Smart microgrid & system integration

Lesson 1: Technologies and smart grid integration

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under the grant agreement No. 101037141. This material reflect only the views of the Consortium, and the EC cannot be held responsible for any use that may be made of the information in it.

In this video you will learn:

- Main components of smart microgrids
  - Operation modes of smart microgrids
    - Modules of smart microgrid controller
      - Intelligent energy management
        - Advanced (micro)grid monitoring
          - Advanced microgrid power con

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Components of a smart microgrid

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Distribution network

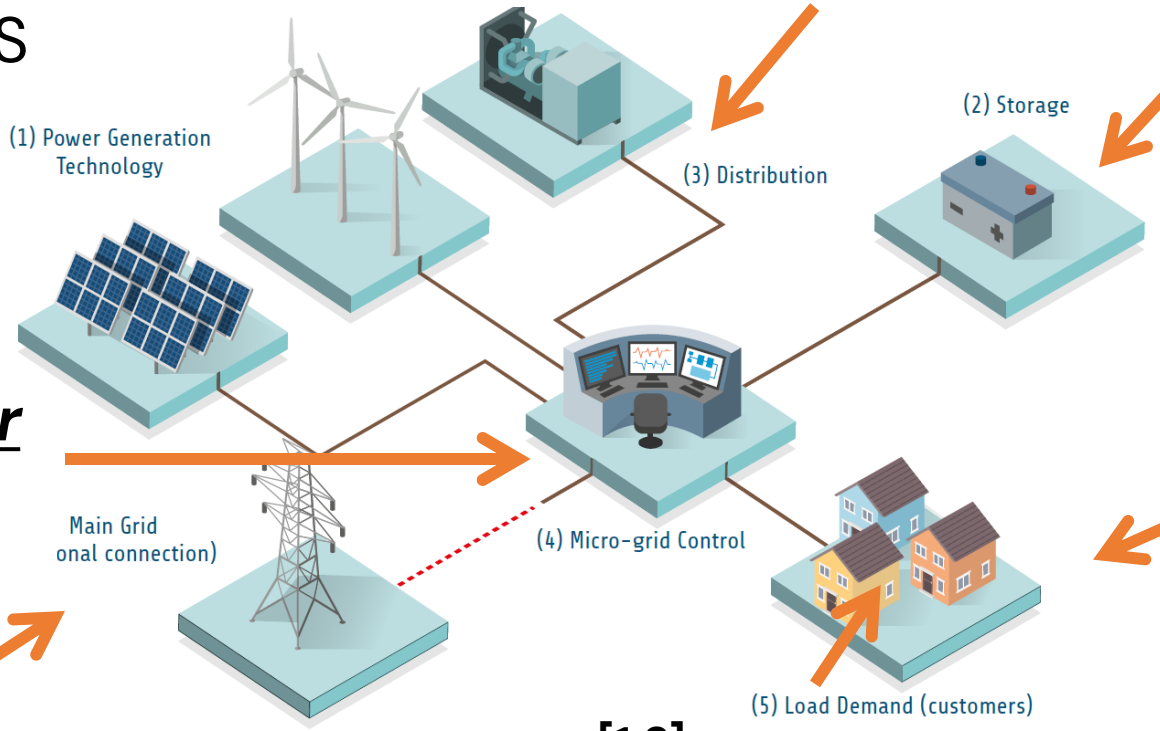
Grid infrastructure and assets, including electrical lines, transformers, protections, etc.

Generation facilities

RES or non-RES

Energy storage

Backup & balance services
Batteries, flywheels or hydro pumped-storage



Main controller

Energy and power control

Consumption loads

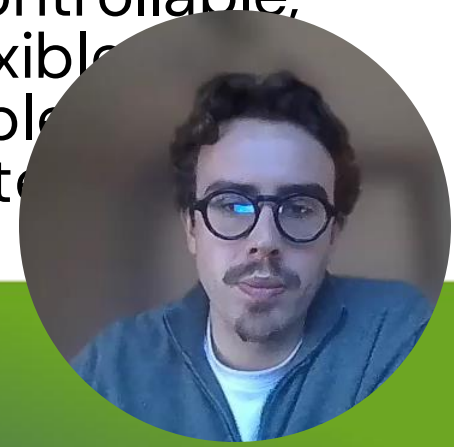
Energy-consuming devices which can be:

- (un)controllable,
- (in)flexible,
- shiftable,
- (un)interruptible

Main grid

In on-grid microgrids

[1,2]



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Operation modes of smart microgrids

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*Microgrids are **classified** into isolated and non-isolated microgrids [3].*

Isolated (or off-grid)

Have no electrical connection to a wider electric power system

Non-isolated (or on-grid)

Can act as controllable units to the utility electric power system

Operation modes

Grid-connected mode

Ensure internal energy balance and synchronization with the main grid

Islanded mode

Provide short-term stability optimization to maintain voltage

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Main modules of a microgrid controller

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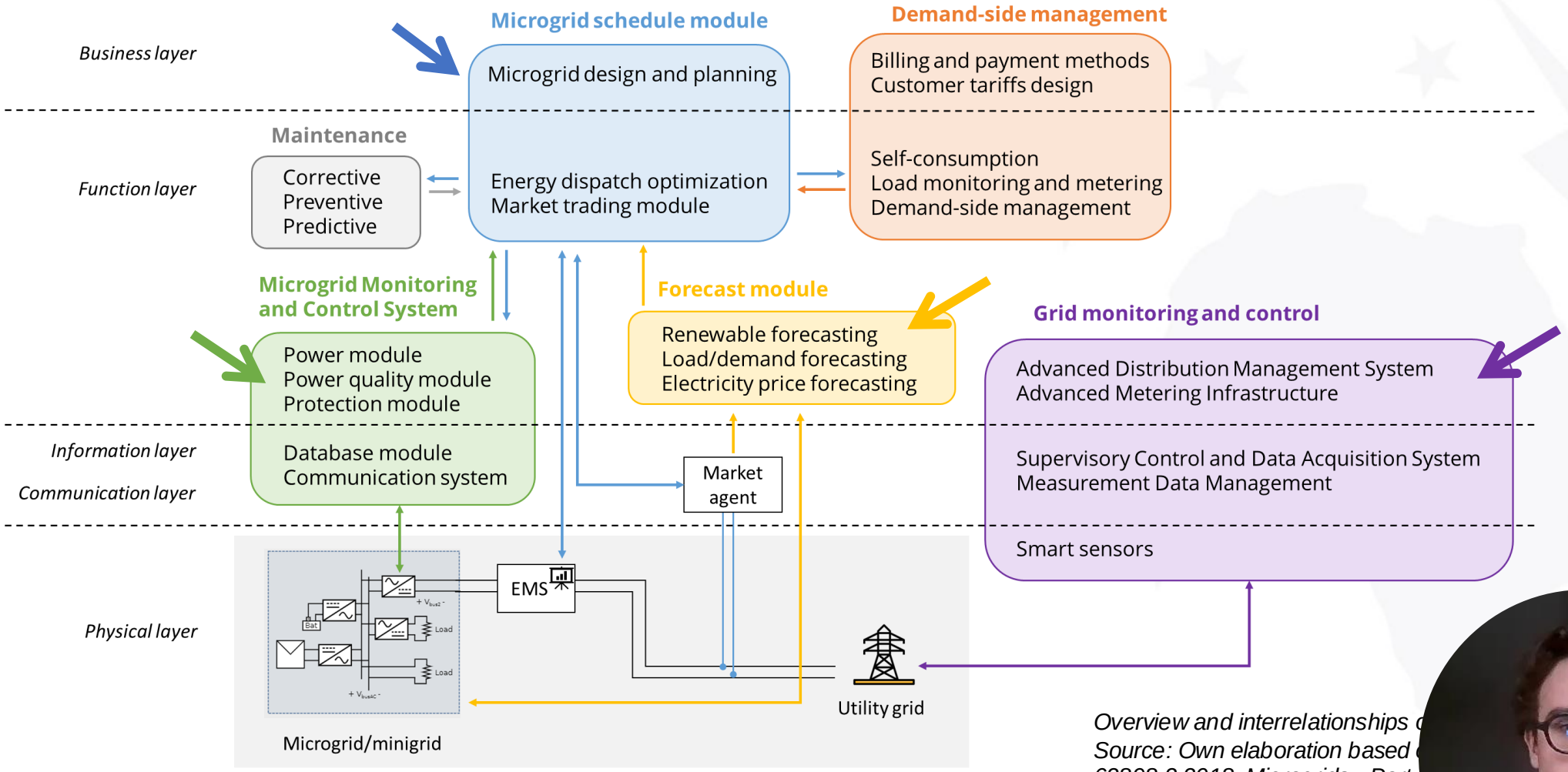

