Smart grid challenges

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UnCoVerCPS Workshop

Voltage control of MV networks

The presence of DGs may produce voltage increases, power flow inversion and inverse currents.

→ Voltage profile control becomes seriously important!

Major challenges:

- Finding a good **system model**
- Deal with a **complex control problem**

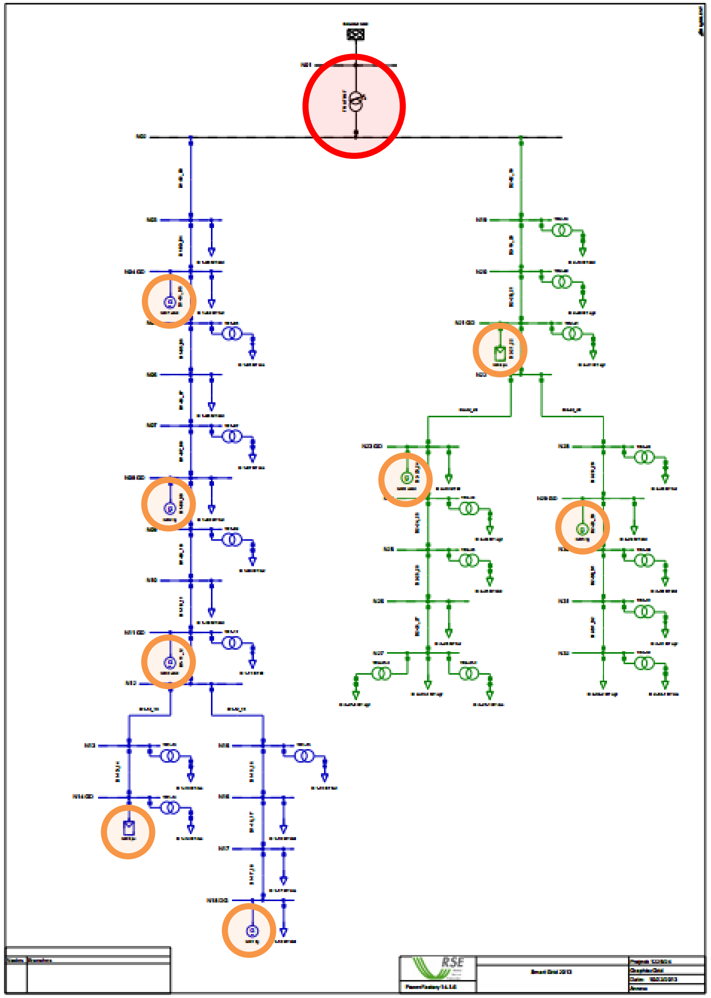
Possible solution:

- **impulse response MIMO model**
- **hierarchical control**

→ DGs power factors

→ OLTC transformer

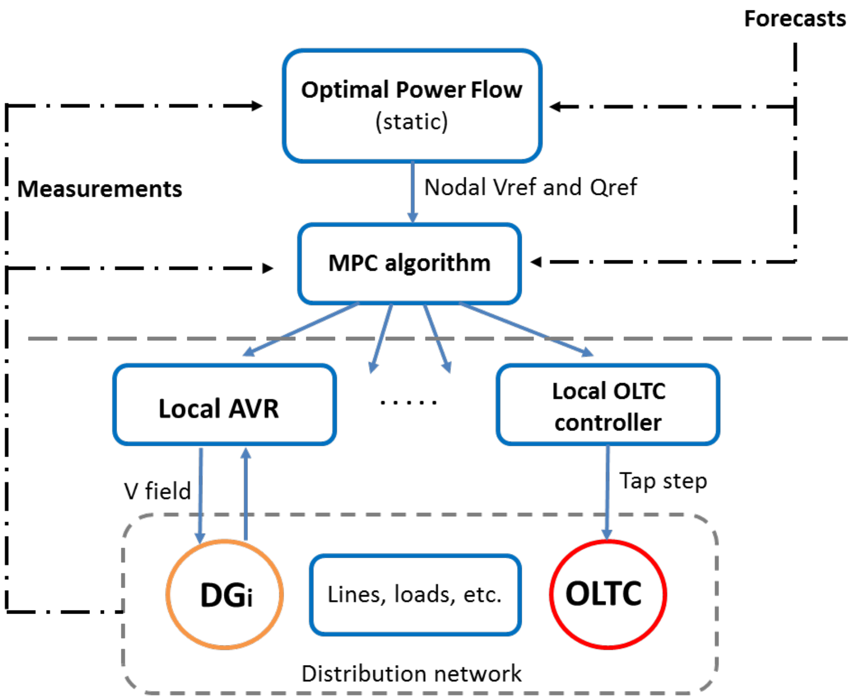
(On-Load Tap Changer)



