Optimal Control of Microgrid

Brain Hackathon 12-14 March 2021

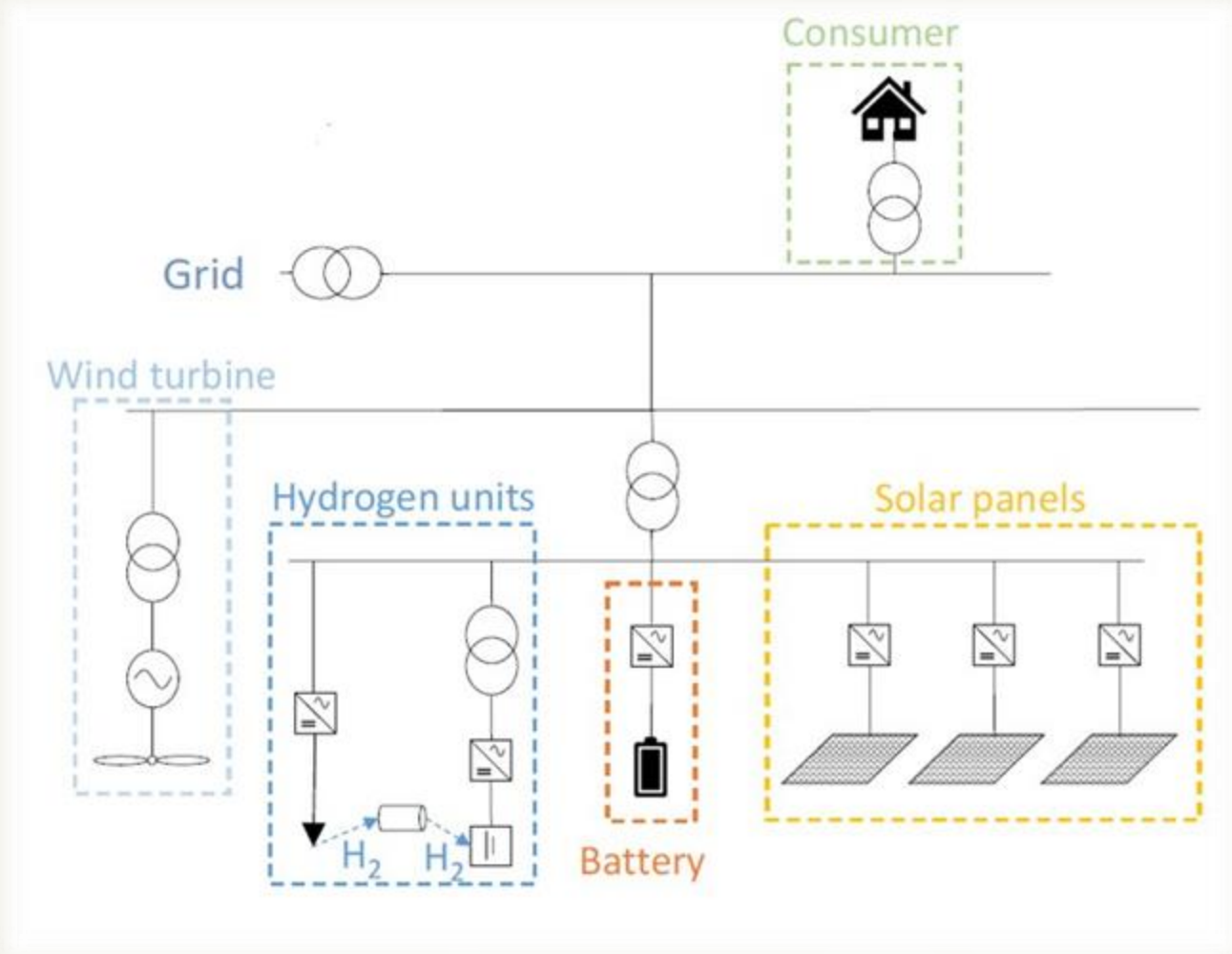
Collaboration: TrønderEnergi and NTNU CityXChange