Overview and interrelationships c
Source: Own elaboration based
62898-2:2018: Microgrids - Part

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Intelligent energy management (I)

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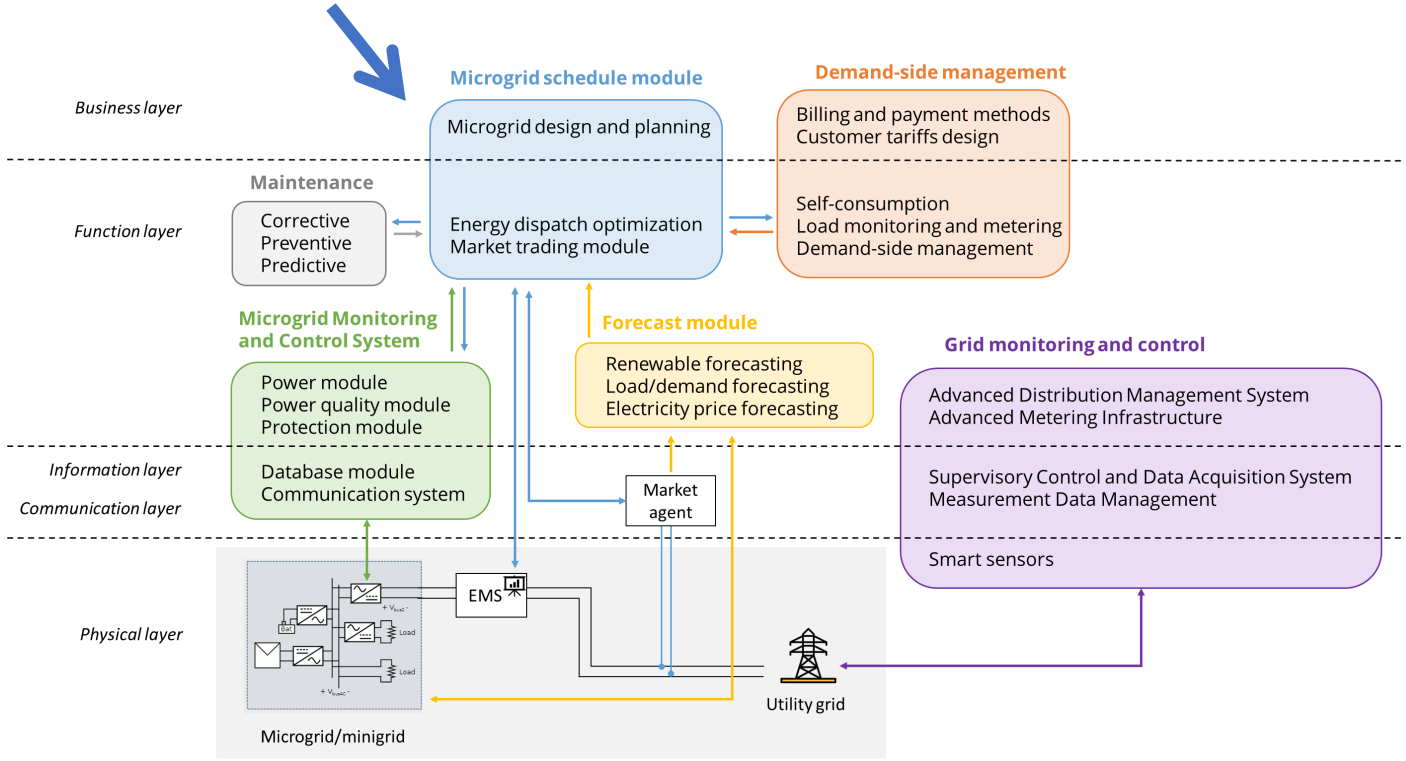
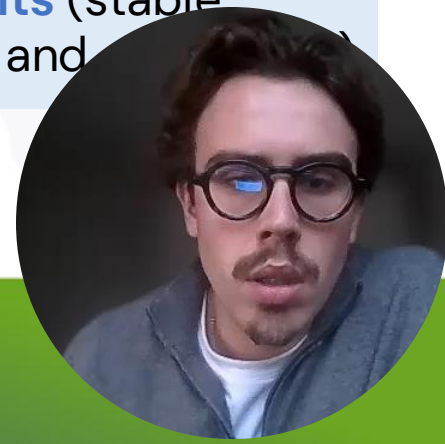


