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THE EMERGING TECHNOLOGIES: the drivers for digital transformation in business and education

Empowering Communities: The Future of Energy

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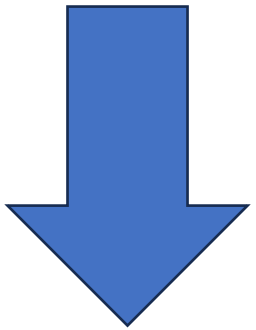
Energy transition

- EU involved in its **transition** to a cleaner energy system:
  - **Climate Neutrality**: net-zero greenhouse gas emissions by 2050.
  - **Renewable Energy sources**: increase RE in the energy mix.
  - **Energy Efficiency**: better use of the resources.
  - **Just Transition**: socially just and leaving no one behind.



Energy communities

Renewable Energy Communities

- A **renewable energy community** (REC) is a legal entity:
  a) based on **open and voluntary participation**, is **autonomous**, and is **effectively controlled by shareholders or members that are located in the proximity** of the renewable energy projects that ar owned and developed by that legal entity;
  b) the shareholders or members of which are **natural persons, SMEs or local authorities**, including municipalities;
  c) the **primary purpose** of which **is to provide environmental, economic or social community ber** for its shareholders or members or for the local are where it operates, **rather than financial profits**.

Renewable Energy Communities

RECS are entitled to **produce, consume, store and sell renewable energy**, including through renewables power purchase agreements, to **share renewable energy** within the community, and to **access all suitable markets**.

REC benefits

Minimizing **Energy Exchange** with the Grid.

Increasing **Self-Consumption.**

Enhancing Energy **Autonomy**.

Optimizing Energy Use.

Reducing **Carbon Footprint**.

Reduce Energy **Costs**.

Reduction of transmission and distribution **losses** by producing and consuming energy locally.

Managing **congestions** at the distribution level.

Deferring part of the future **infrastructure** investments.

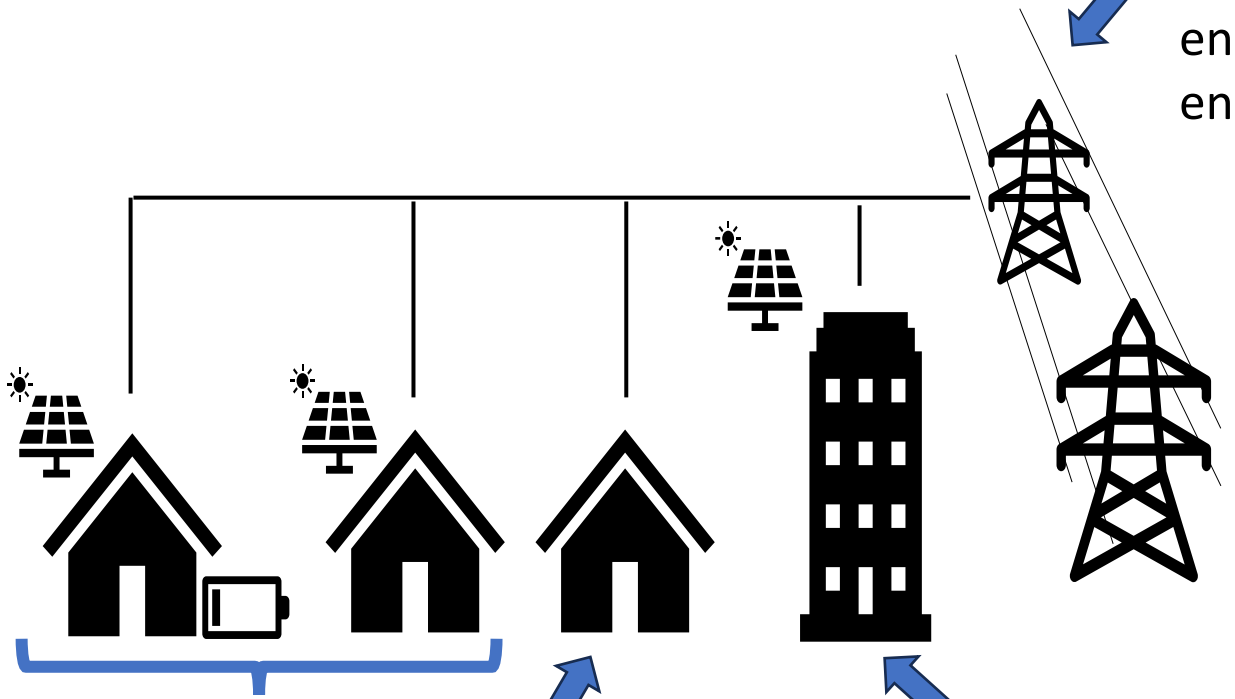
Encourage the **production** and use of renewable energy sources within the community.