The Rye Microgrid

- System to deliver electricity to a small neighbourhood at Rye (1 farm, 3 households)
- Goal to minimise usage of electricity from the grid
- Production units
  - Wind turbine
  - Photovoltaic (PV) panels
- Storage units
  - Battery energy storage system
  - Hydrogen energy storage system

Microgrid: Goal and control

- Purpose is
  to provide electricity locally and sustainably
- Current control system
  is myopic and rule based
- Our wish is a smarter and anticipative control system

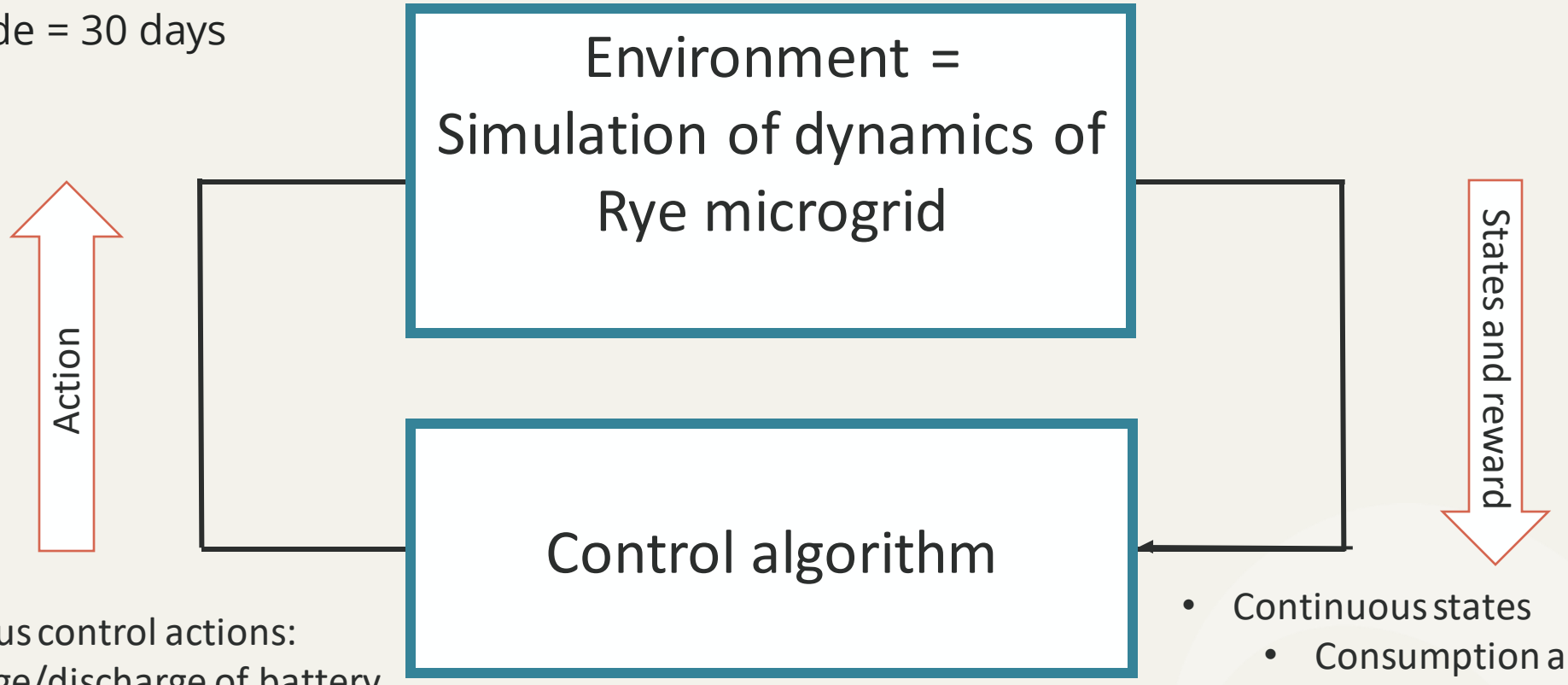


Control task: requirements

- Minimise cost of imported electricity from the grid
  - Per-unit cost and peak import tariff
- Control actions:
  - Direct: Charge and discharge storages
  - Implicit: Import electricity from grid
  - Implicit last resort action: Curtail / throw away excess production
- Observations:
  - Consumption, Wind production and PV production are stochastic variables
    - (Partly function of the weather)
- Constraints/ Limitations:
  - Consumption must be met at all times, through wind or PV production, discharge from storages or from grid
  - There are limits on storage, as well as charge and discharge limits
  - Energy is lost in the conversion process to the storage
  - Energy produced in the microgrid cannot be fed into the grid