Overview and interrelationships of smart microgrids modules. Source: Own elaboration based on [3] IEC. (2018). IEC TS 62898-2:2018: Microgrids - Part 2: Guidelines for operation.

Microgrid schedule module

Starting from design and planning phases to meet demand reliably and economically from a long-term optimization and dispatch:

- ✓ **Microgrid design and planning**
- ✓ **Unit commitment** (conventional generation activations and ramps)
- ✓ **Long-term bilateral power purchase agreements** (stable energy price for RES and



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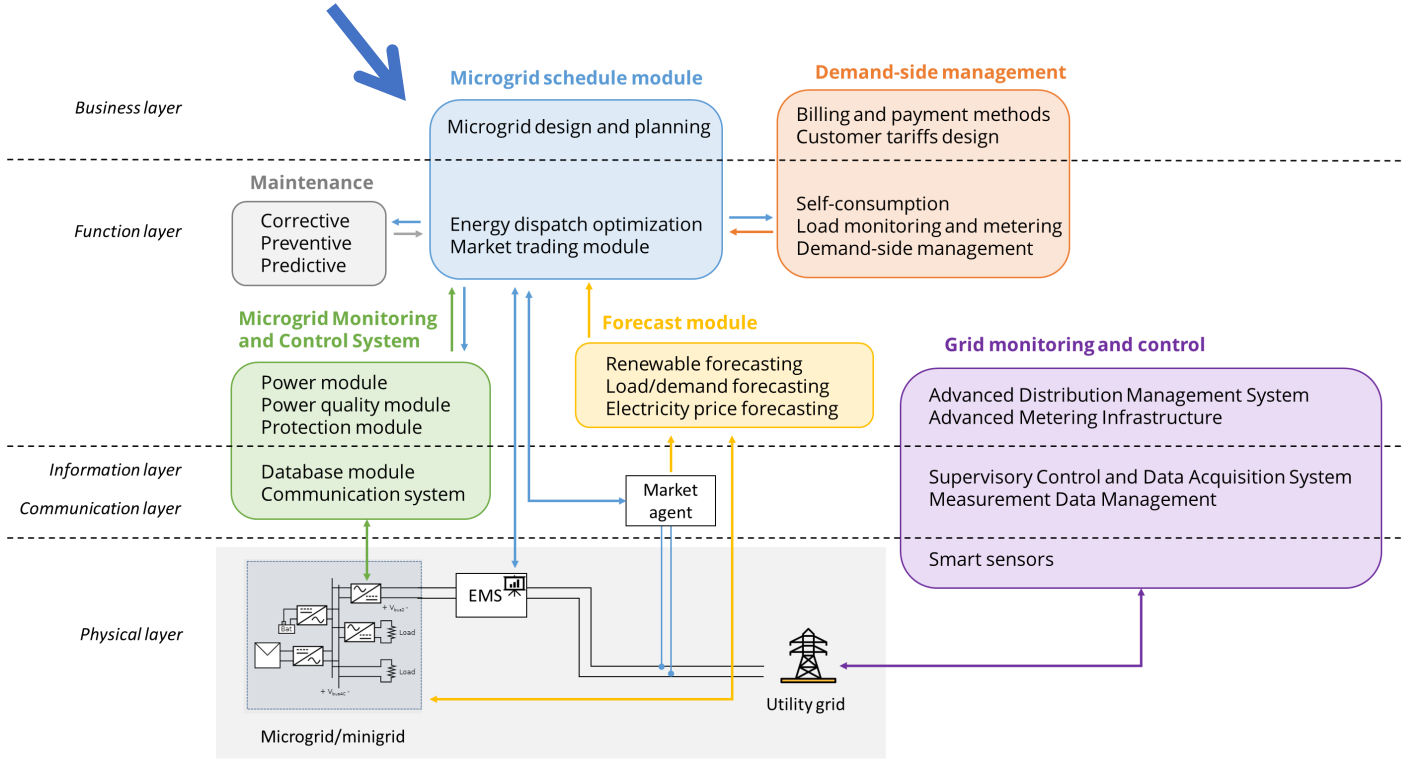
Intelligent energy management (II)



