

Towards real time optimization in active distribution networks using Hardware-in-the-Loop

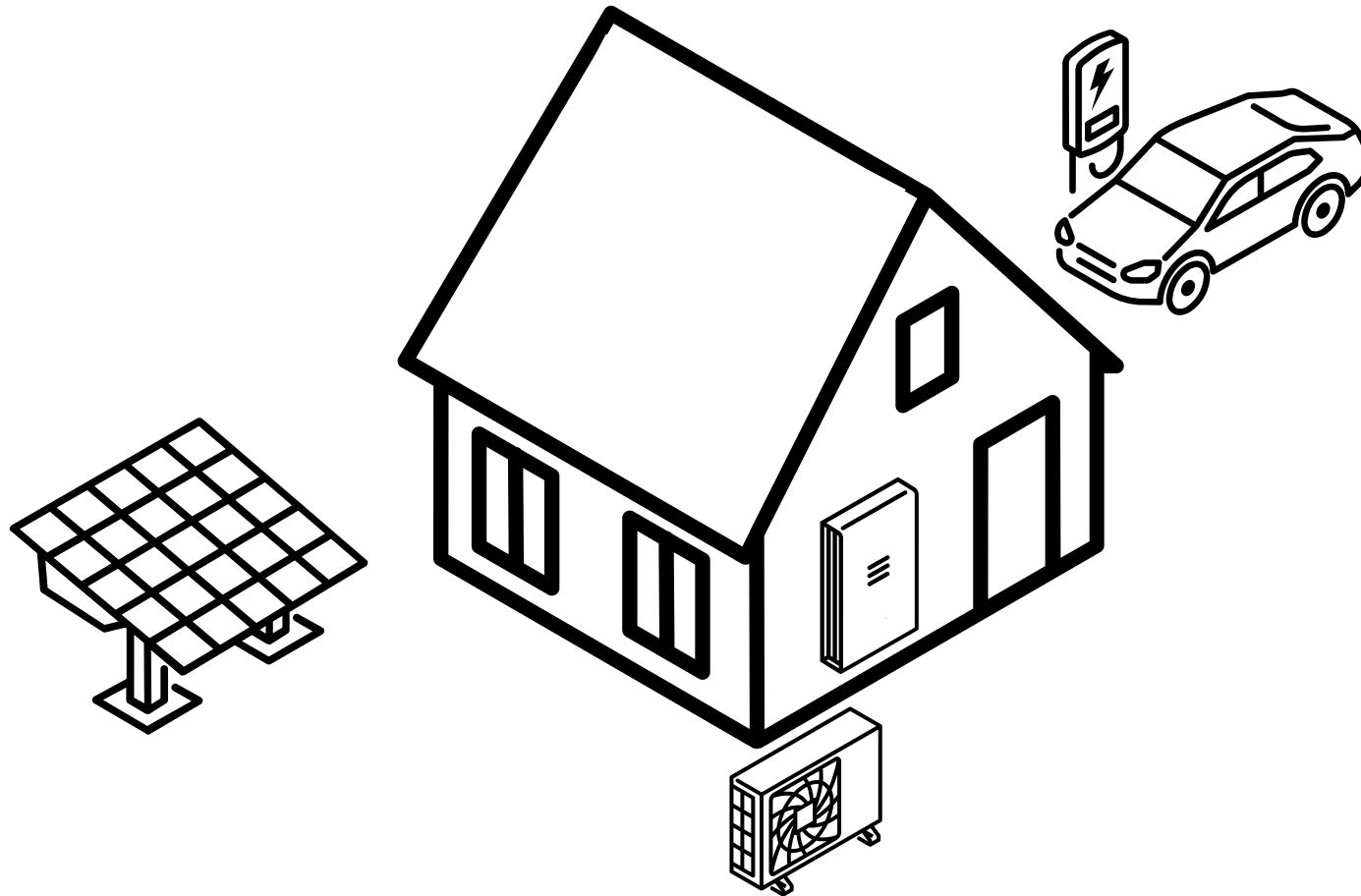
Clément Moureau & Bastien Ewabank

Densys week

22nd March 2024



Evolution of production and consumption means





