Electrical Grid Management

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Motivation

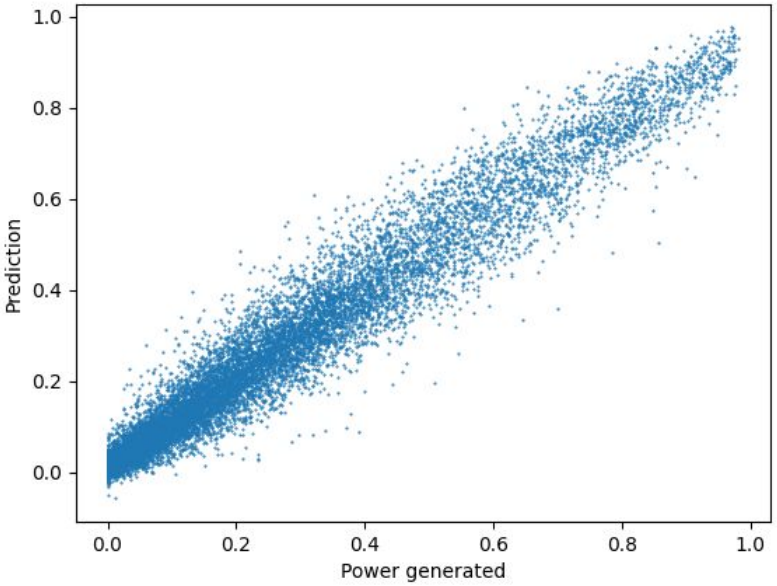
- Volatility of renewable energy
- Backup energy sources - e.g. hydro, gas
- Gas - around two hours to ramp up power
- Renewable energy generation depends on weather
- We can predict it, if we have meteorological data

Prediction

01 Dataset on temperature, wind, humidity and turbine power for every hour over five years

02 MLP model should use current data to predict power generated two hours later

03 Training model on part of the data, then validating it

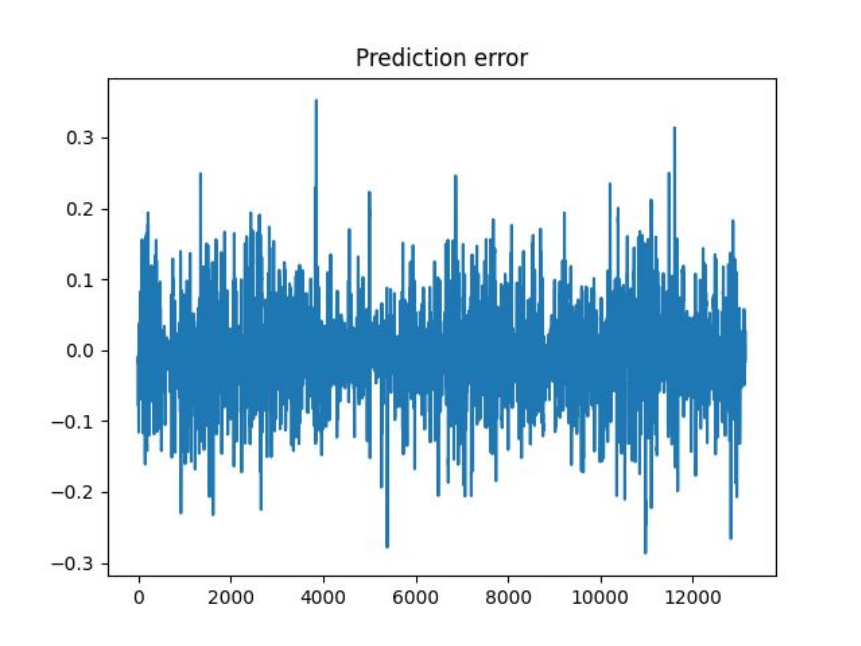


Validation

- $R^2 = 0.95$

Energy Backup

- Estimate wind energy production
- Use gas to supply the rest
- Prediction error? Blackout 💀
- Add a battery maybe



Battery

- Large enough to absorb errors
- 6 x S.D. of prediction error

Prescription

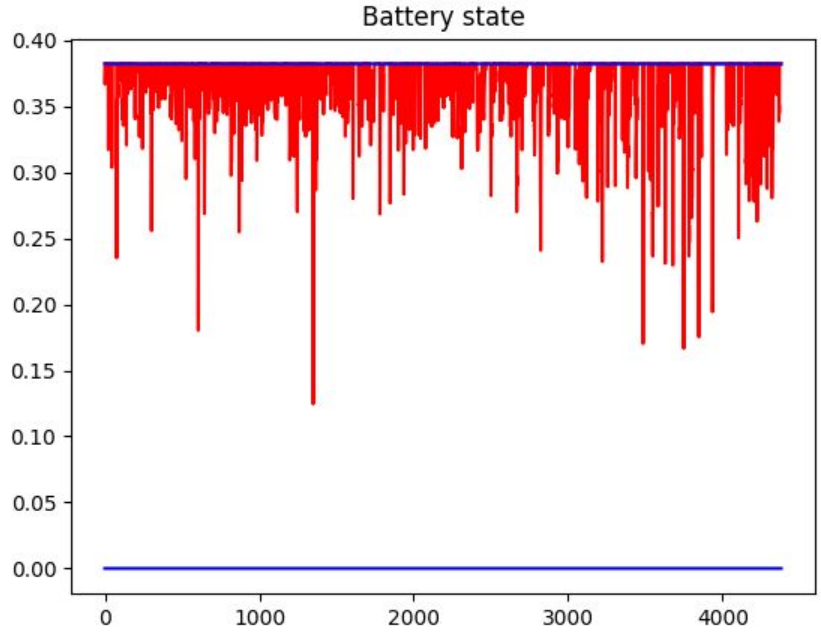
01 Calculate how much gas power to generate for balancing fluctuations