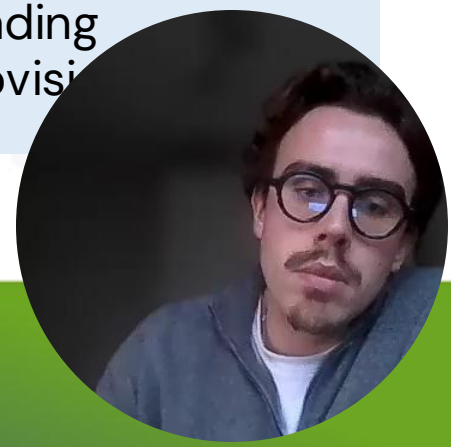
Overview and interrelationships of smart microgrids modules. Source: Own elaboration based on [3] IEC. (2018). IEC TS 62898-2:2018: Microgrids - Part 2: Guidelines for operation.

Microgrid schedule module

Daily energy dispatch: resource dispatch based on multiple objectives (security/technical/economic goals) considering different technical, system operation and robustness constraints

Market trading: manage optimally imported/exported energy flows, while internal energy dispatch is maintained

- ✓ Wholesale market trading
- ✓ Ancillary services provisi



Intelligent energy management (III)

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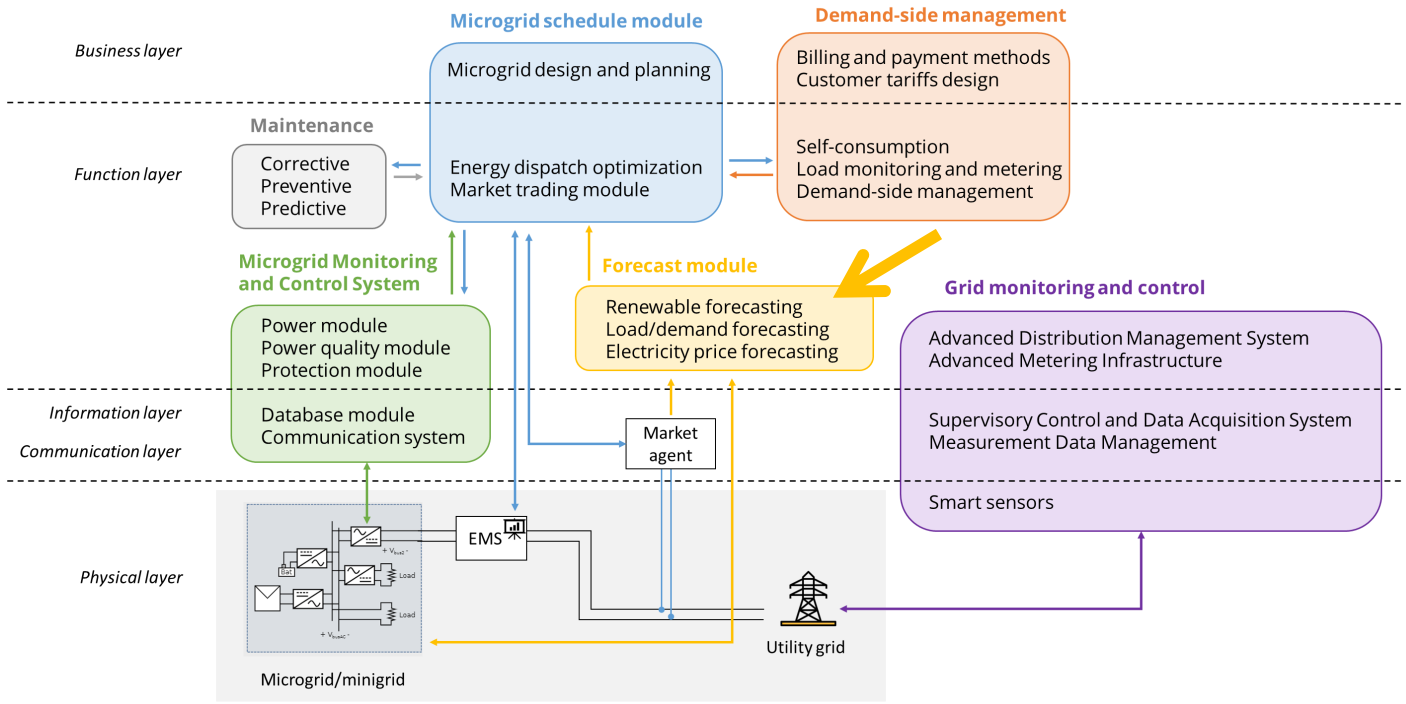
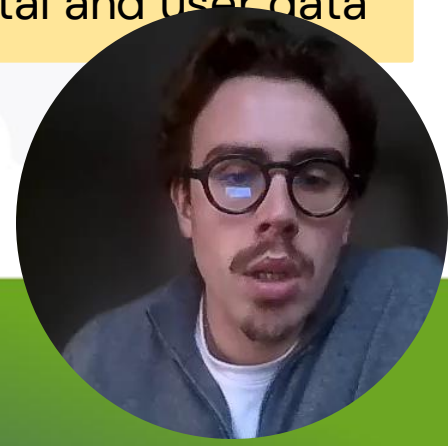