Distribution Network : Yesterday

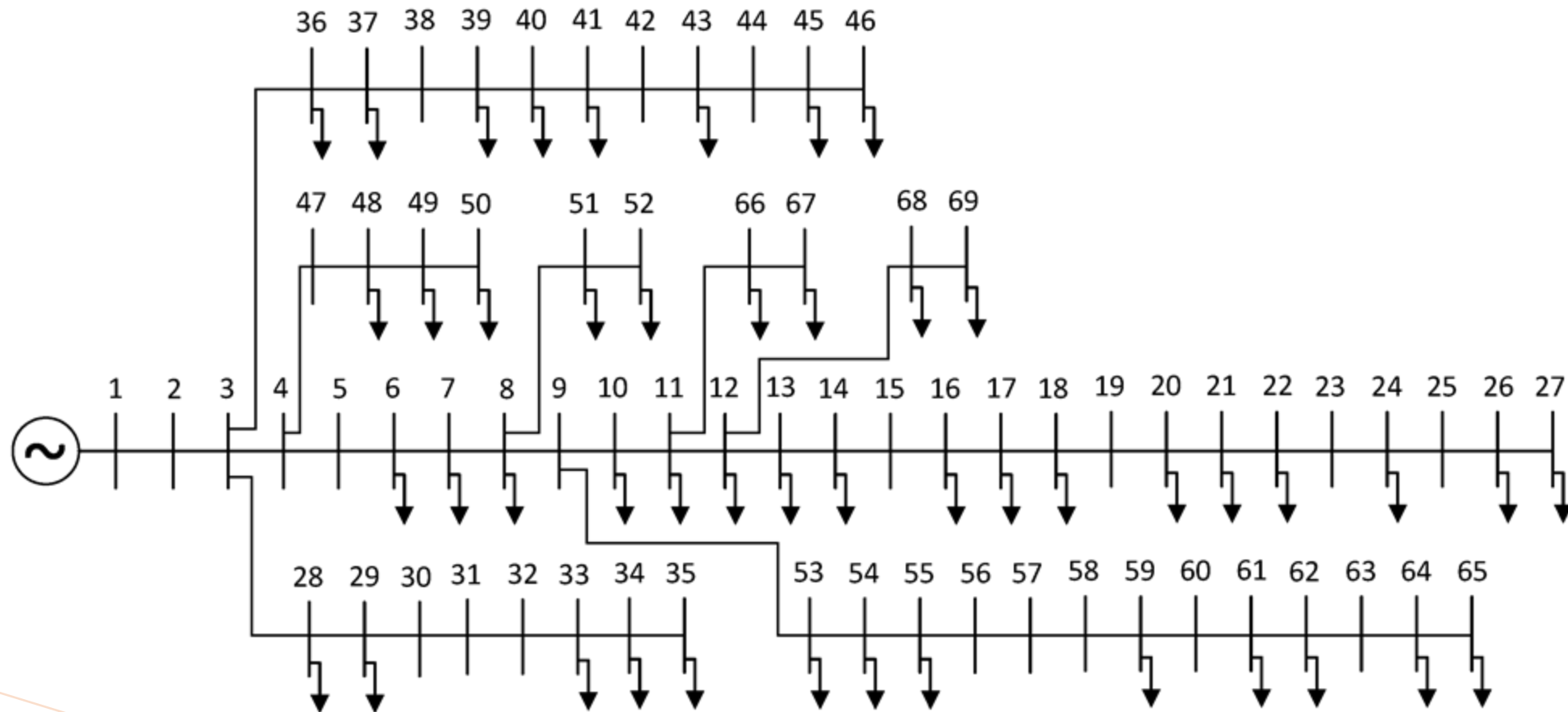


Figure 1 : Radial distribution network of 69 nodes [1]



Distribution Network : Yesterday

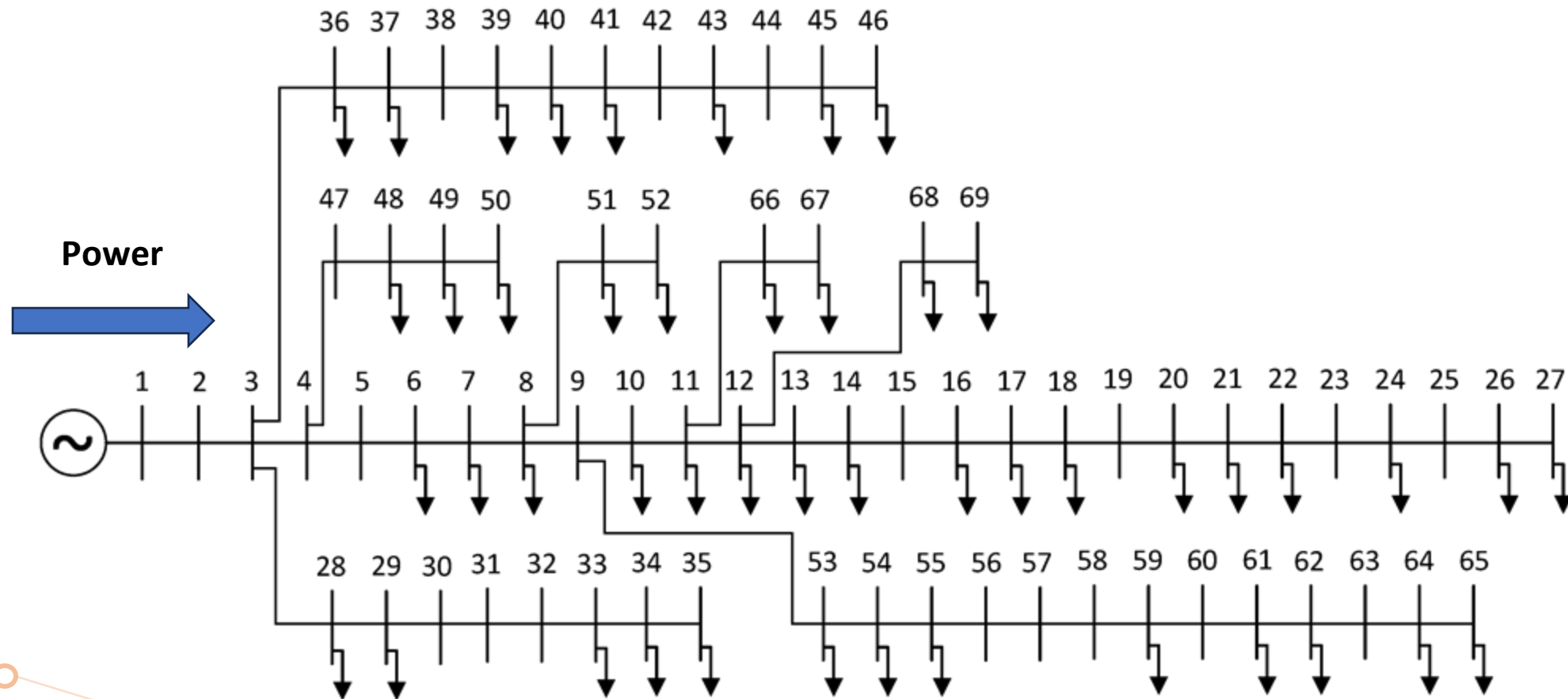


Figure 1 : Radial distribution network of 69 nœuds [1]