02 The difference between energy consumption and production is stored to or taken from the battery

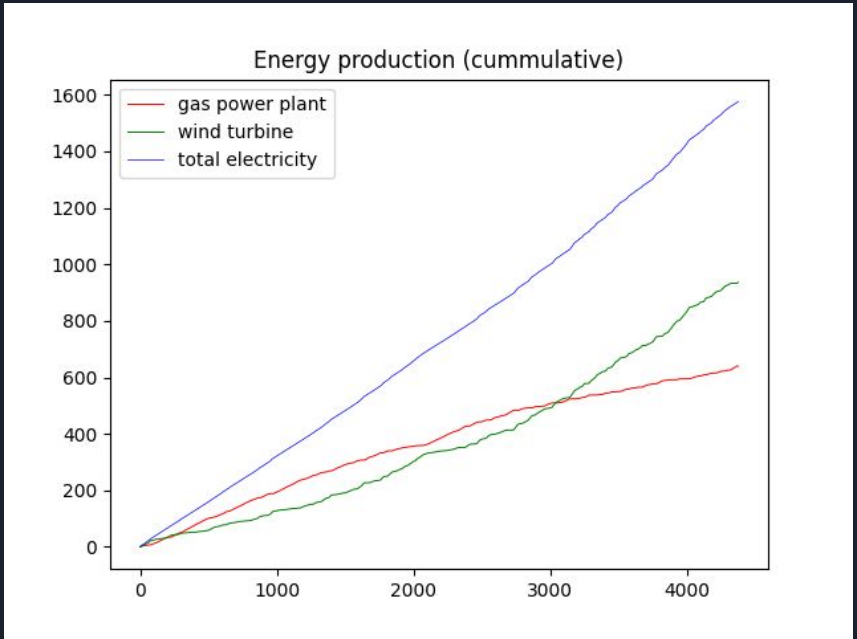
03 Aim to meet the demand and refill battery for future needs

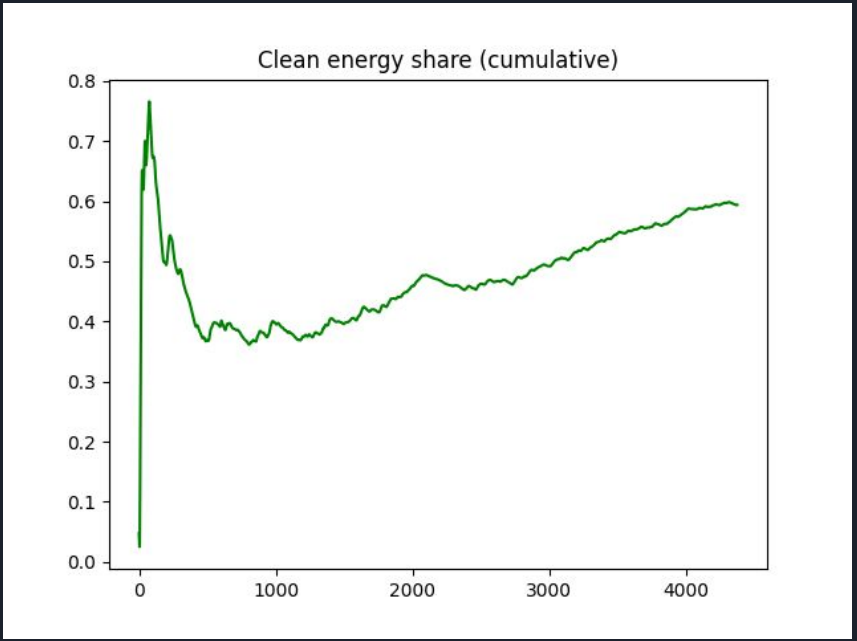
Simulation

- Blue lines - limits of battery
- Red line - battery state
- No blackout for six months 🎉



Energy Production





Assumptions

- Assuming constant demand for simplicity
  - It does matter in practice, we'd just add one more MLP, prescription would remain the same
- Assuming excess electricity is not a problem
  - Both wind turbines and gas power plants can ramp down quickly to avoid overgeneration

Training

- Dataset split into three parts - for training MLP (first 60 %), for validation and estimating error SD (next 30 %), and for simulation (last 10 %)
- Using scikit-learn for MLP regression
- The rest is statistics using numpy and matplotlib

Possible extensions

01 Add cost considerations in deciding battery size

02 Avoid overproduction to reduce gas consumption

03 Multiple electricity sources with different properties

Thank you!

Dataset source:
https://www.kaggle.com/datasets/mubashirrahim/wind-power-generation-data-forecasting