Foster Community **Engagement**.

Social impact: combat Energy Poverty, create local jobs, environmental sustainability.

REC main actors

DSO (distribution system operators): managing the distribution network and ensuring the reliable delivery of energy.

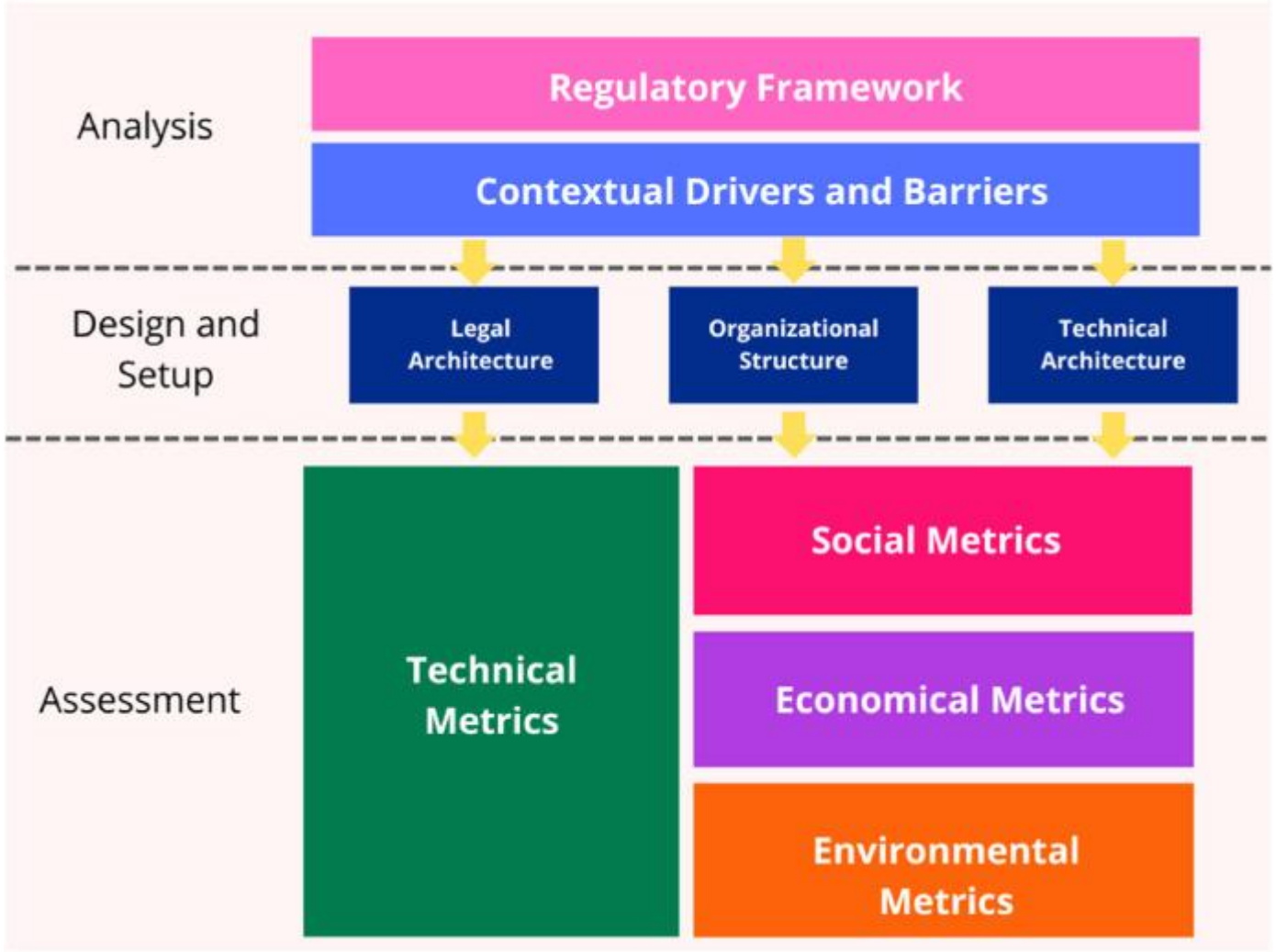


Prosumers: both produce and consume energy.

Consumers: only consume energy, do not have generation.

Local authorities and public institutions: schools, hospitals, municipal building, etc.

REC implementation model



Source: Sajjad Ahmed, Ancuța Maria Magurean, Renewable Energy Communities: Towards a new sustainable model of energy production and sharing, Energy Strategy Reviews, 2024.