Distribution Network : Today

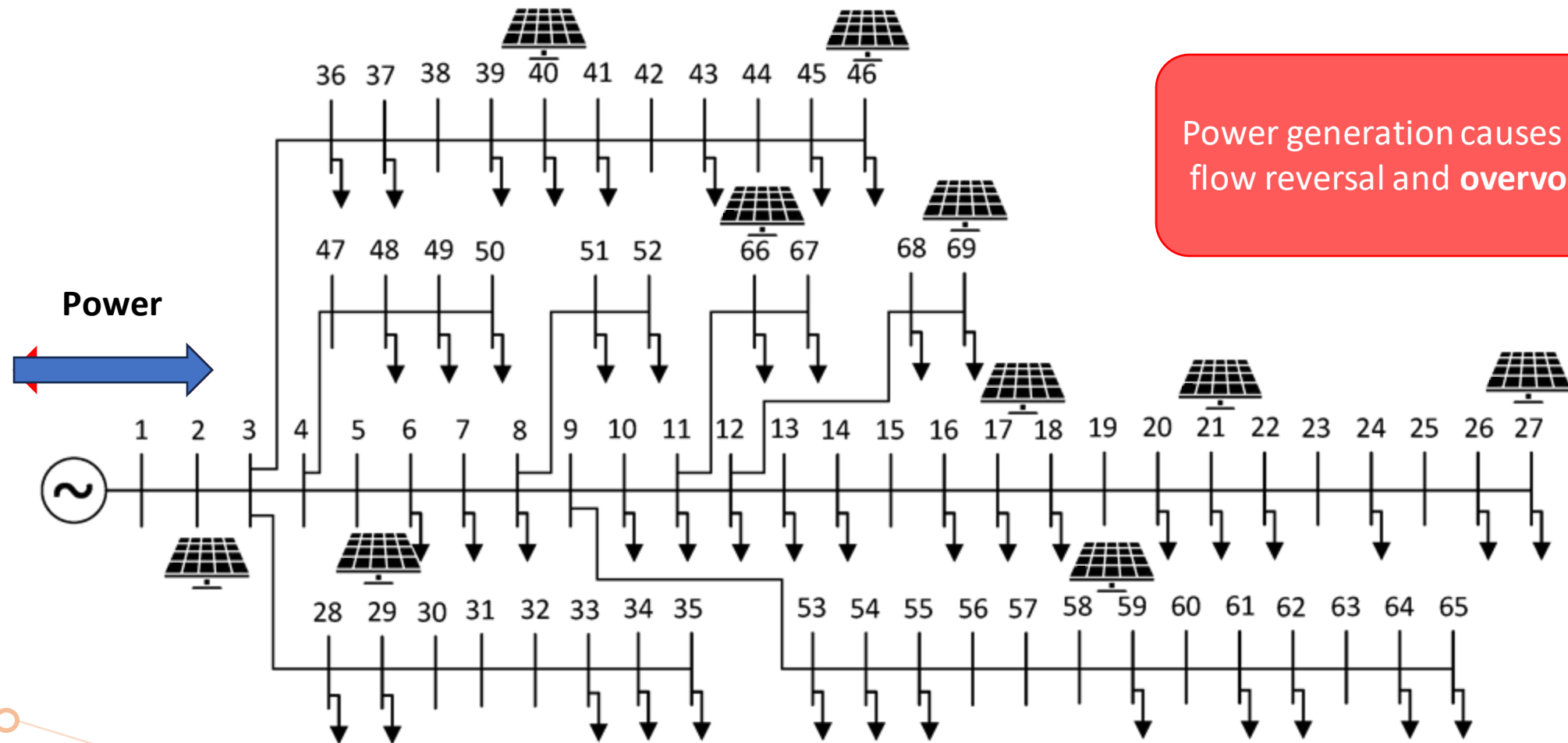


Figure 1 : Radial distribution network of 69 nodes [1]

Distribution Network : Today

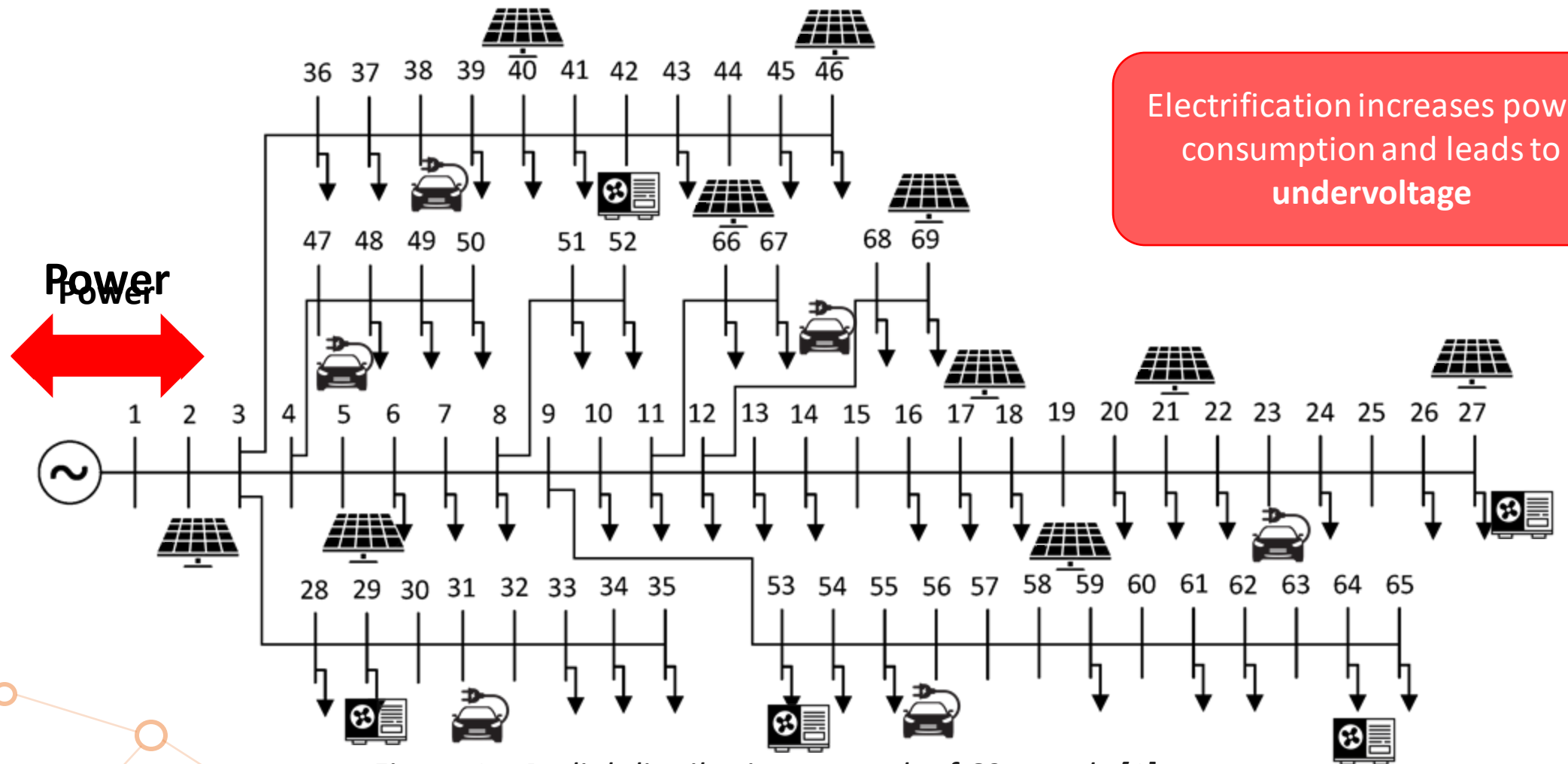


Figure 1 : Radial distribution network of 69 nodes [1]



