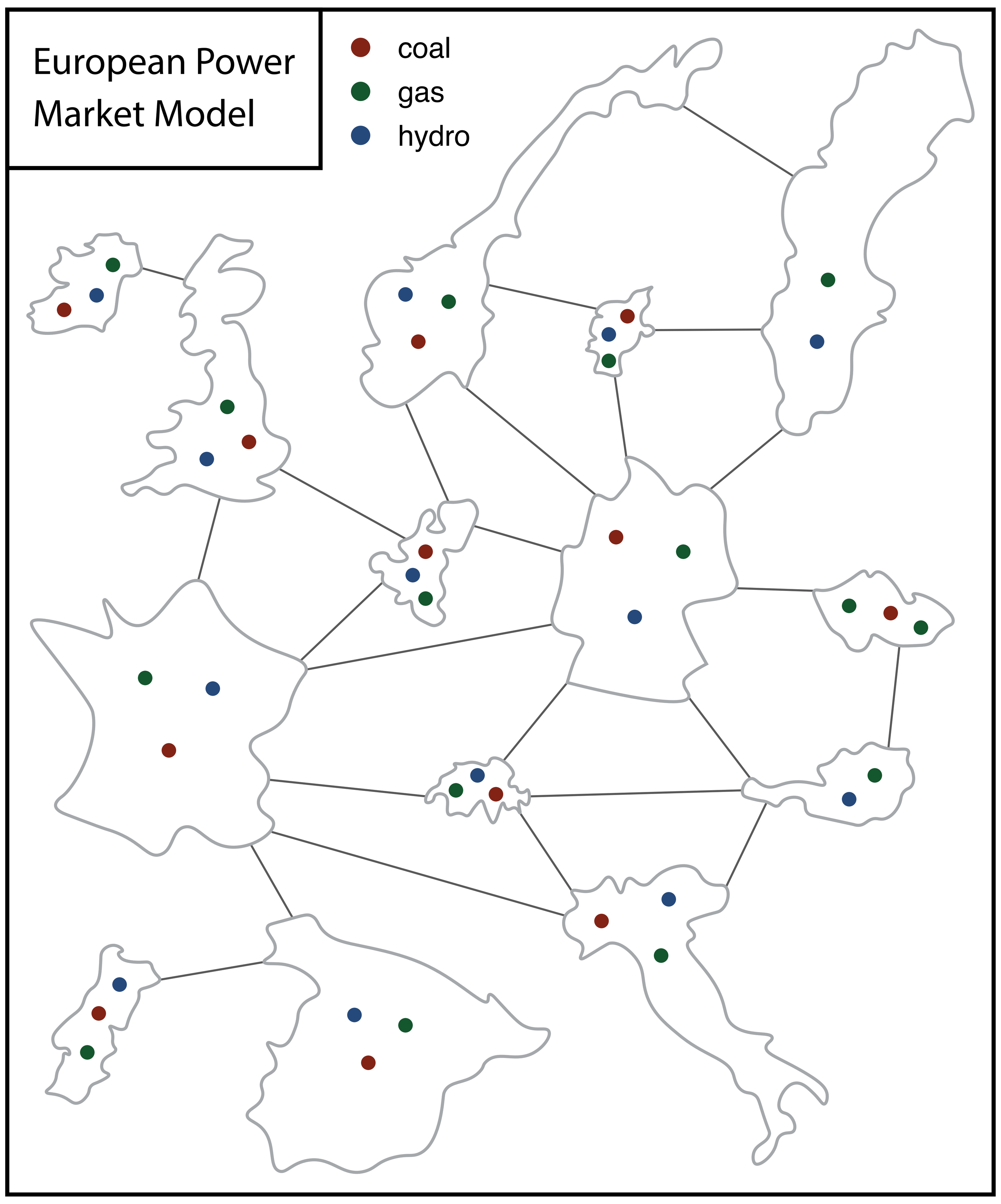
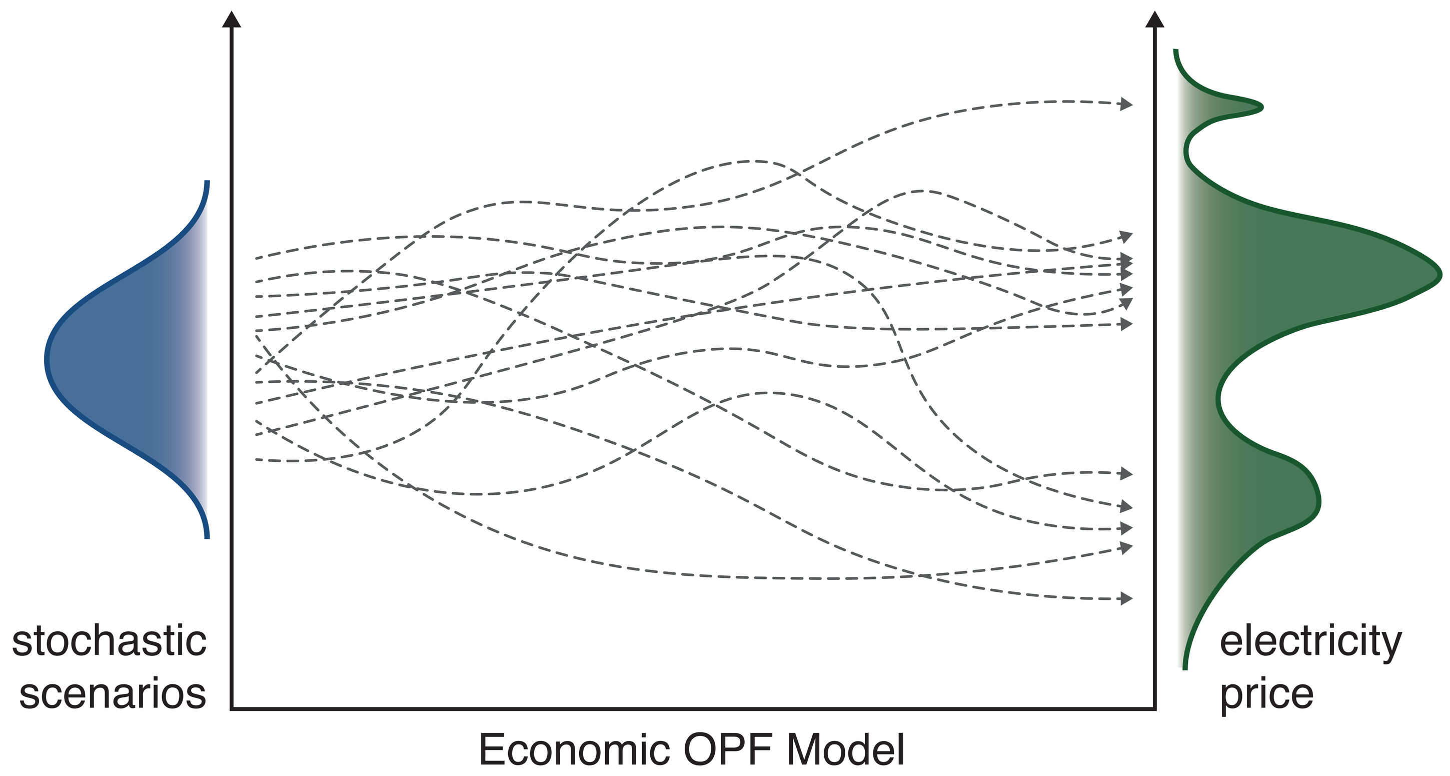


Fig. 1 - Conceptual representation of the European Power Market Model. Model optimizes over 43 market zones, 13 generator types, ~600 individual generators, and from 40 to 256 time periods.

Fig. 3 - When the batch of scenarios is processed the results form a price distribution. Quantifying uncertainty in regional price forecasts helps traders understand the financial risk involved in a given trade.



Simulation Process

1. Process weather data

Weather forecasts arrive 4x daily in data dumps that present 50 different equiprobable scenarios with hundreds of weather variables at 0.2° Resolution.

2. Form demand and renewables generation profiles

For each weather scenario use proprietary models to form expected demand and renewables generation profiles for each market zone for each time period.

3. Generate batch of simulation scenarios

Combine demand and renewables generation profiles with stochastic fuel price trajectories to form a batch of simulation scenarios.

4. Run scenarios through the market model

Process each scenario in the batch through the Economic OPF Model to estimate generator dispatch in each zone given the scenario.

5. Form price expectations

For each market zone at each time period form a distribution of prices based on the cost function of the marginal generator.

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