Rural radial network, 20 kV
Feeder 1: 27 km, Feeder 2: 37 km

Voltage control of MV networks

Hierarchical control structure



Energy management of grid-connected microgrids

Goal:
- Optimal **long-term** scheduling of microgrid **production/consumption**
- **Short term** tracking of the planned activities

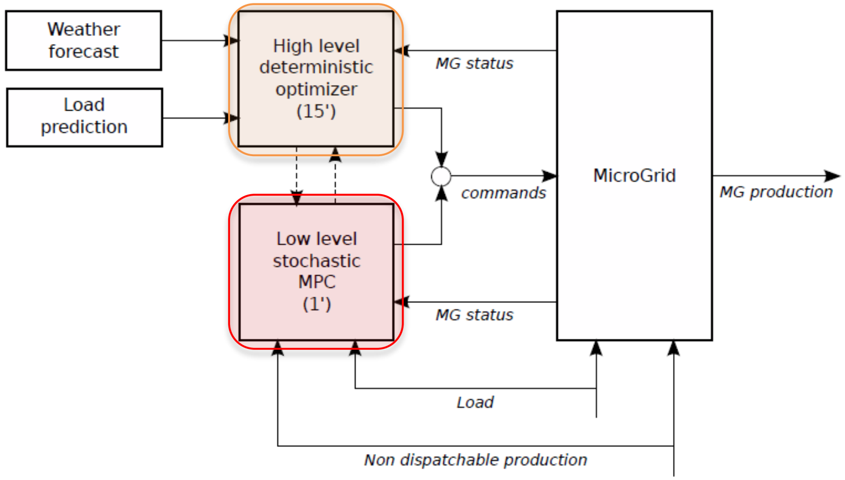
Solution: **Two-layer structure**

- Deterministic high level optimization (15’)

