Multi-Timescale Production Planning of Integrated Heat and Electricity Systems Participating in Electricity Markets

Helen Saragih, Kristian Sandström, Stavros Vouros
School of Innovation, Design and Engineering, Mälardalens University

Introduction

A reliable power grid must maintain a fixed frequency by balancing supply and demand in real-time. In Sweden, electricity demand is expected to double by 2045, while the increasing share of renewables introduces greater uncertainty to the power system. This calls for flexible resources to ensure grid stability.

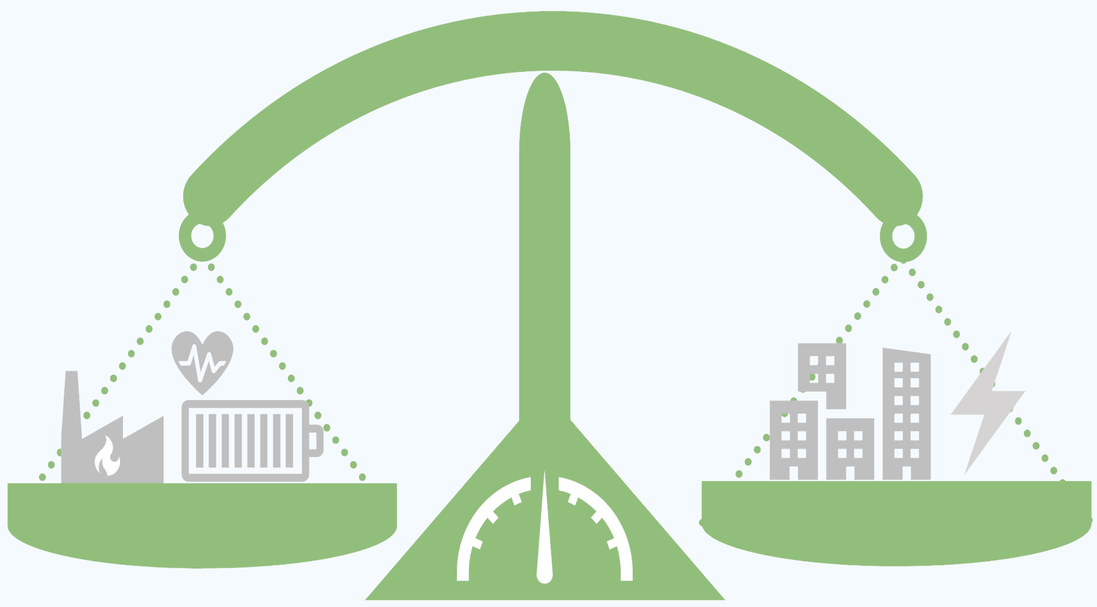
Electricity is mainly traded ahead of time, and forecast is used at the time of decision-making, which is subject to uncertainty. This makes decision-making increasingly difficult, especially when planning operations over multiple time windows.

Batteries are used to provide balancing support due to their fast response, but they have limited energy capacity and degrade over time. Combined Heat and Power (CHP) plants are widely used in Sweden for co-producing electricity and district heating, but their flexibility remains underutilized. Coupling batteries with CHP plants offers a way to enhance short-term and long-term operational resilience by combining the complementary characteristics of both technologies.

This research investigates how assets in the heating and electricity sectors can use data-driven strategies, particularly model predictive control and reinforcement learning, to make informed operational decisions over time under uncertainty and improve system resilience.

Objective

- Explore how heat and electricity assets can jointly enhance operational resilience.
- Identify uncertainties that impact decision-making and market participation.
- Use data-driven strategies to improve decisions under uncertainty.
- Evaluate learning-based methods to optimize operations over time.

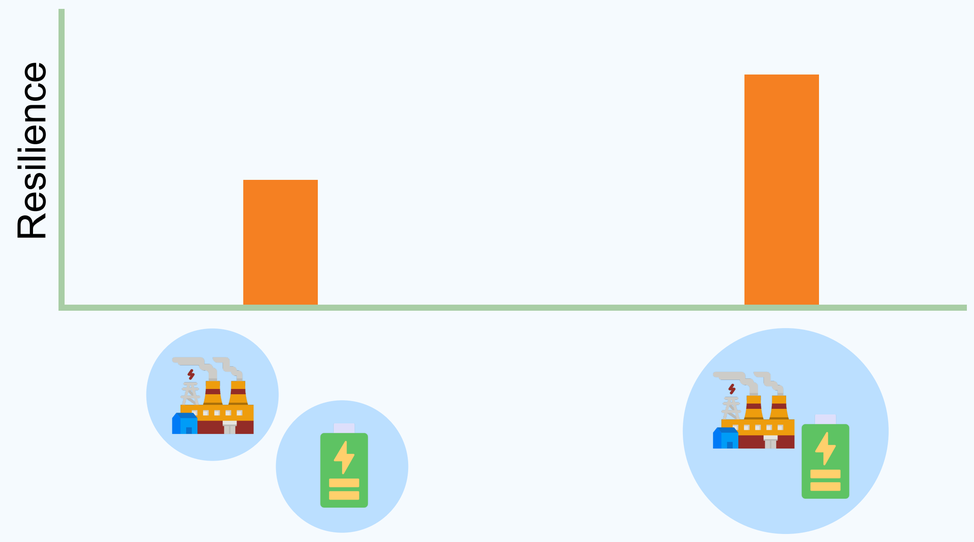


Method

This research uses a machine learning approach, specifically reinforcement learning (RL), to model decision-making in energy systems under uncertainty.

- Data collection: Gather data on district heating demand, market prices, weather, and grid parameters from public sources and industrial partners.
- Scenario generation: Create various scenarios to capture uncertainties.
- Training: Use the data to train an RL agent that learns to balance short-term and long-term decisions.
- Evaluation: Assess performance using resilience metrics.

Expected results



System Overview