AI for smart grids and renewable energy

Ann Nowé

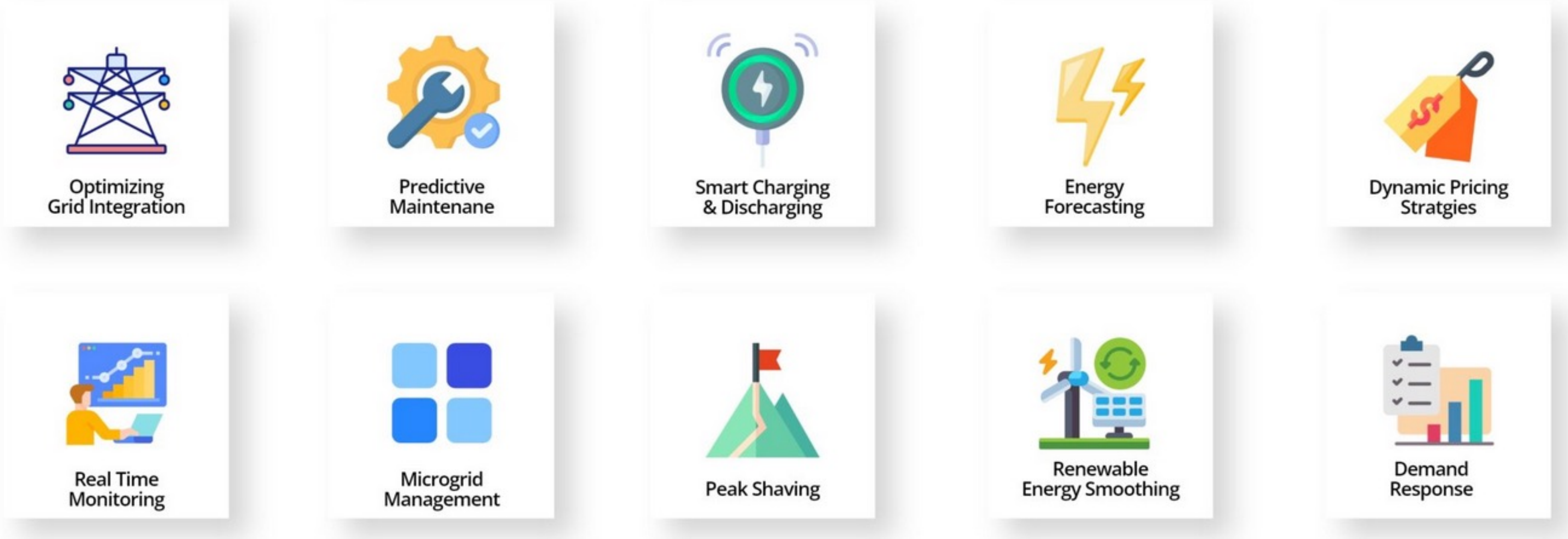
AI lab VUB

November 26th, 2024

ai.vub.ac.be

Powering the future - AI innovations in the energy sector
26 November 2024

Applications of AI in the energy sector



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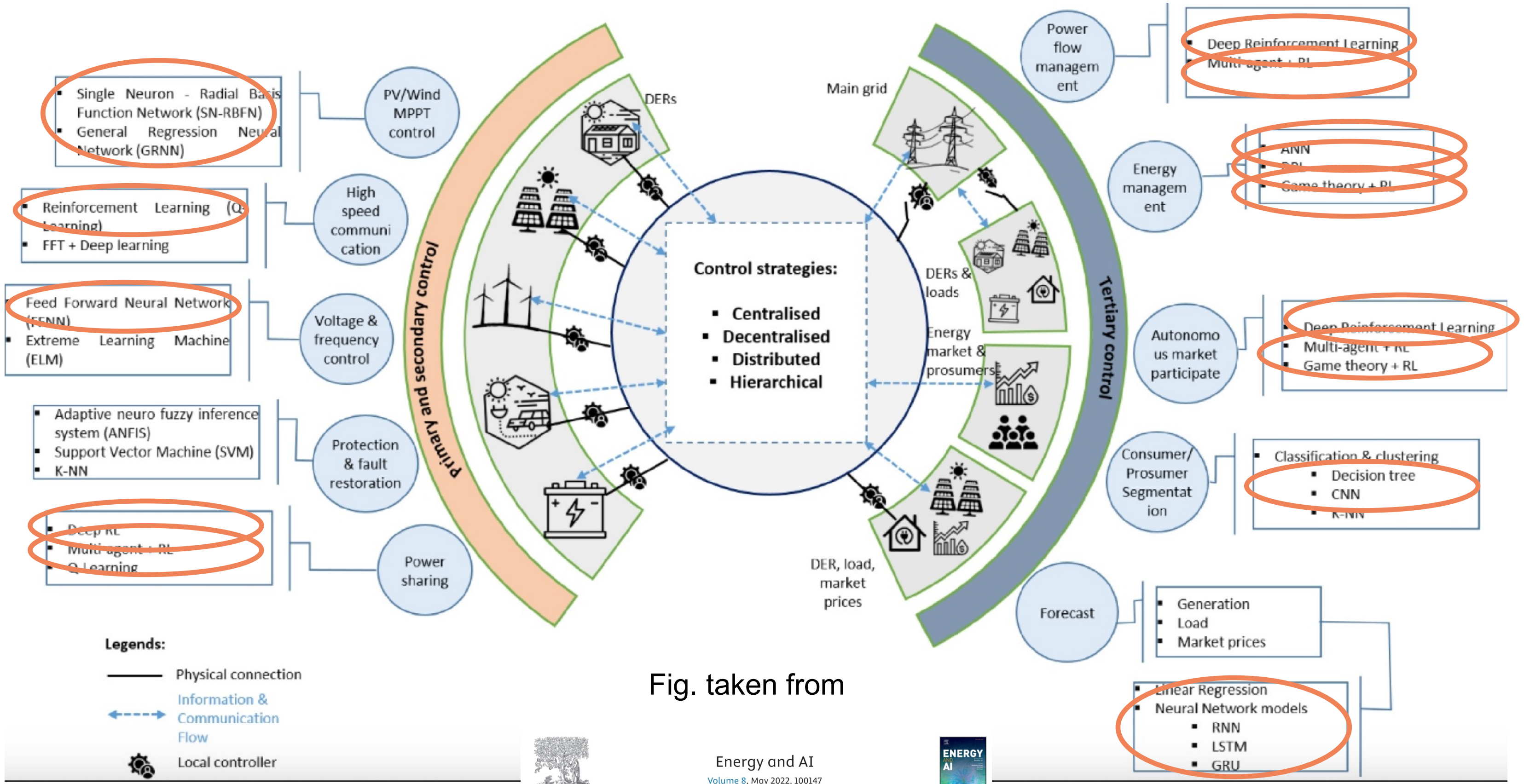
Applications of AI in the energy sector



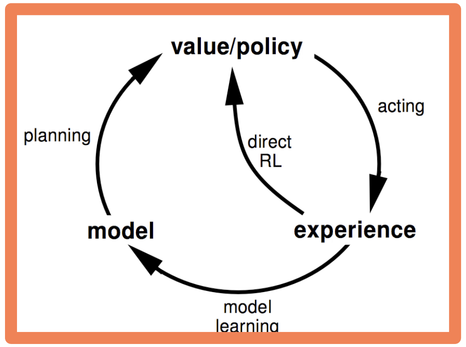


Fig. taken from

Energy and AI
Volume 8, May 2022, 100147

Review

Implementation of artificial intelligence techniques in microgrid control environment: Current progress and future scopes

Rohit Trivedi, Shafi Khadem

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research-article

Clustering methodology for smart metering data based on local and global features

Authors: Leticia Arco, Gladys Casas, Ann Nowé | Authors Info & Claims

IML '17: Proceedings of the 1st International Conference on Internet of Things and Machine Learning • Article No.: 65, Pages 1 - 13
https://doi.org/10.1145/3109761.3158398

Published: 17 October 2017 Publication History

Check for updates

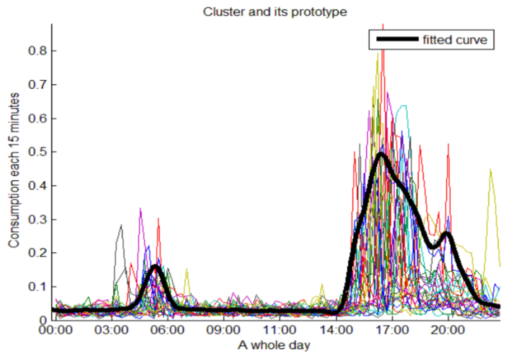

Figure 19: Medium consumption prototype with small consumption peaks in the morning and high consumption peaks in the afternoon.