Challenges:

- **Inconsistency** in the implementation of **EU directives across countries**: difficult the standardization of practices.
- **High costs, technical complexities and maturity of some technologies** (BESS): barriers for small communities.
- Accessing **energy markets** and securing **fair prices** for energy.
- Assuring that RECS are **equitable** and produce benefits to all community members.
- Improving the **efficiency** of the overall performance of REC.

Regulatory framework

23%	32%	at least 42.5%
share of renewables in EU energy consumption 2022	2030 target set in 2018	new binding target for 2030, but aiming for 45%

- **Two key EU directives** shape the framework for energy communities across Europe:
  - Directive 2018/2001 (REDIII) on renewable energy.
  - Directive 2019/944 (E-Directive) on electricity.

Regulatory framework

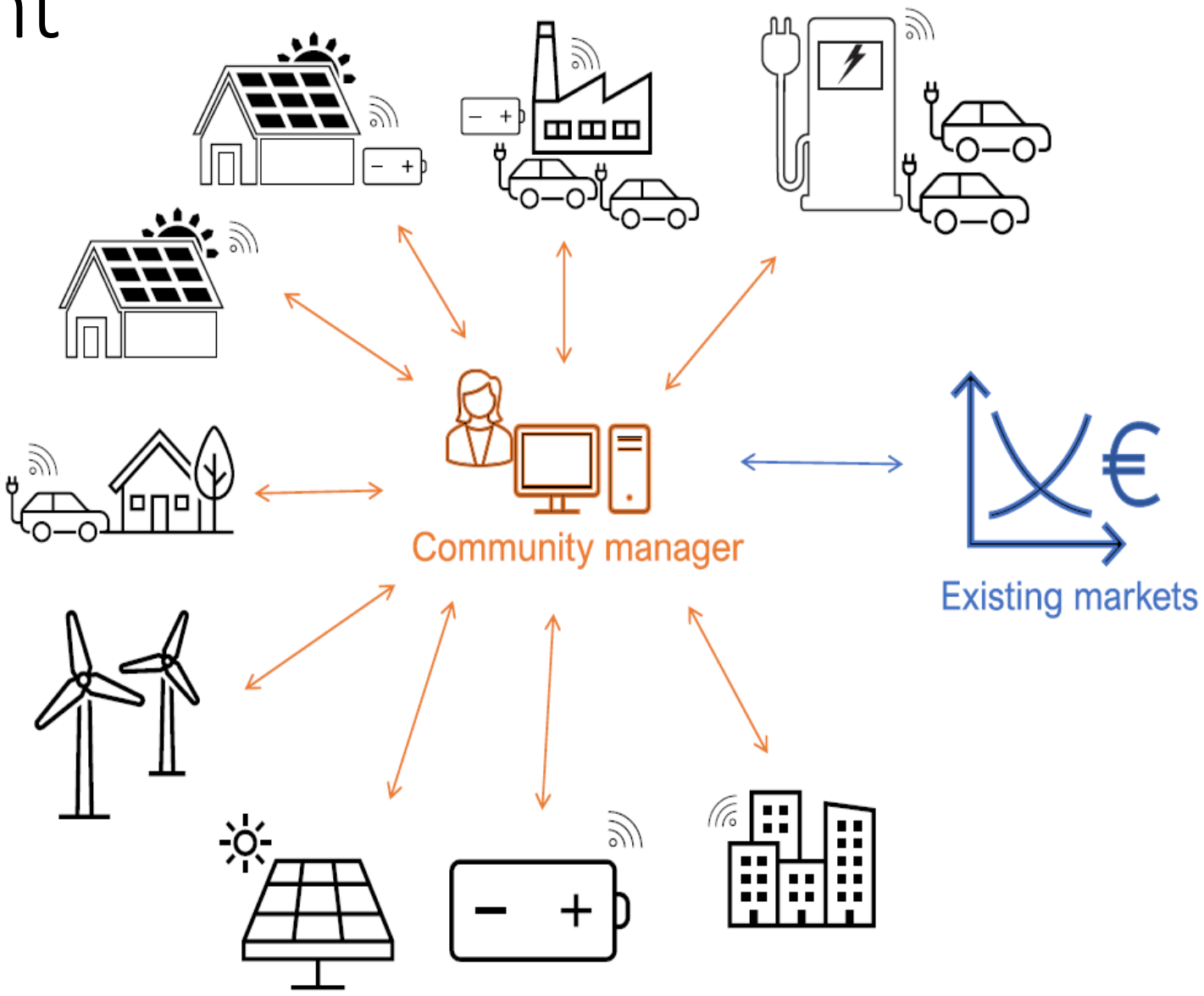
- In România:
  - Potential
    - 1200-1600 peak sun hours (>1200).
    - Prosumers (households, institutions and companies): 40k in 2022, 100k in 2024.
  - Regulation:
    - Work in progress.
    - **Integrated National Energy and Climate Plan** of Romania 2021-2030 (draft).
    - The **Clean Energy Package**: ensures energy communities can participate in the energy market, with provisions for flexibility in grid connection and energy-sharing.
    - Electricity and Natural Gas **Law No. 123/2012** (amended in 2022 to regulate energy communities).
    - **Order 17/2022** from Romania's Energy Regulatory Authority (ANRE): refines the grid connection process for energy producers, including energy communities.