Distribution Network : Tomorrow

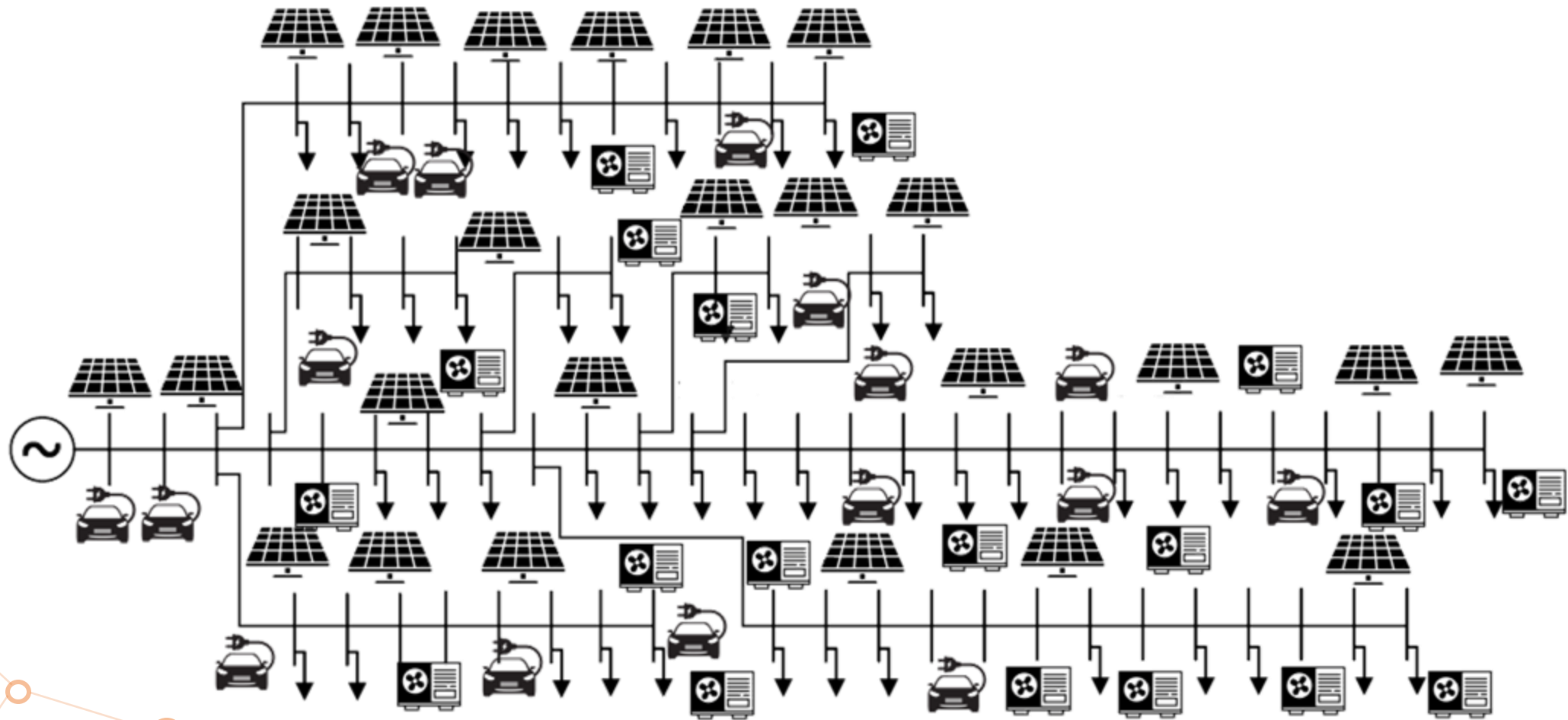
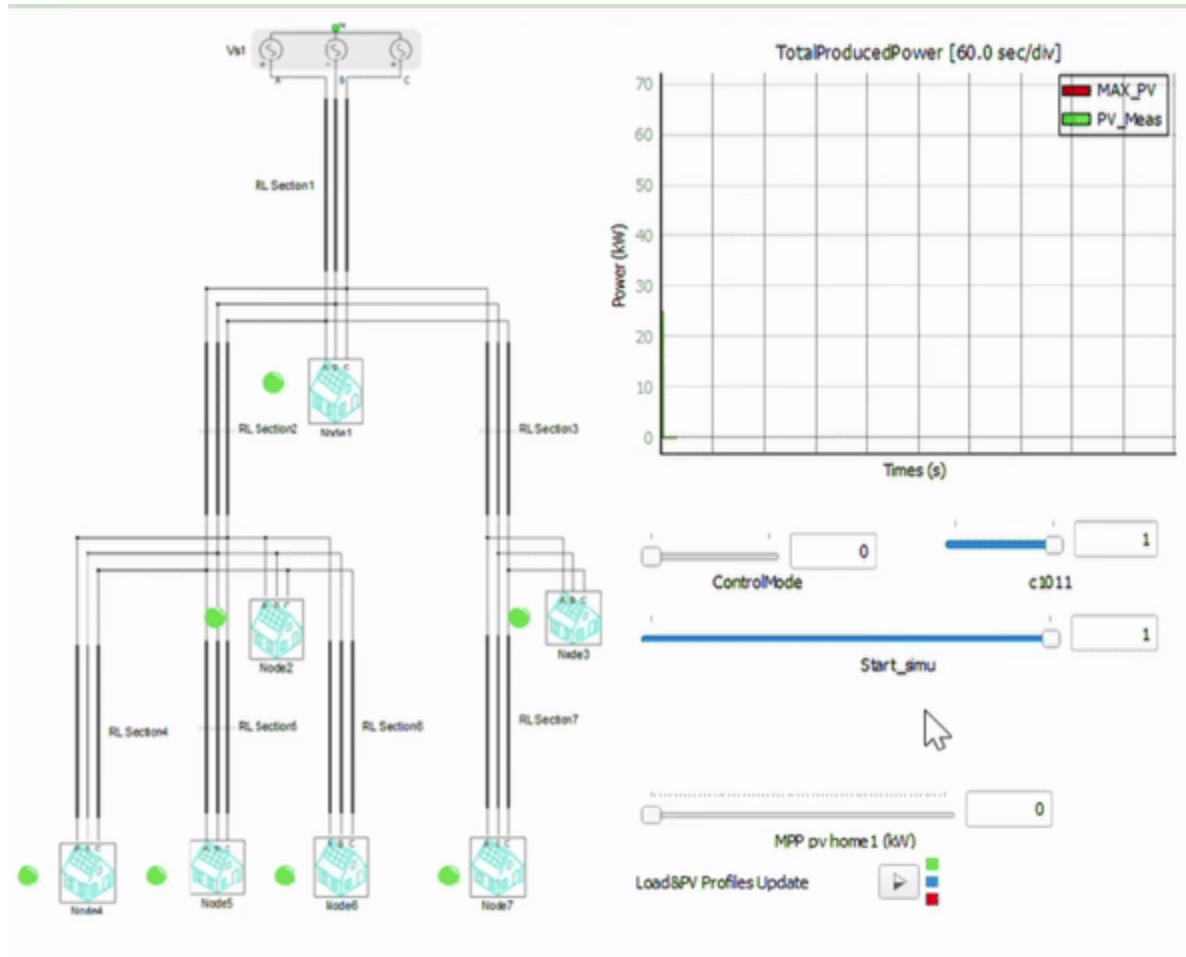


Figure 1 : Radial distribution network of 69 nodes [1]