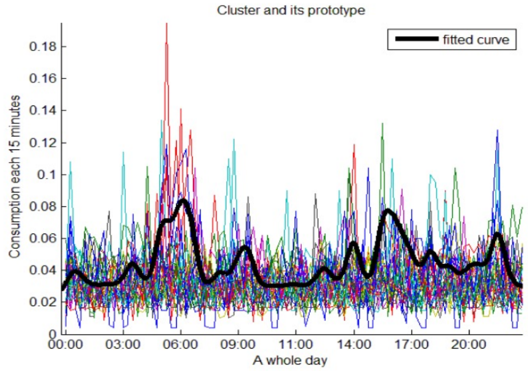

Figure 23: Low and stable consumption prototype.

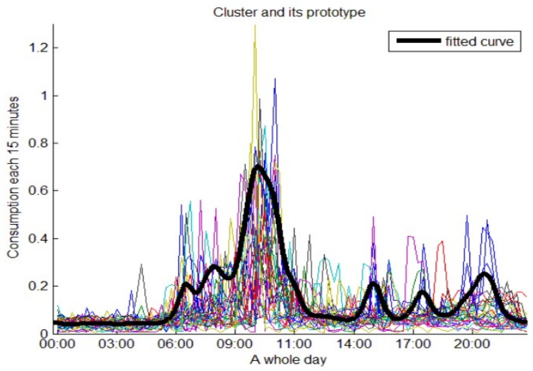

Figure 16: Medium consumption prototype with the higher consumption in the morning.

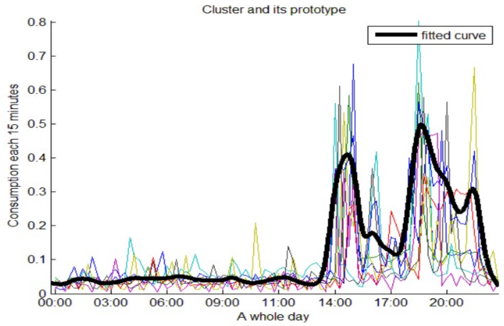

Figure 18: Medium consumption prototypes with the higher consumption at afternoon-night.

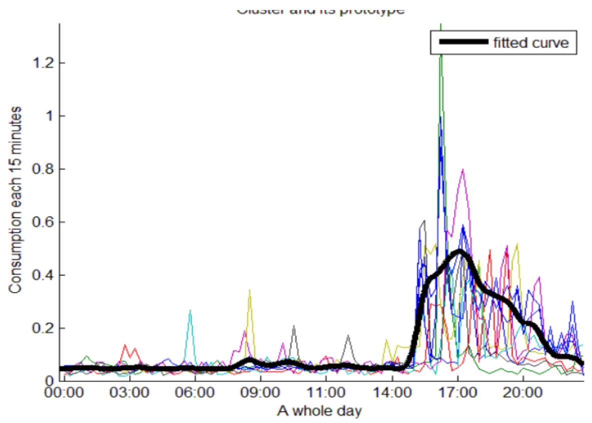

Figure 17: Medium consumption prototype with the higher consumption in the afternoon.

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Use case | PV monitoring & self-consumption