  Economic scheduling of production over 24h considering **predictions**

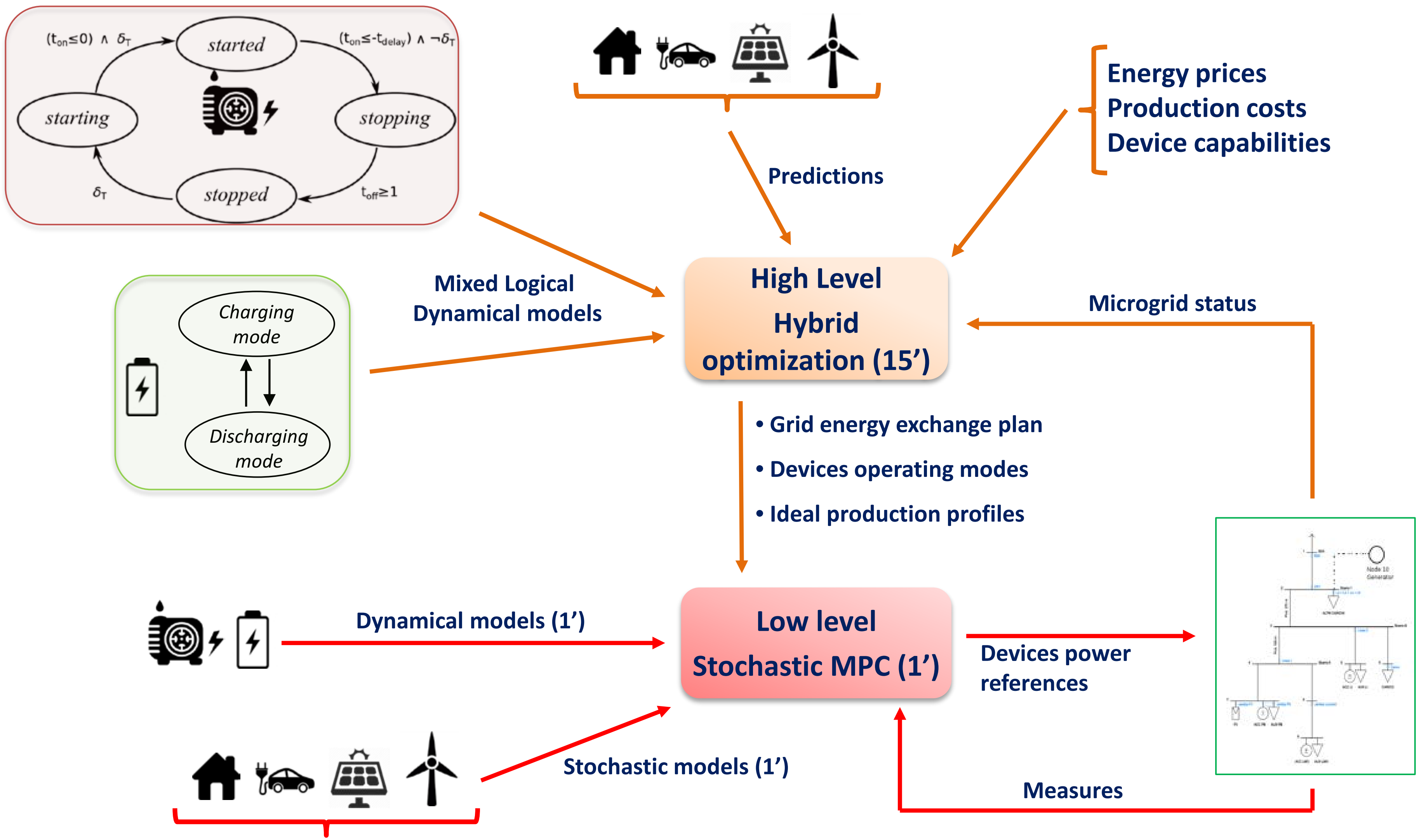
- Stochastic low level shrinking horizon MPC (1’)

  Minimize integral of the error of the grid exchange



- Offline optimization: Day-ahead plan definition based on forecasts
- Online optimization: Intra-day update aiming to respect the declared exchange profile