Control loop – interface controller and simulator

- Resolution = one hour
- One episode = 30 days



- Continuous control actions:
  - charge/discharge of battery
  - charge/discharge of hydrogen storage

- Continuous states
  - Consumption and production, battery storage,
  - hydrogen and battery storage
  - Grid import and spot market price
- Reward: Cost of grid import

Simulator of Rye microgrid

- Technical details
  - Python
  - Implemented as OpenAI Gym (generic interface for any control system)
  - GitHub repo: https://github.com/TronderEnergi/tronderenergi-ai-hackathon-2021
    - Includes simulator-code and assignment text

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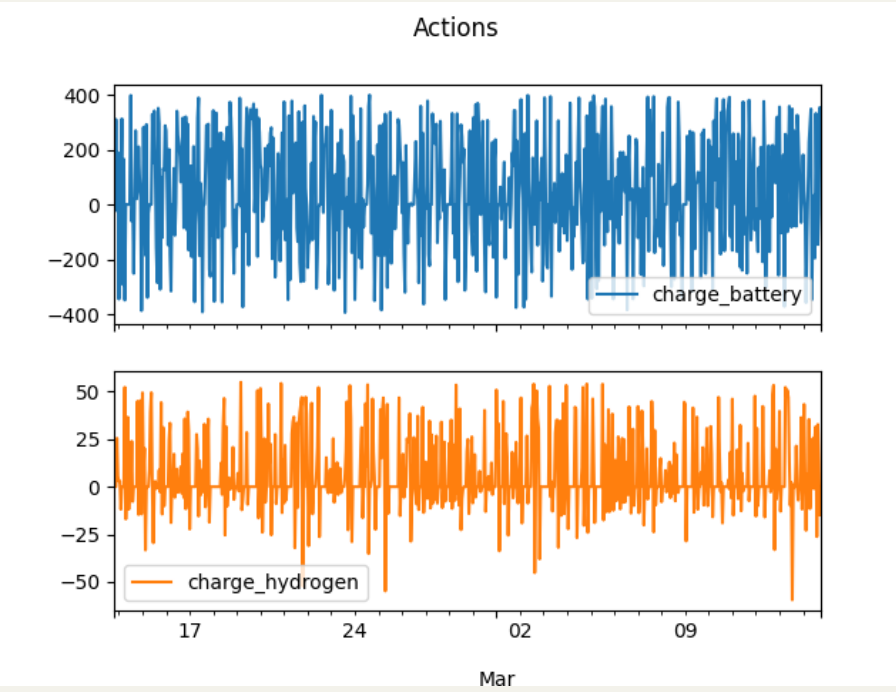
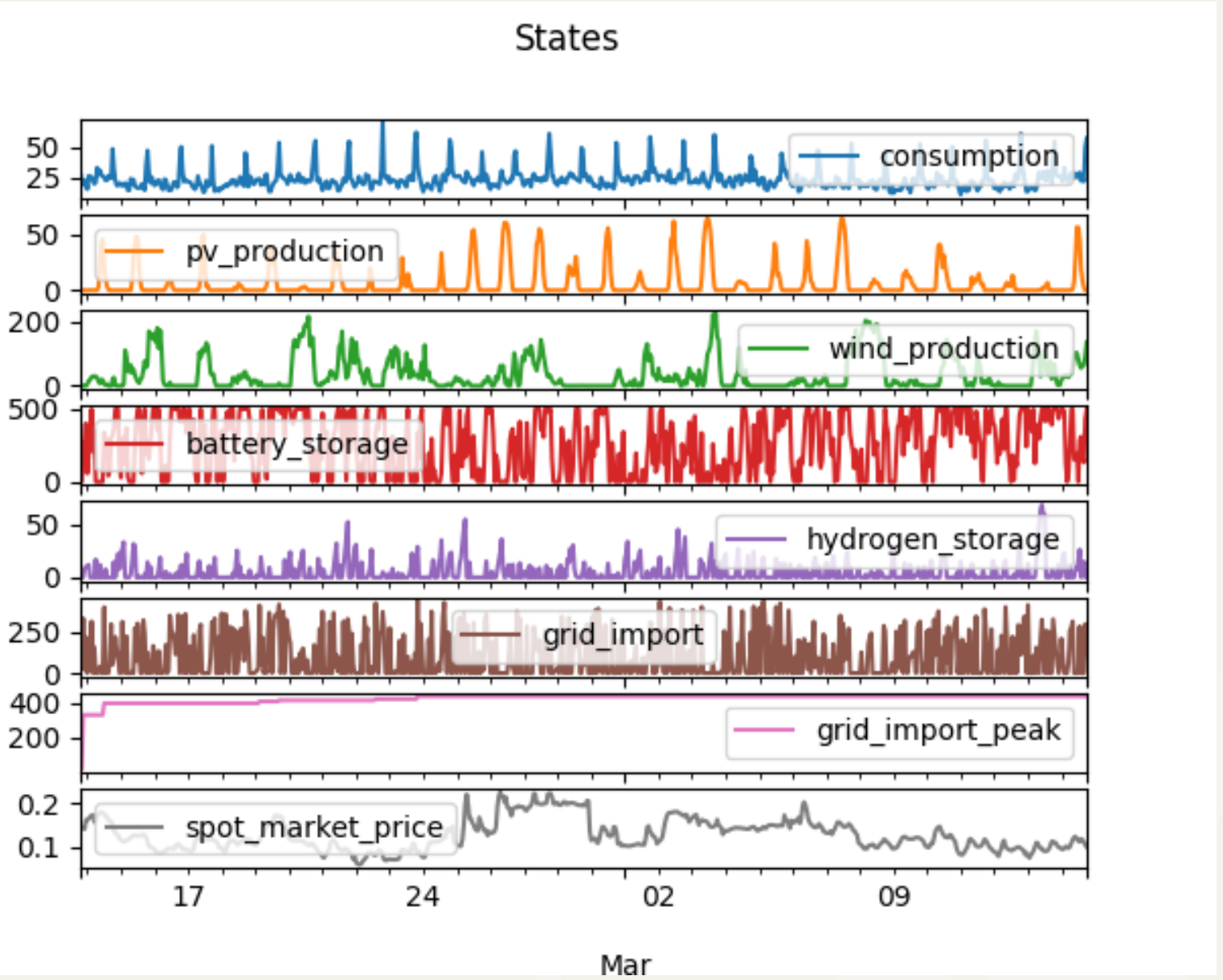
Example random agent

```python
def main() -> None:
    data = pd.read_csv("data/train.csv", index_col=0, parse_dates=True)
    env = RyeFlexEnv(data)

    agent = RandomActionAgent(action_space=env.action_space)
    plotter = RyeFlexEnvEpisodePlotter()
    info = {}
    done = False

    while not done:
        action = agent.get_action()
        state, reward, done, info = env.step(action)
        plotter.update(info)

    print(f"Your score is: {info['cumulative_reward']}")
    plotter.plot_episode()
```