Maximising PV usage for EV charging using advanced AI techniques

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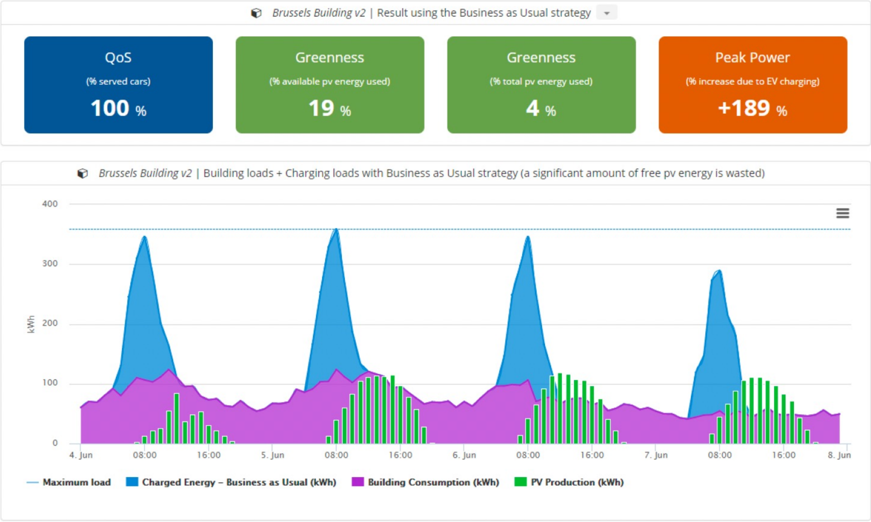
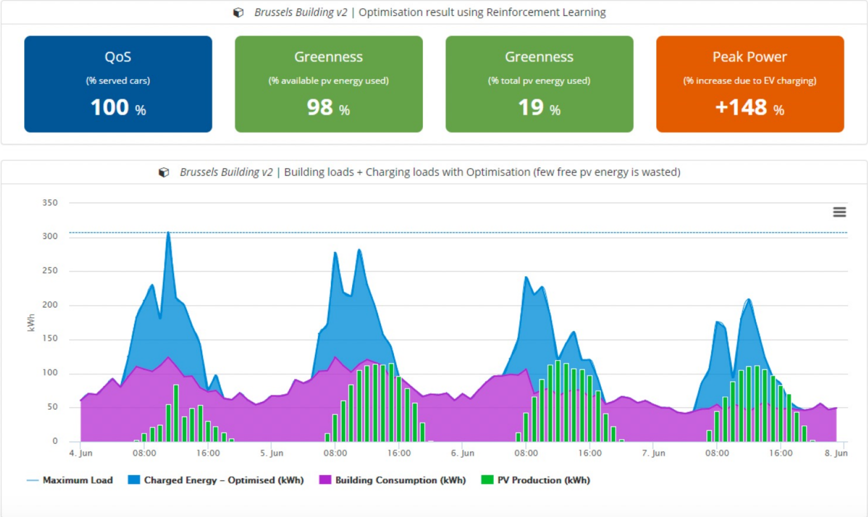


Charging of electric vehicles – Business-As-Usual situation



Charging of electric vehicles – using Reinforcement Learning

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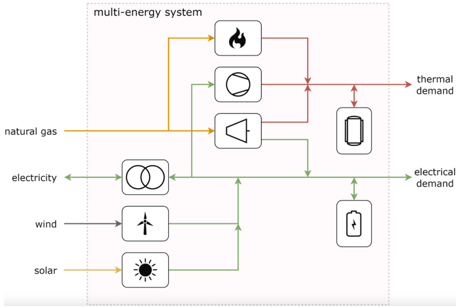
Energy and AI
Volume 12, April 2023, 100227

Safe reinforcement learning for multi-energy management systems with known constraint functions

Glenn Ceusters [a b c], Luis Ramirez Camargo [b d], Rüdiger Franke [a], Ann Nowé [c], Maarten Messagie [b]

VLAIO Baekeland PhD with ABB



Algorithm 1: SafeFallback

Input: initialize RL algorithm, initialize constraint functions in sets X and U, initialize safe fallback policy π^{safe}
for $k = 0, 1, 2, \ldots$ **do**
  Observe state s and select action a
  if *constraint check* = *True* **then**
    keep selected action a as safe action a^{safe}
  else
    get safe action a^{safe} from safe fallback policy π^{safe}
  end
  Execute a^{safe} in the environment
  Observe next state s', reward r and done signal d to indicate whether s' is terminal
  Give experience tuple (s, a^{safe}, r, s', d) **and if** $a^{safe} \neq a$: $(s, a, r - c, s', d)$ with cost c
  If s' is terminal, reset environment state
end

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Input: initialize RL algorithm, initialize constraint functions in sets X and U, initialize safe fallback policy π^{safe}
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end

Highlights

- RL learns policies that outperform MPC
- A (near-to) optimal multi-energy management policy can be learned safely.
- Any reinforcement learning algorithm can be used safely.
- Hard-constraint guarantees without solving a mathematical program.
- Constraints can be formulated independently from the (optimal) control technique
- Better policies can be found starting with an initial safe fallback policy.