Overview and interrelationships of smart microgrids modules. Source: Own elaboration.

Forecasting module

- ✓ **Load, generation and price predictions**
- ✓ To support the decision-making process of the dispatch optimization
- ✓ Use of historical data, technology features, environmental and user data



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Advanced (micro)grid monitoring

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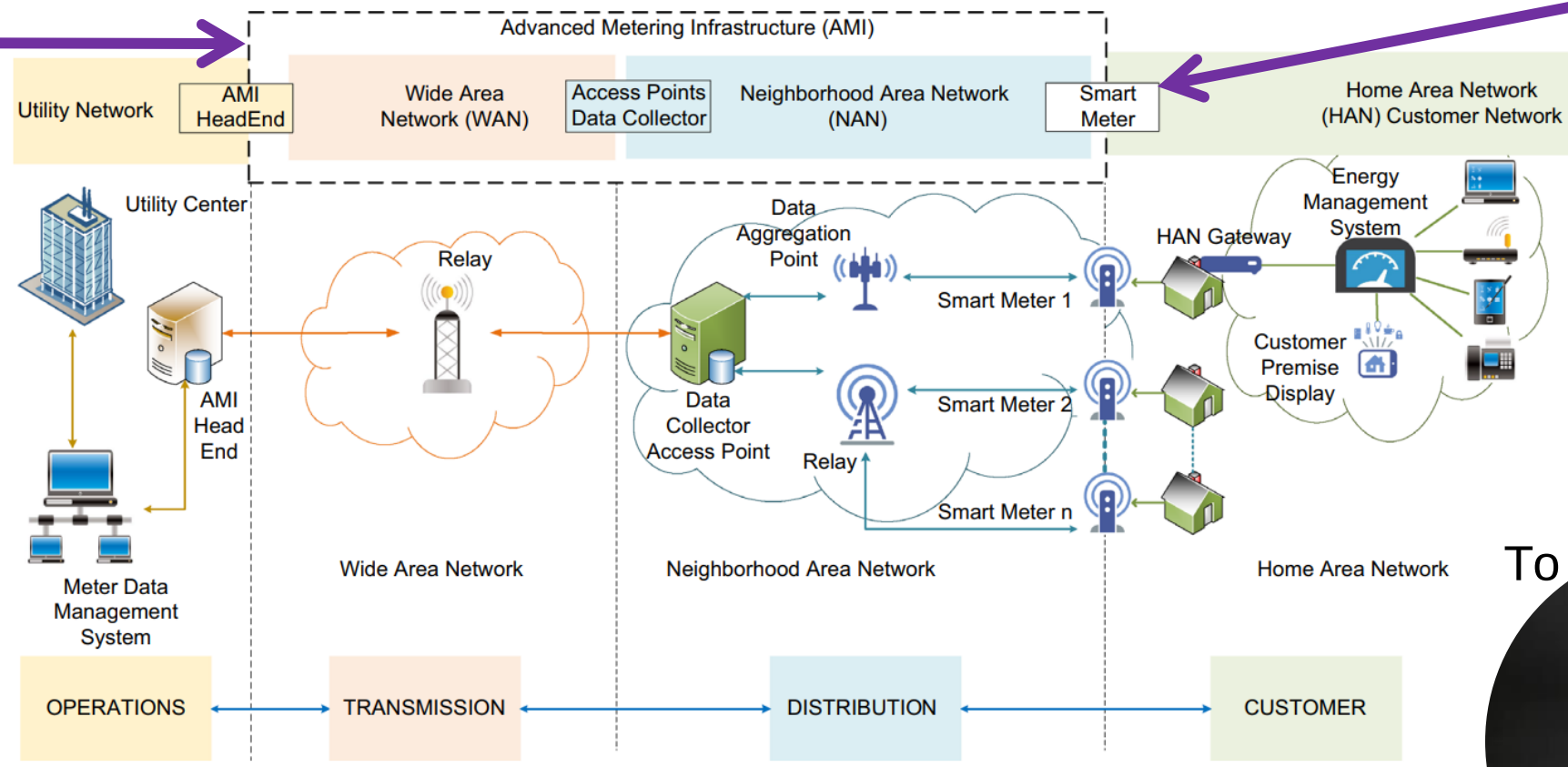
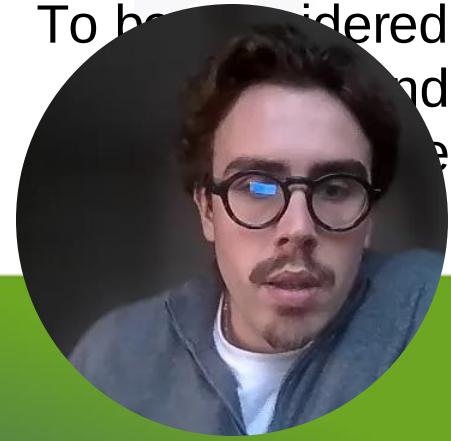
Advanced grid monitoring enables higher grid observability, end-user metering, rapid diagnosis, and other advanced functionalities to supervise and control better smart microgrids [4,5].

Advanced Metering Infrastructure (AMI)