Energy management of grid-connected microgrids

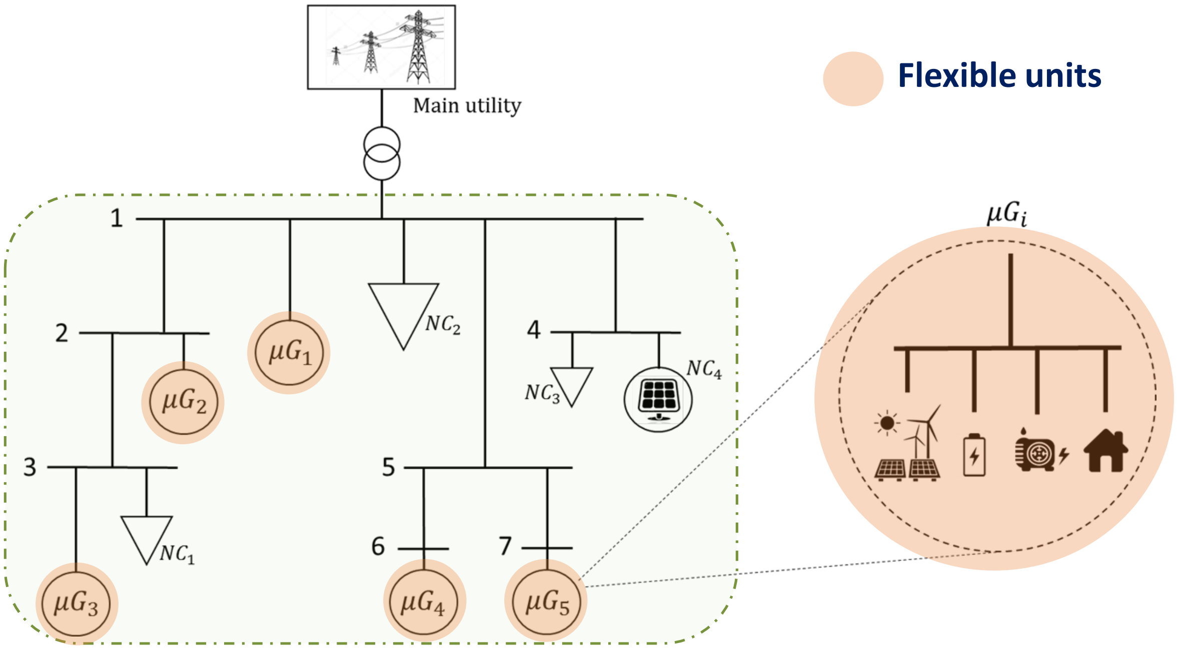


Multi-microgrid aggregator providing ancillary services

Problem: MPC microgrid control may be economically convenient, but

- No **ancillary services** (negligible impact on grid system)
- **Transmission System Operator and Distribution System Operator** have to interact with **many microgrids that want to make profit**

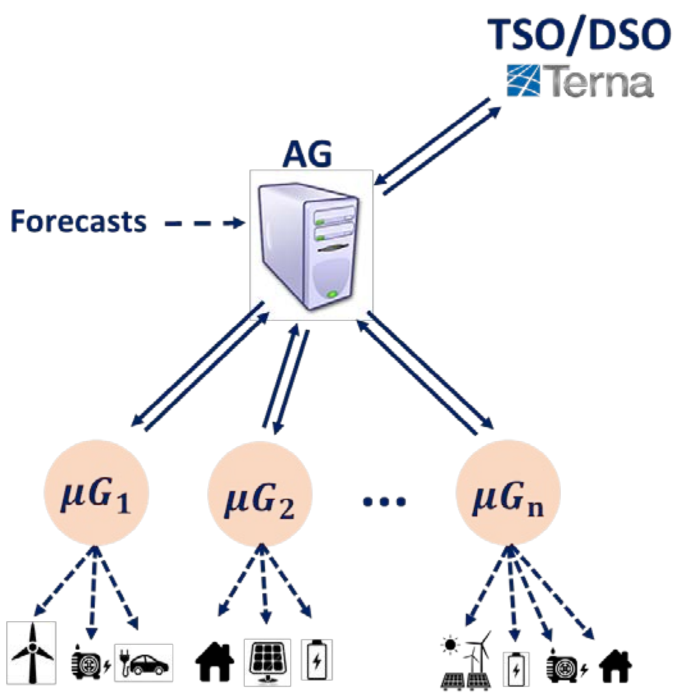
Solution: Multi-**microgrids coordination** as part of an **Aggregator** (AG)



Multi-microgrid aggregator providing ancillary services

Aggregator objectives:

- Day-ahead scheduled energy exchange
- **Ancillary services (**e.g. **primary reserve, minimum equivalent inertia**)
- Reactive power management for nodal voltages control



Aggregator energy exchange
Ancillary services

Microgrids coordination →

- **Privacy issues**: Microgrids would not like to be controlled and to share their internal info
- **Too complex** problem

Microgrid hierarchical control

Network cluster control and coordination using DC lines

The existing **distribution networks** are not structured for consistent **diffusion of distributed generators** because of:

- **Bidirectional** and **consistent AC power flows**
- **High variability and uncertainty**

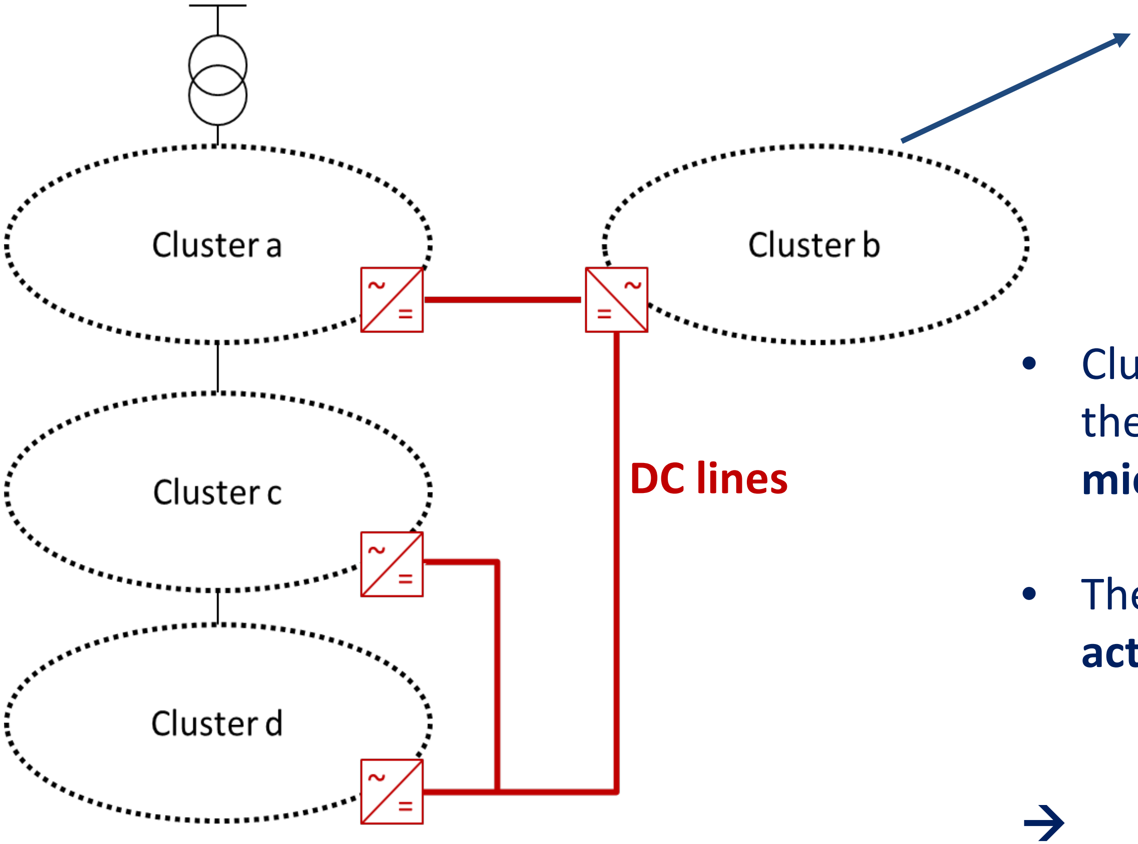
However:

- **Microgrids** can offer their **flexibility** to **compensate uncertainties.**
- Additional **mesh DC power lines** are considered a valiable solution to redistribute power flows and **exchange power** among **network areas**.

→ Lower losses, fully controllable flows.

Proposed solution: **Cluster-based approach**

Network cluster control and coordination using DC lines



- **Microgrids**
- **Loads**
- **Renewables sources**

- Clusters try to internally **autobalance** their uncertainties exploiting **microgrids' reserves.**
- They can **interact** and **exchange active power** through **DC lines**

→ **Hierarchical MPC approach**

Thank you