Research Context



PV inverter tripping
→ Wasted Energy 😞

Tripping Cause :
MPPT controller +
overvoltage protection



Solutions

- ▶ Strengthening the electrical grid → **Costly**



Source de l'image : Sieds.fr

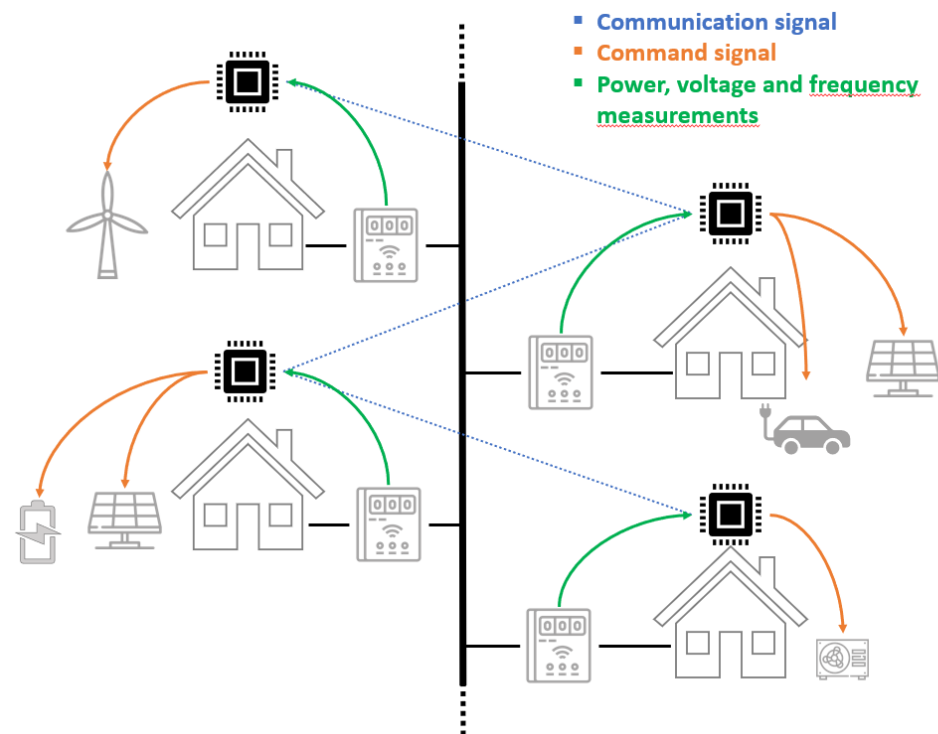


Solutions

► Strengthening the electrical grid



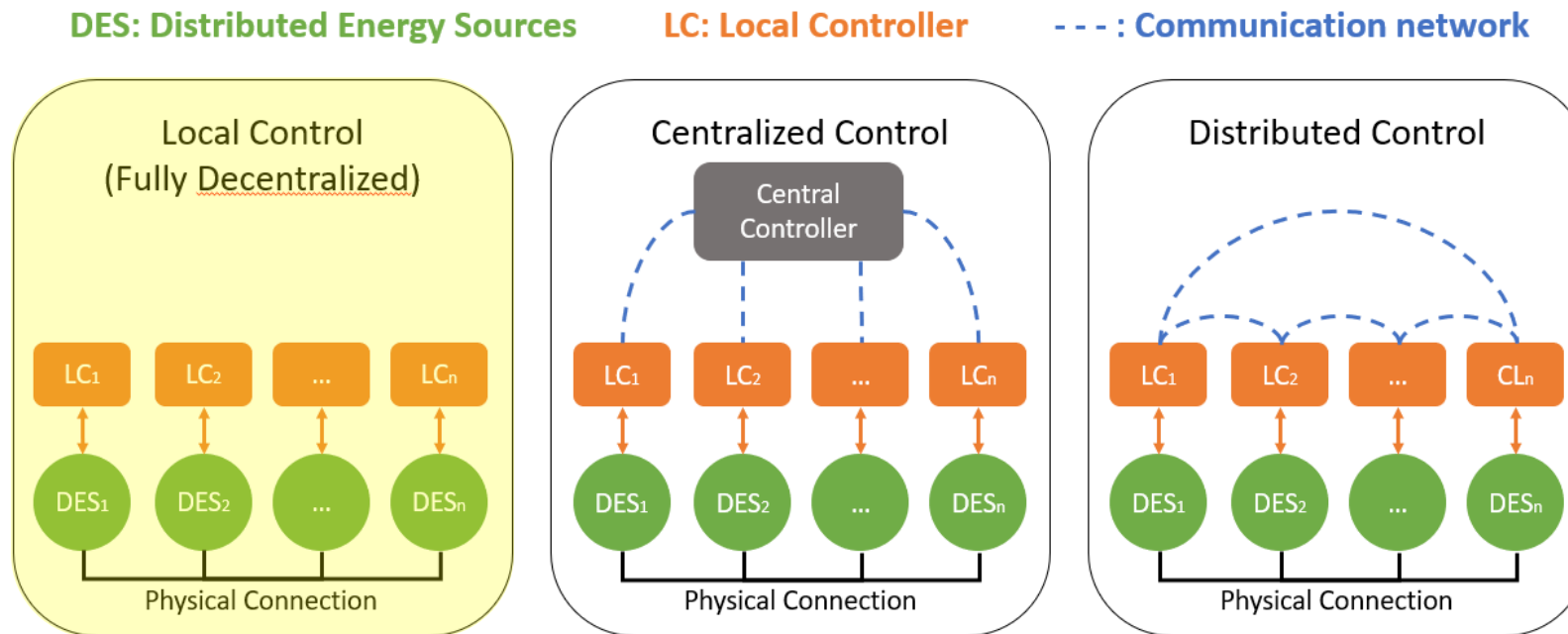
► Leveraging the flexibility of low-carbon technologies (LCTs)





Solutions : Decentralized Control

- ▶ Leveraging the flexibility of low-carbon technologies (LCTs) through an optimal control