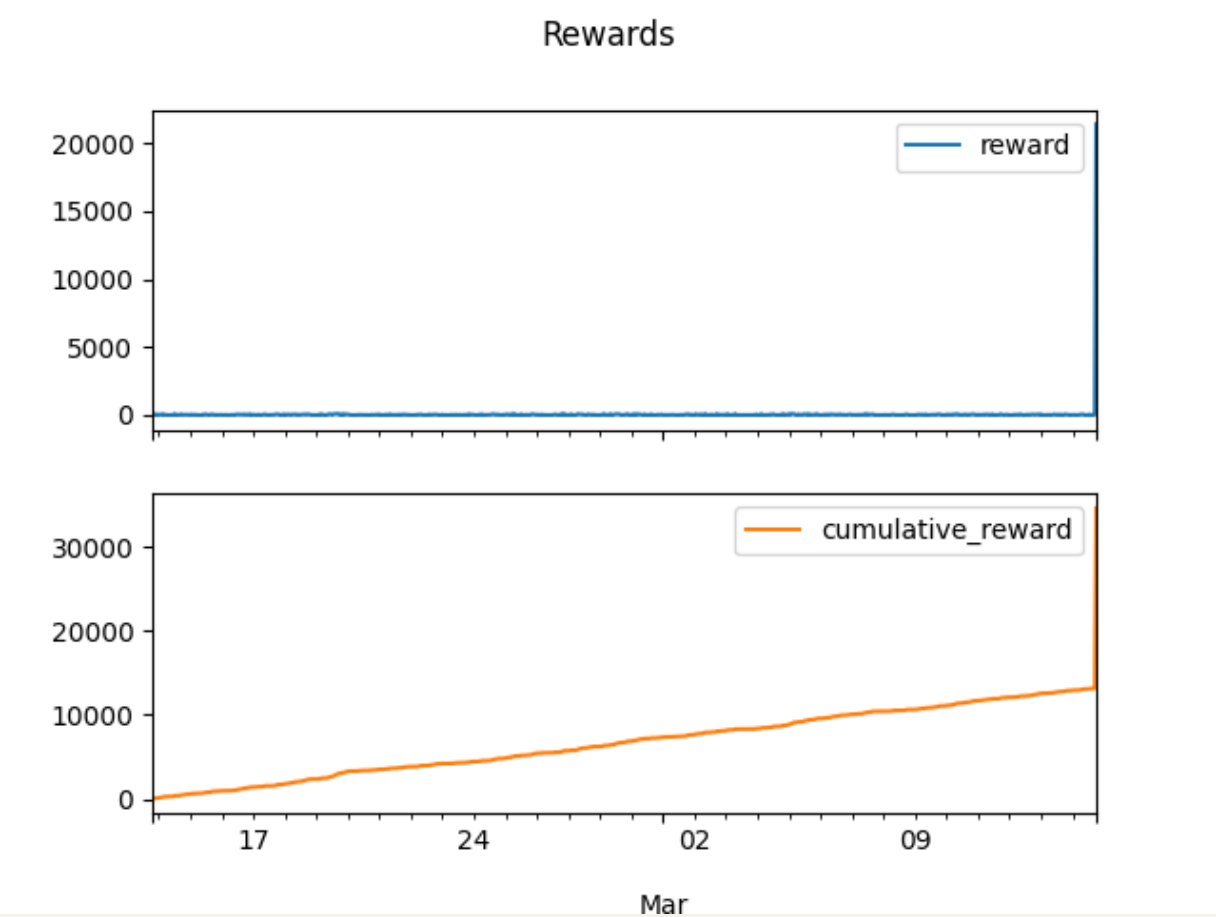
- Link: https://github.com/TronderEnergi/tronderenergi-ai-hackathon-2021/blob/main/scripts/random_action.py