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EU FP7 Marie-Curie IAPP project with partners [Vrije Universiteit Brussel] and [Sensing & Control Systems] – an SME in Barcelona, Spain.

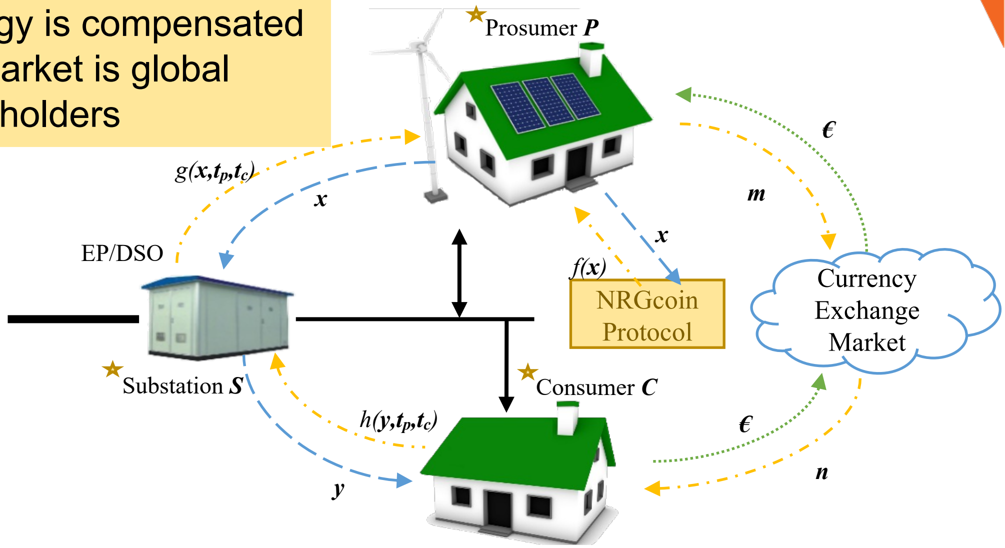
SCANERGY

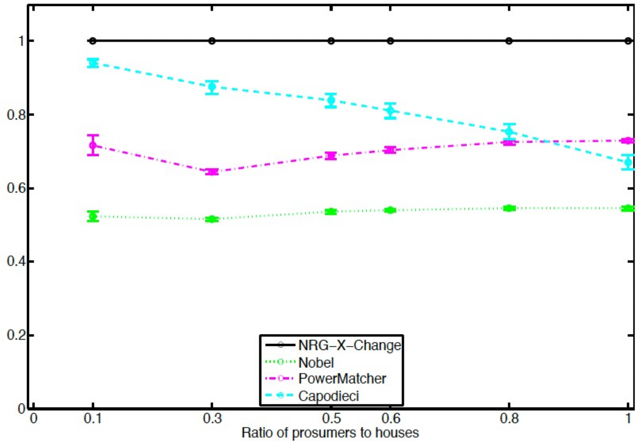
The Scanergy Project
a SCAlable and modular system for eNERGY trading between prosumers

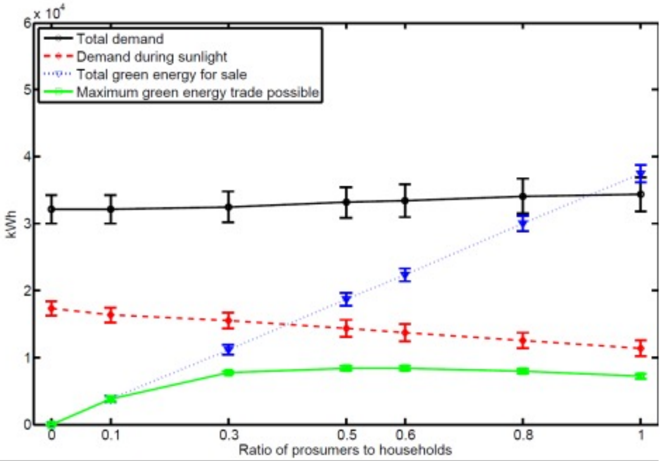
Scanergy is an EU FP7 Marie Curie Industry-Academia Partnerships and Pathways (IAPP) project running for 3 years between February 2013 and January 2016. The project is a partnership between Vrije Universiteit Brussel in Belgium and Sensing & Control Systems - an SME in Barcelona, Spain.