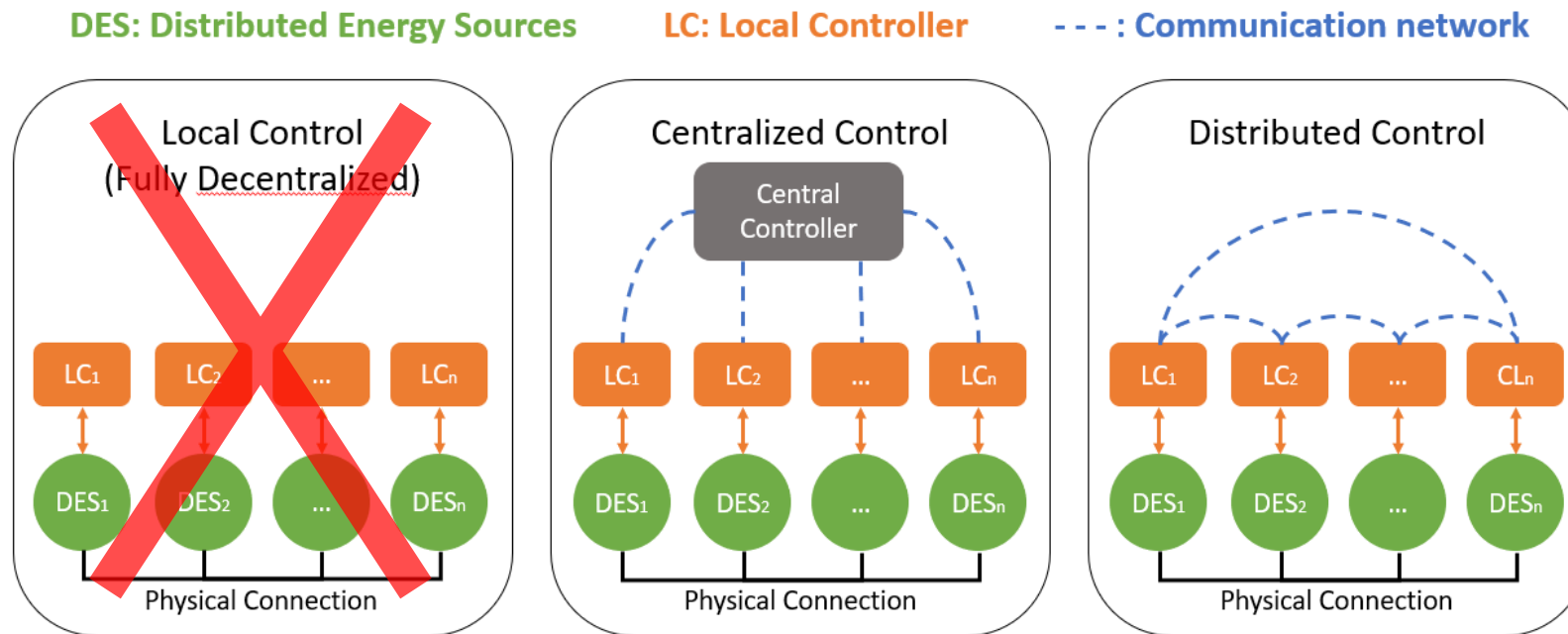


Implemented right now



Solutions : Decentralized Control

- ▶ Leveraging the flexibility of low-carbon technologies (LCTs) through an optimal control



Implemented right now

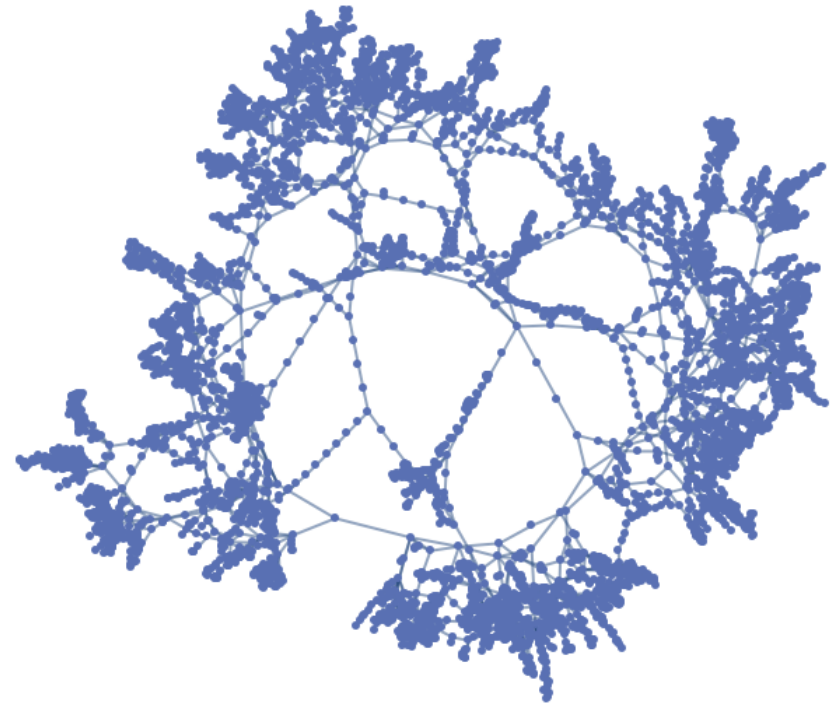
➔ Sub-optimal results



Solutions : Centralized Control

Centralized control ?

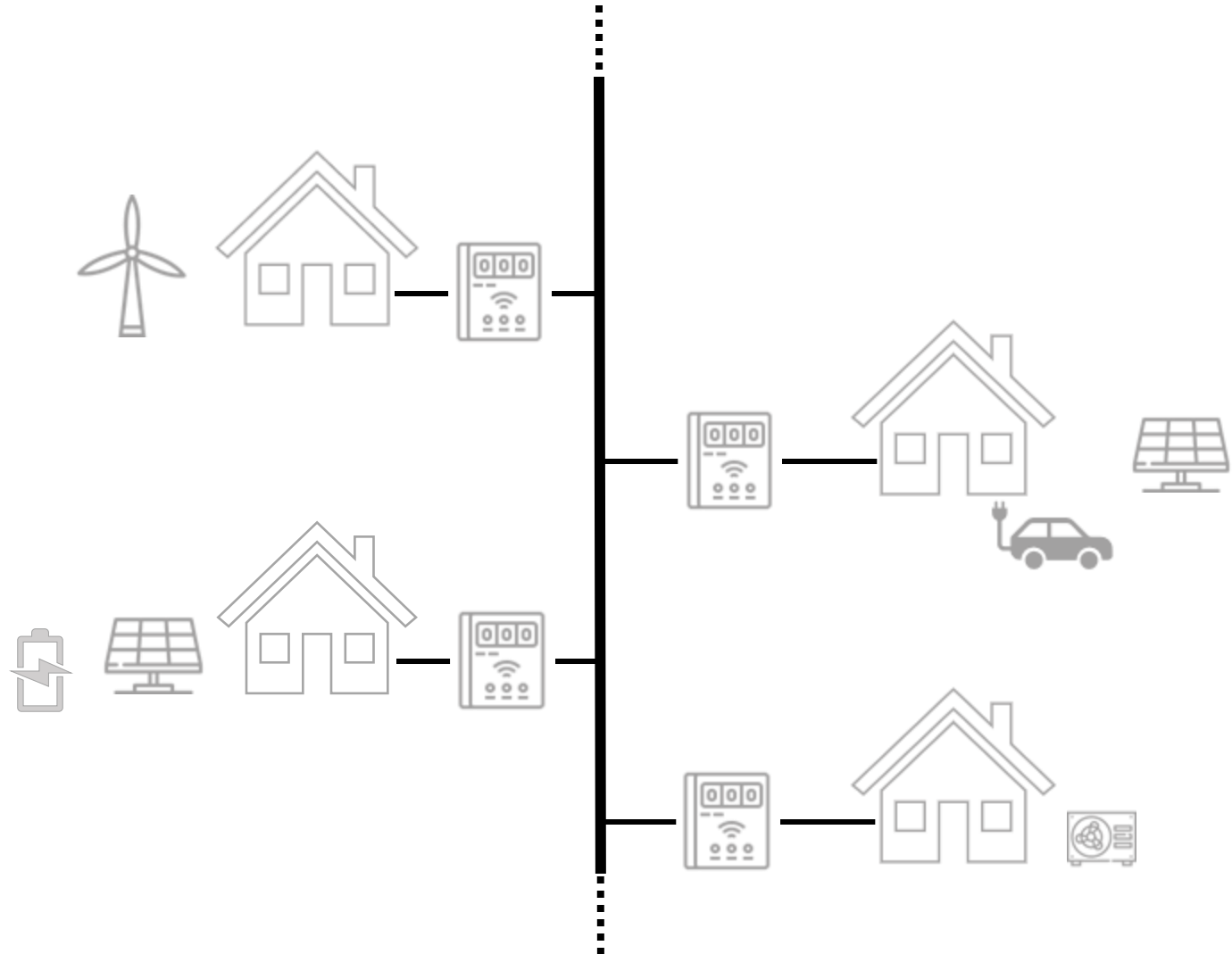
- Requires communication links between the centralized controller and ALL network nodes
→ **Scalability issue**
- Requires significant computing infrastructure
- Single point of failure



