LIÈGE université
Sciences Appliquées

Introduction and objectives

Optimization and machine learning applied to microgrid optimal control, optimal design, and forecasting

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February 11, 2025

Access to the course material

https://github.com/bcornelusse/DENSYS-school

Overview

1. Introduction

2. Microgrids and distribution networks

3. Microgrid control levels

Introduction

Goal of the week

Apply optimization and machine learning to microgrid optimal control, optimal design, and forecasting.

The objectives are for you to learn to

- Model and optimize a microgrid (without the electrical grid)
- Build power and energy management systems
- Make some forecasts of electricity generation and consumption
- Apply optimization
- Apply machine learning
- Code in Python

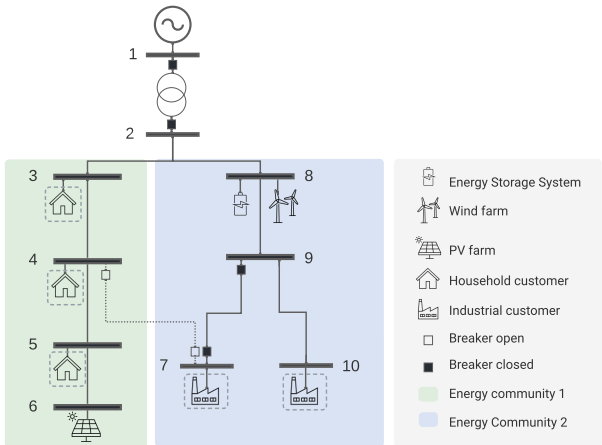
Microgrids and distribution networks

Microgrids

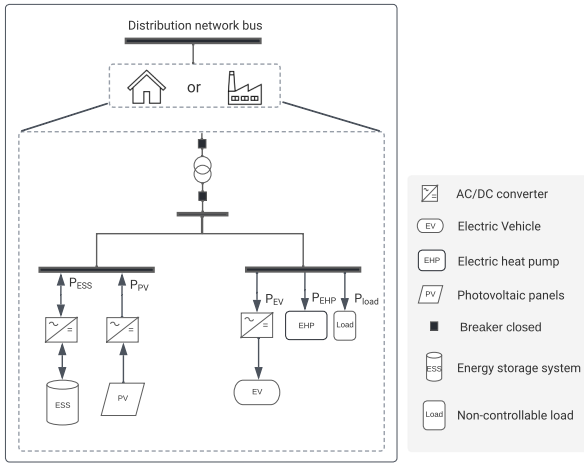
A microgrid definition

A small electrical network composed of decentralized energy resources, loads, and energy storage devices. It is controlled and operated locally. It can connect or disconnect from the main grid.

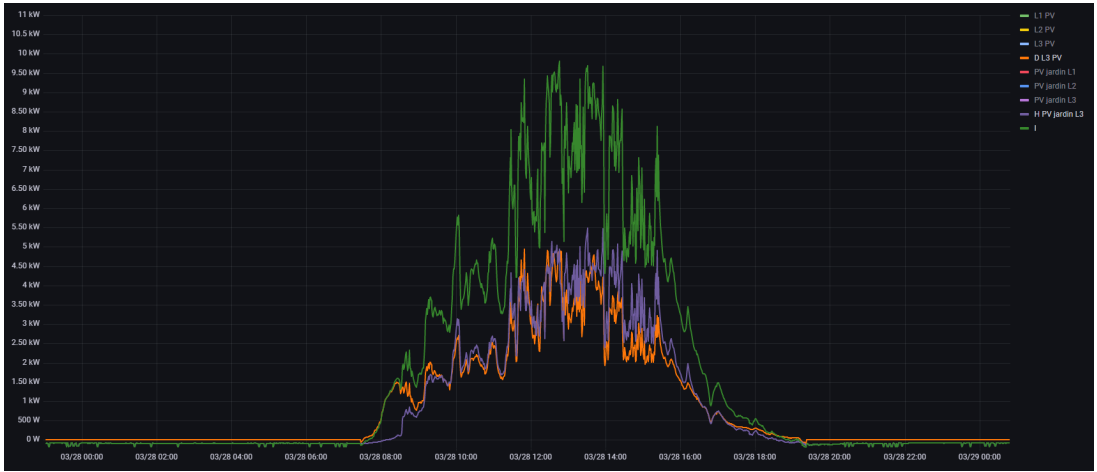
Schematic representation of a microgrid



Behind a connection point



Temporal dimension: photovoltaic generation



Microgrid control levels

Microgrid controller

Microgrid controller
Software that senses the microgrid (currents, voltages, frequency, etc.) and takes control actions to operate the microgrid safely, reliably, and optimally.

In practice, a microgrid is run by multiple controllers because there are several levels of control, which differ by their spatial and temporal scopes.

Next to technological advances in production, consumption, and storage, controllers are crucial elements for advanced microgrids.

The four control levels in a microgrid

Table 1: The four control levels

Level	Function
1	Device level control
2	Local area control
3	Supervisory control
4	Public grid interaction

Level 1: device level control

- Generator control
- PV panel + MPPT + inverter
- A great variety of interfaces for loads
- Battery storage: battery management system (BMS)
- Battery inverter/charger
- Islanding detection: Automatic transfer switch

Level 2: local area control

- Fast, automatic load/generation control to ensure constant balance and achieve stable operating points:
  - regulate active and reactive power in AC microgrids
  - achieving stable operation may be a challenging problem because of the:
    - dynamic response mismatches between loads and sources,
    - generated power capacity close to the nominal load,
    - reduced added energy storage in generator rotors (if any).
- (Unplanned) disconnection management
- Resynchronization

Level 3: supervisory control

- Generation and load dispatch
- Economic optimization
- Spinning reserve
- Forecasting
- Data visualization and data management

Level 4: public grid interaction

- Distribution Management System interaction
- Electricity markets
- Ancillary services markets