Smart meters/sensors



To be considered



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Advanced microgrid power control (I)

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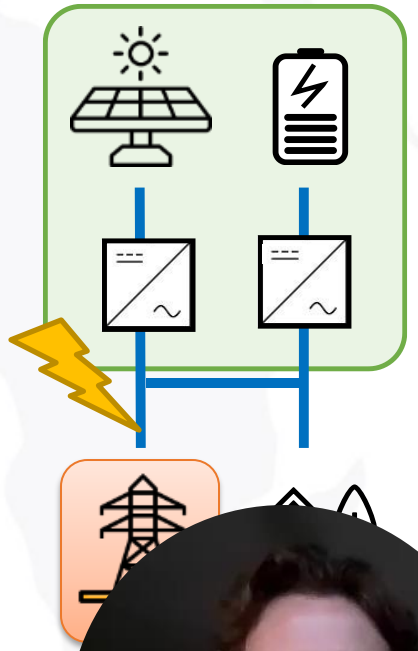
Advanced microgrid control needs to perform several functions like **islanding detection and protection**, power quality monitoring and microgrid protection [6,7].

Islanding detection and protection

- Under islanding operation, the **uninterrupted power supply** feeds microgrid loads
- Islanding detection helps in limiting the **fault propagation**
- **Unplanned islanding** can hamper power stability, quality and protection requirements.
- **Detection** by monitoring the rate of change of frequency, voltage fluctuation, etc.