We don´t need RECs

… we need **Smart RECs!!**

REC management

- Community-based market.



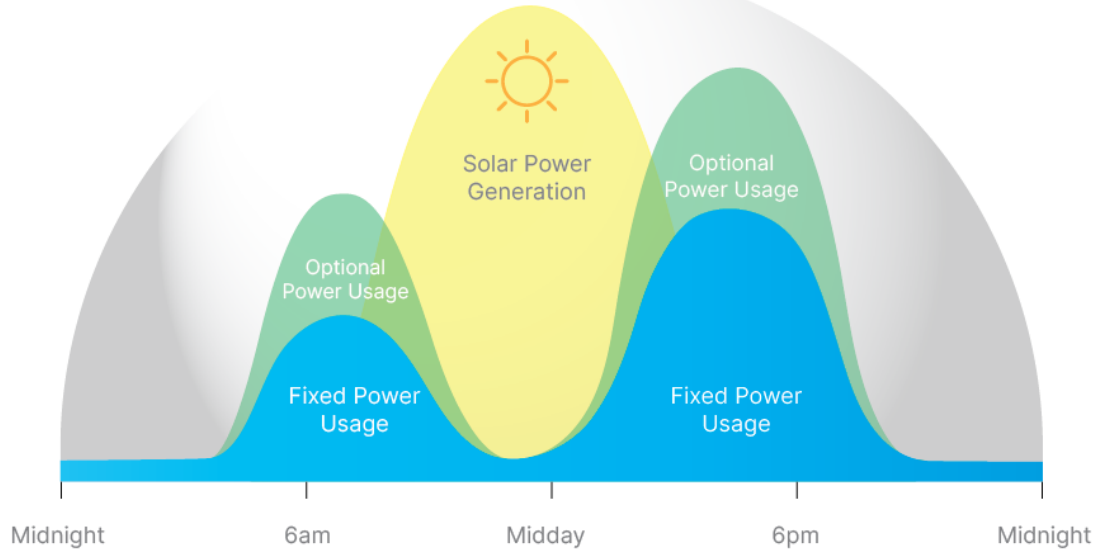
Source: Rubi Rana et al, Modelling and Simulation Approaches for Local Energy Community Integrated Distribution Networks, IEEE Access, 2022.

REC management

- Objectives:
  - Minimize the **global costs** of the energy community.
  - Maximize the local consumption of renewable energy, or in other words, to **minimize the exchanges with the public grid**.

How?

Scheduling members' loads (flexibility).