Example random agent





Example random agent



Your score is:
41342.76834 NOK

Data

- Simulator uses historical data of consumption, production and spot market prices
- Additional data provided: Weather data
  - NB: It is allowed to use other data sources if desired
- Hourly data
- We have split it into training and testing dataset
  - Training dataset: Used during development (2020 January – 2021 January)
  - Test dataset: Used for evaluation and provided on Saturday 18.00

Design of control algorithm

- Your imagination is the only limit!
  - Solution only need to interface with the simulator (and not allowed to change simulator)
  - NB: Allowed/encouraged to do feature engineering and/or reward shaping based on simulator output/data etc.
- Examples
  - Traditional optimization (LP, QP, LQR, MPC etc.)
  - Greedy algorithms
  - Search algorithms
  - Evolutionary algorithms
  - Deep reinforcement learning
- Combine several ML and/or optimization-solutions:
  - Create forecasts of certain states to help control-algorithm?

Evaluation

- Score = cumulative reward for test period
  - Reproducibility - we can run your code to get the same/similar score
- Methodology
  - Method selection
  - System design
  - System implementation
- Presentation
  - Score
  - Plots with actions and environment state
  - Explanation and justification of choices made

Mentors

Odd Erik

Gleb

Gro

Aleksander

Ella-Lovise

Erik

Raquel

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The best of luck and good hacking!