Scanergy aims to develop a scalable and modular system for energy trading between producers and consumers of energy in the smart grid. These end users can collectively reduce their carbon footprint, as well as their dependence on fossil-fueled power plants by trading locally-produced renewable energy.

Highlights
- P2C
- Only used green energy is compensated
- Currency exchange market is global
- Beneficial for all stakeholders







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More info : nrgcoin.org

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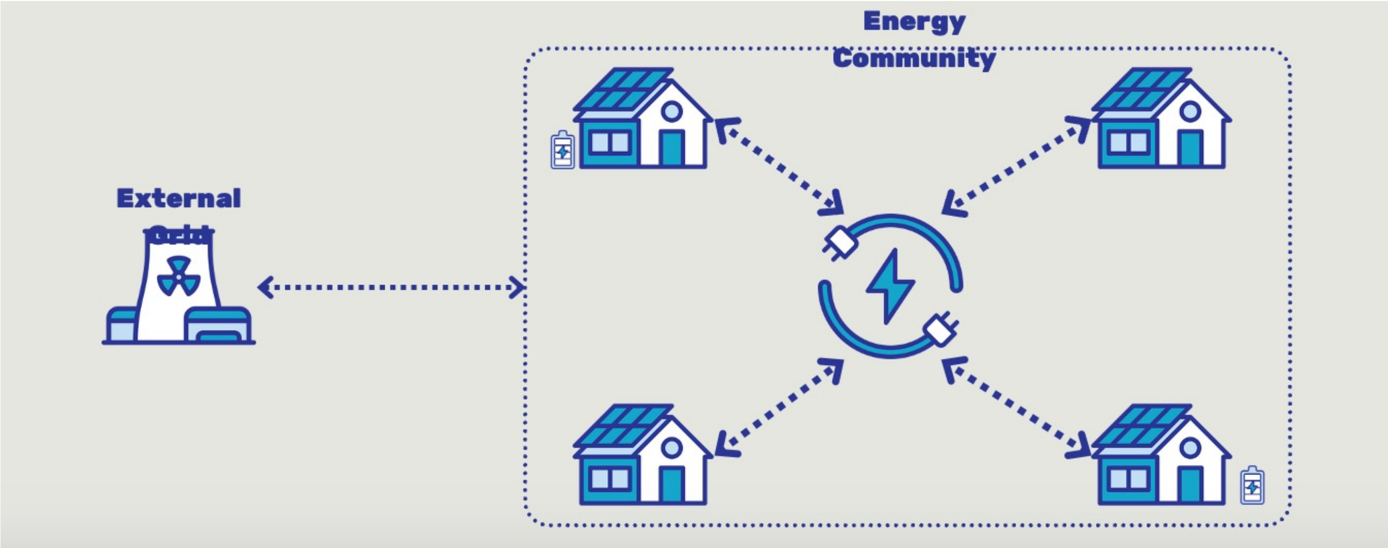
COOMEP Objectives

Designing and implementing the regulatory sandbox for the energy use-case

Enable the testing of different energy exchange mechanisms to assess the anticipated outcomes and to evaluate their legal and ethical implications.



COOMEP Objectives

- Develop a **simulation-based sandbox** that enables the study of**:**
  - Different energy exchange mechanisms or regulatory solutions
  - The impact of heterogeneous agents with varying capabilities
  - The effect of changes in the system on the overall performance

COOMEP METHODOLOGY

Sophistication

Rule-Based Agents

Simple RL: Q-Learning

Deep RL: PPO

Assets

PV Panels

Battery

Objectives

Financial gain

Sustainability

Social welfare

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Allows to incorporate diiferent consuption and production profiles