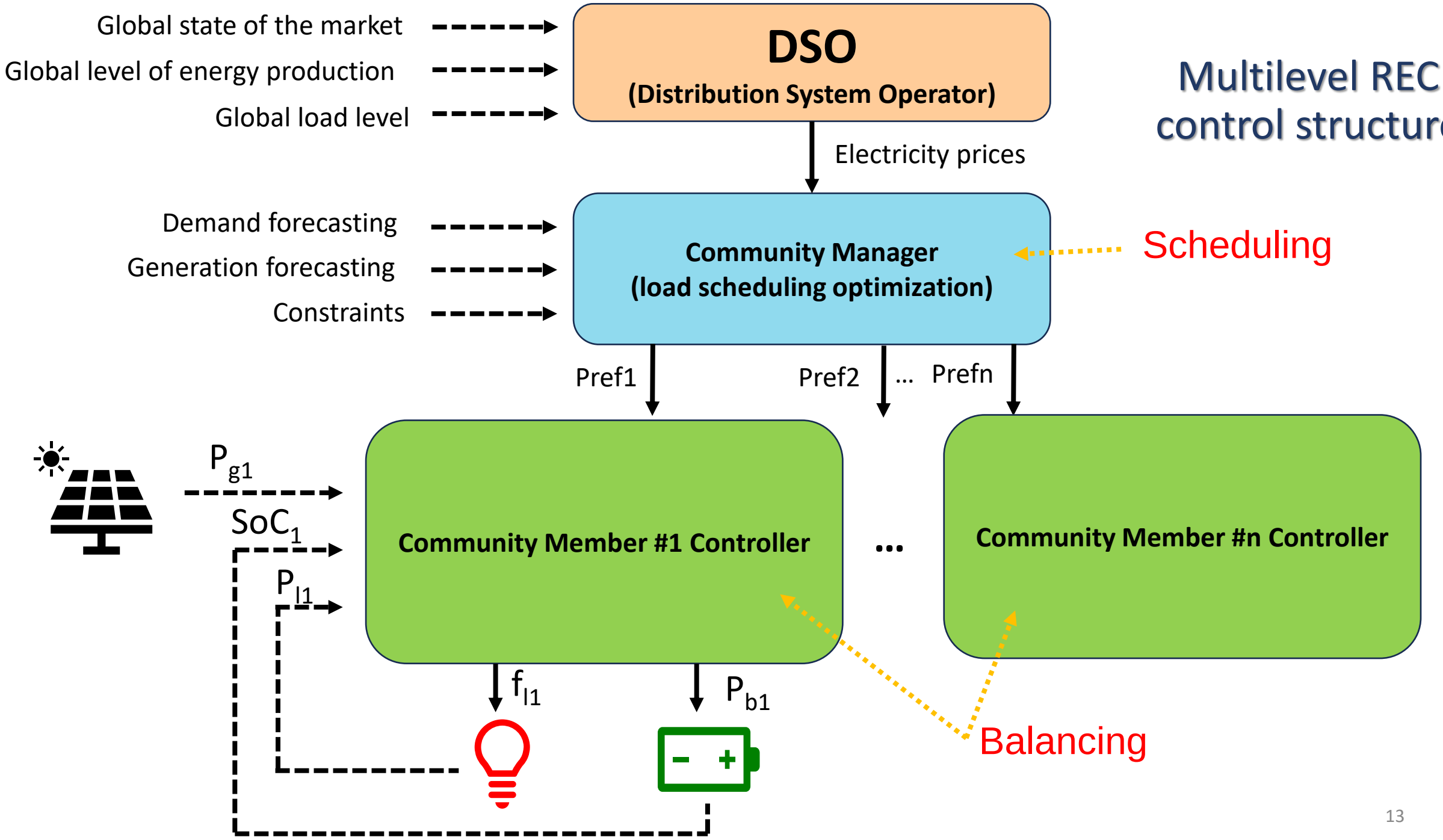


Source: powerpal.net

Efficient use of BESS.

Source: Deutz.com.au

Multilevel REC control structure



Modelling methods

- **Physical modelling**.
- **Statistical Methods**
  - Time Series Analysis: analyzing historical data to identify trends, seasonality, and cyclical components.
    - ARIMA (AutoRegressive Integrated Moving Average).
    - Exponential Smoothing: A family of techniques that assigns exponentially decreasing weights to older observations.
  - Regression Analysis (Linear and non linear).
- **Machine Learning Techniques**
  - Long Short-Term Memory (LSTM) Networks.
  - Gated recurrent units (GRU).
  - Support Vector Machines (SVMs.
  - Random Forests.
- **Hybrid Models**:
  - Combination of Statistical and Machine Learning Methods.
  - Ensemble Methods: Combining multiple models (e.g., statistical, ML) to improve accuracy and robustness