→ **Distributed Control**



Schematic Overview of Distributed Control

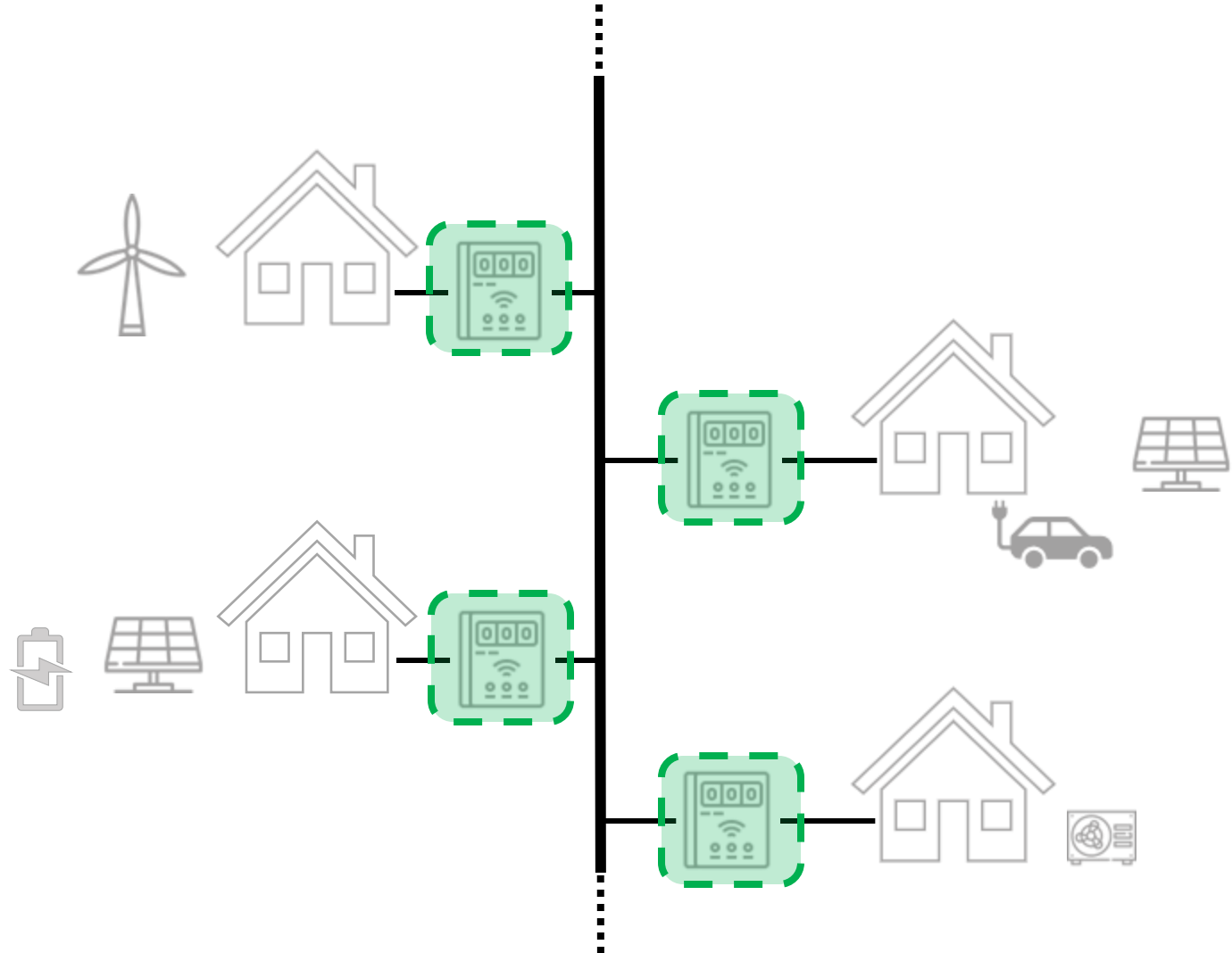




Schematic Overview of Distributed Control

Smart Meters

Measure voltages, currents
and powers



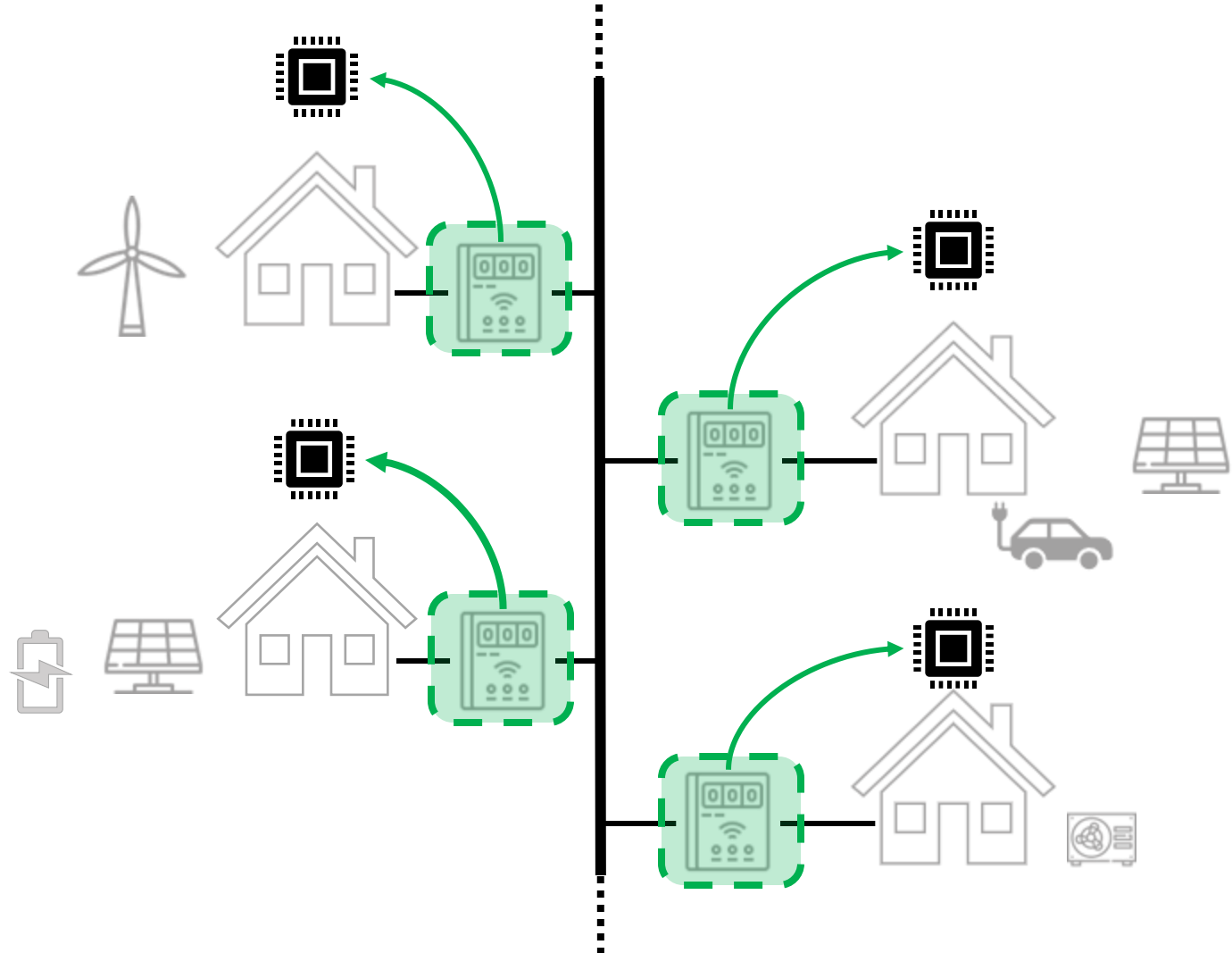


Schematic Overview of Distributed Control