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Advanced microgrid power control (II)

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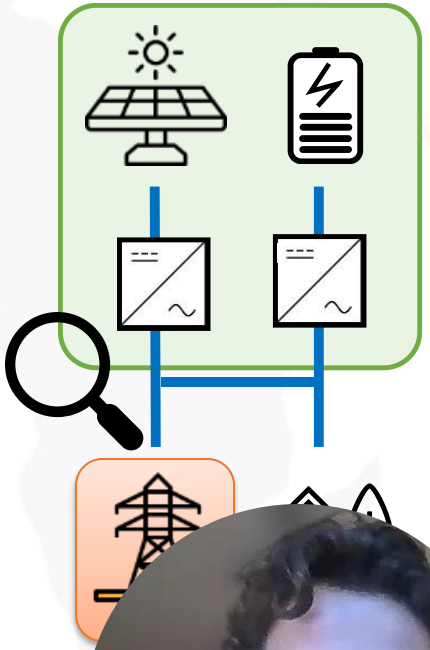
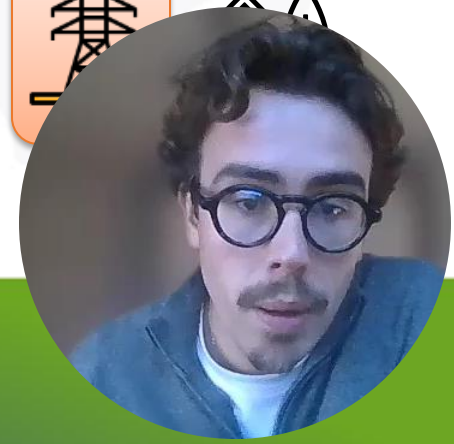
Advanced microgrid control needs to perform several functions like islanding detection and protection, **power quality monitoring** and microgrid protection [6,7].

Power quality monitoring

- Avoid **unacceptable disturbances** to microgrid and other network users
- **Monitor** power quality: threshold-crossing, power factor, and harmonic data
- **Power quality techniques** improve voltage fluctuations, harmonics distortions, voltage flicker, three-phase voltage unbalance, direct current offset and voltage dip or sag





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Advanced microgrid power control (III)

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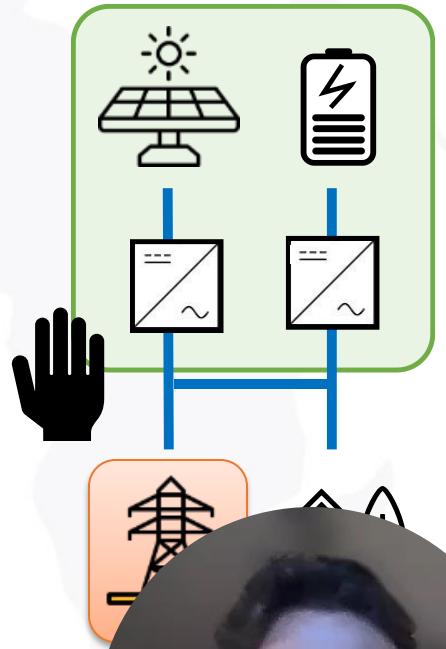
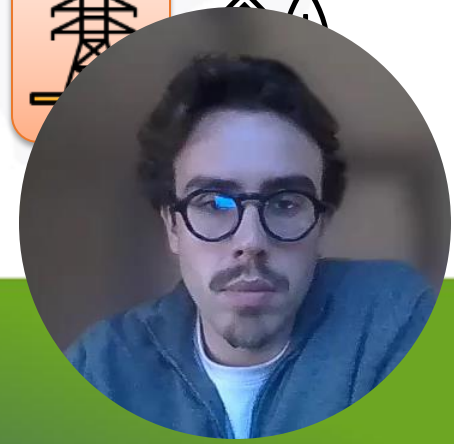
Advanced microgrid control needs to perform several functions like islanding detection and protection, power quality monitoring and **microgrid protection** [6,7].

Microgrid protection

- **Relays** compare the measured data (voltages, currents, power, and frequency) against pre-determined thresholds and, when exceeded, trip signals are sent to the breakers.
- Different protection devices can be implemented:
  - ✓ Voltage-based protection, Overcurrent protection, Differential protection, Distance-based protection
  - ✓ Adaptative devices (real-time data) and other advanced techniques (harmonics, admittance…)





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