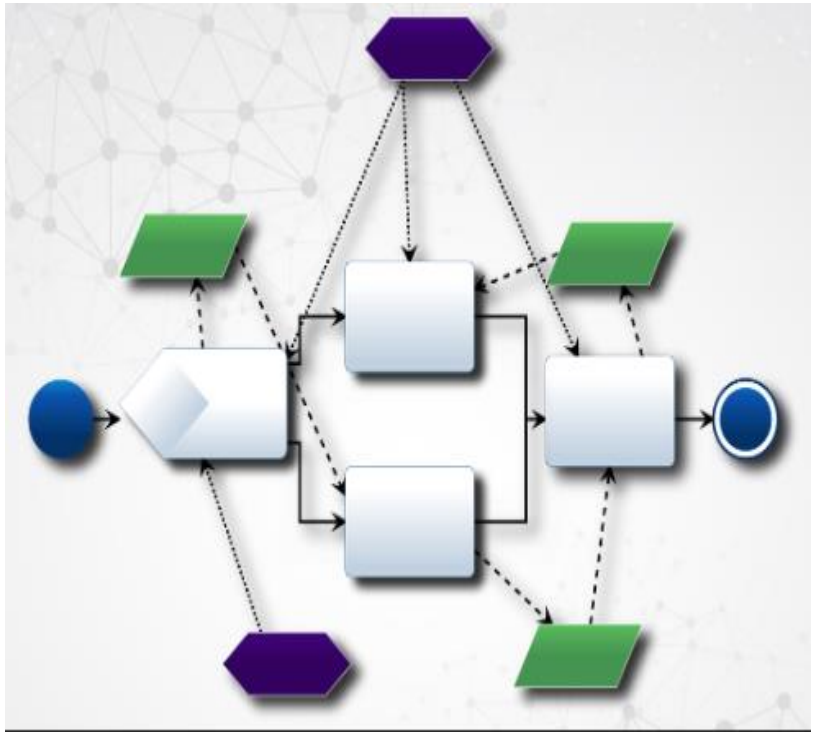


Image: specinnovations.com

Scheduling and Control methods

- **Rule-based** algorithms:
- PID control.
- Optimal control, Model Predictive Controller (**MPC**):
  - Gradient descent methods.
  - Alternating Direction Method of Multipliers (**ADMM**).
- **Game theory** (Shapley Value).
- **Artificial Intelligence** Algorithms:
  - Fuzzy control.
  - Reinforcement learning.

Image: freepik.com

- Forecasting using ML

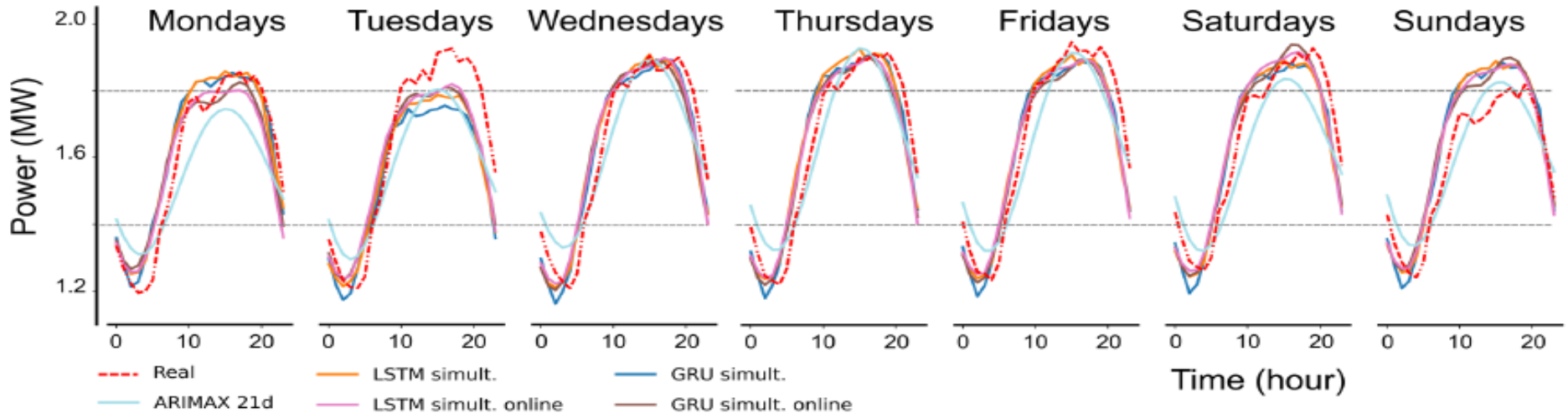


Figure 7: Averaged power demand predictions and real power demand (discontinuous red line) throughout the 24 ho
day of the week using simultaneous predictions as explained in section 2.2