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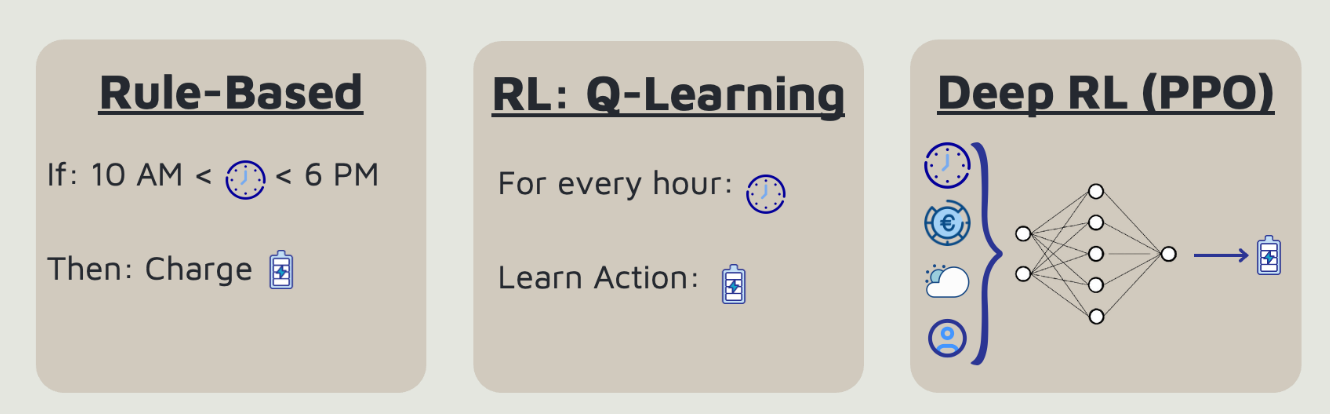
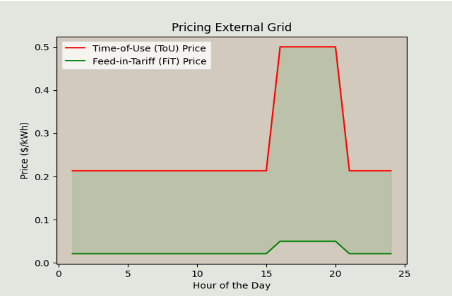
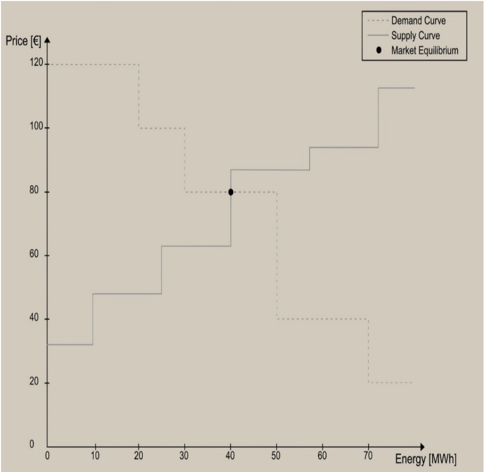
COOMEP METHODOLOGY

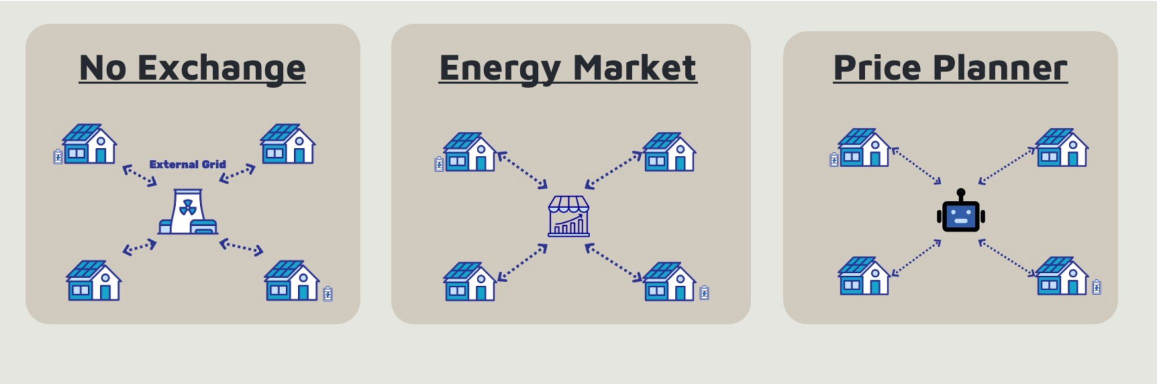
Support a heterogeneous population of agents







Different types of energy exchange mechanisms



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Ann Nowé

More information?

Ann.nowe@vub.be

Ann Nowé

AI lab VUB

November 26th, 2024

ai.vub.ac.be