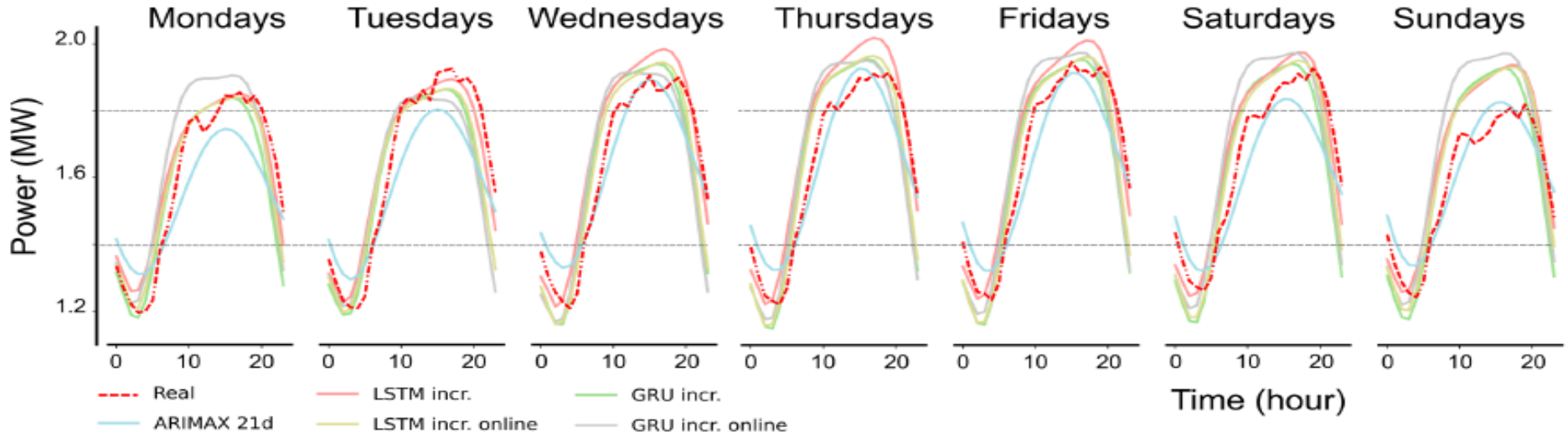


Figure 8: Averaged power demand predictions and real power demand (discontinuous red line) throughout the 24 ho
day of the week using incremental predictions as explained in section 2.2

Modelling and Control methods

- Microgrid control using Fuzzy logic

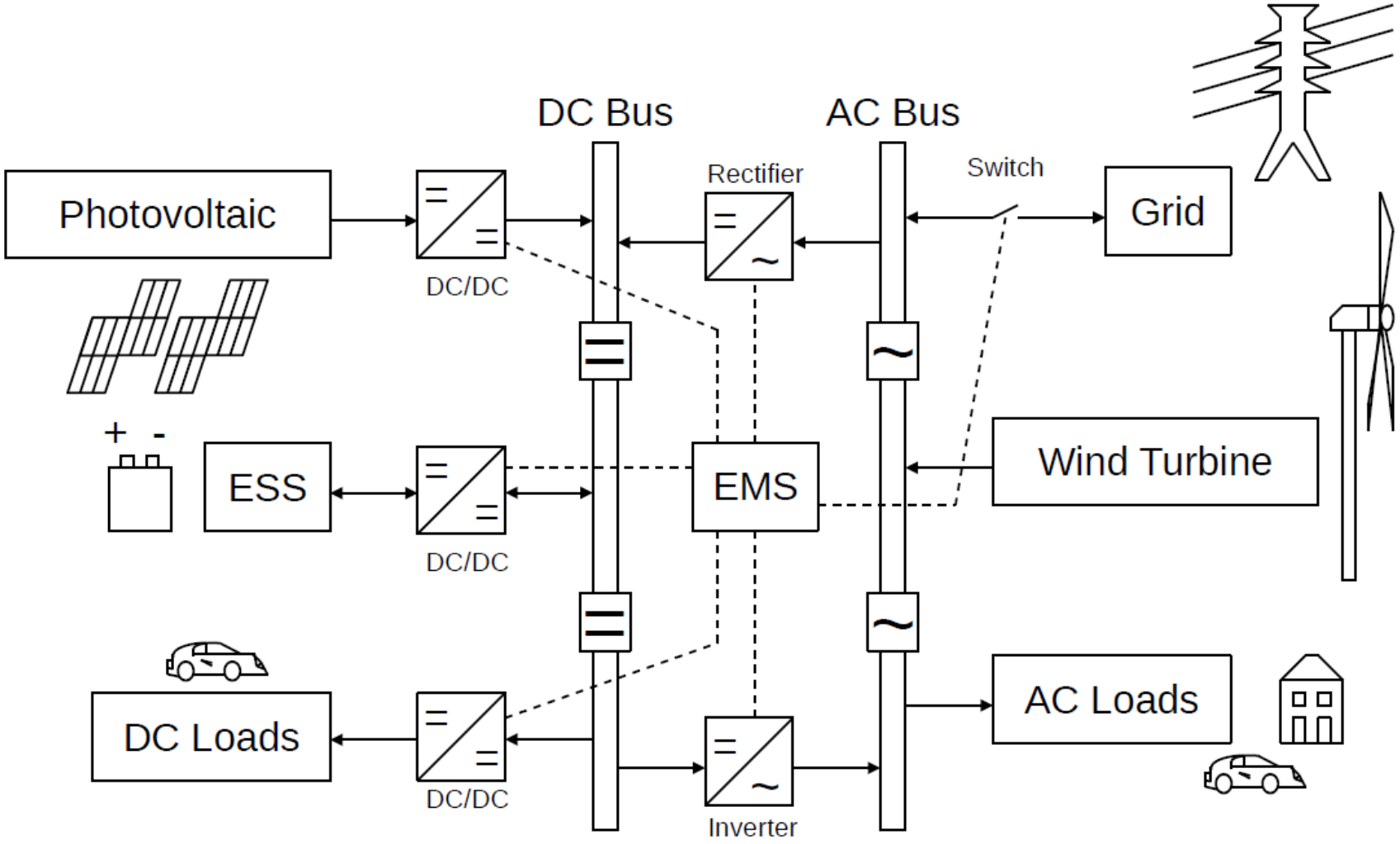
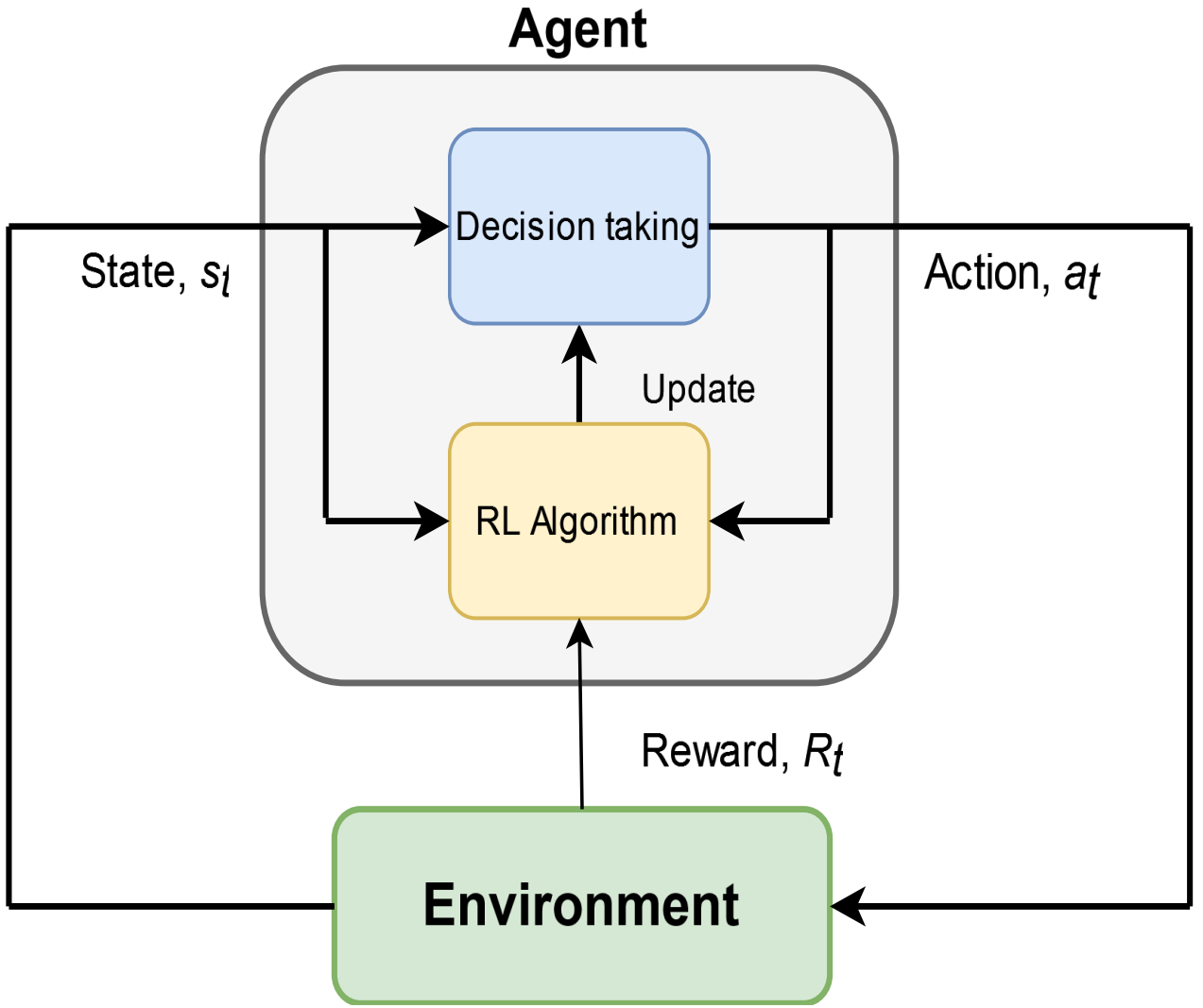


Figure 1: Architecture of an on-grid HRES with an ESS.

Modelling and Control methods

- Management of REC using Reinforcement Learning



Interreg
Atlantic Area

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satcomm
Empowering Energy Communities

SAtComm

SAtComm will enable Energy Communities to take control of their energy profiles and become prosumers by implementing technologies to integrate renewable energy within their locality and maximise their sustainability.

ERDF funding
2.41 M€

Total budget
3.21 M€

Calendar
From 2023 to 2026

https://satcommproject.eu

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To remember …

Important tool for energy transition.

Empowering citizens for climate change mitigation.

National regulation plays a key role.

Great complexity

Many actors involved.

Hundreds of assets in a medium-size REC.

Many constraints.

Challenging optimization problem:

Multilevel structure.

IA algorithms for forecasting and management.