Smart Meters

Measure voltages, currents
and powers

Communicate with
microcontrollers

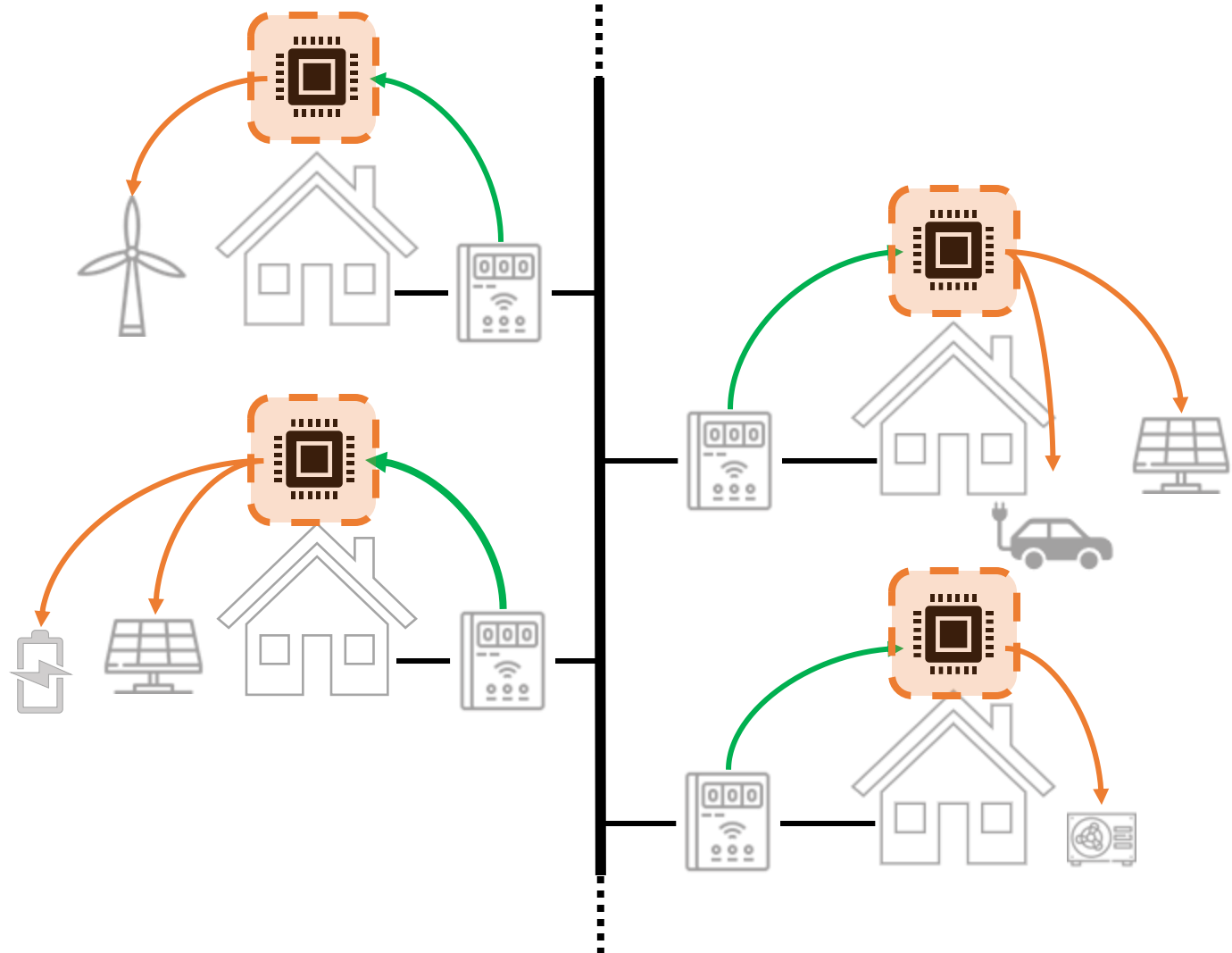




Schematic Overview of Distributed Control

Micro Controllers

Computes the new setpoints and send them to the different devices

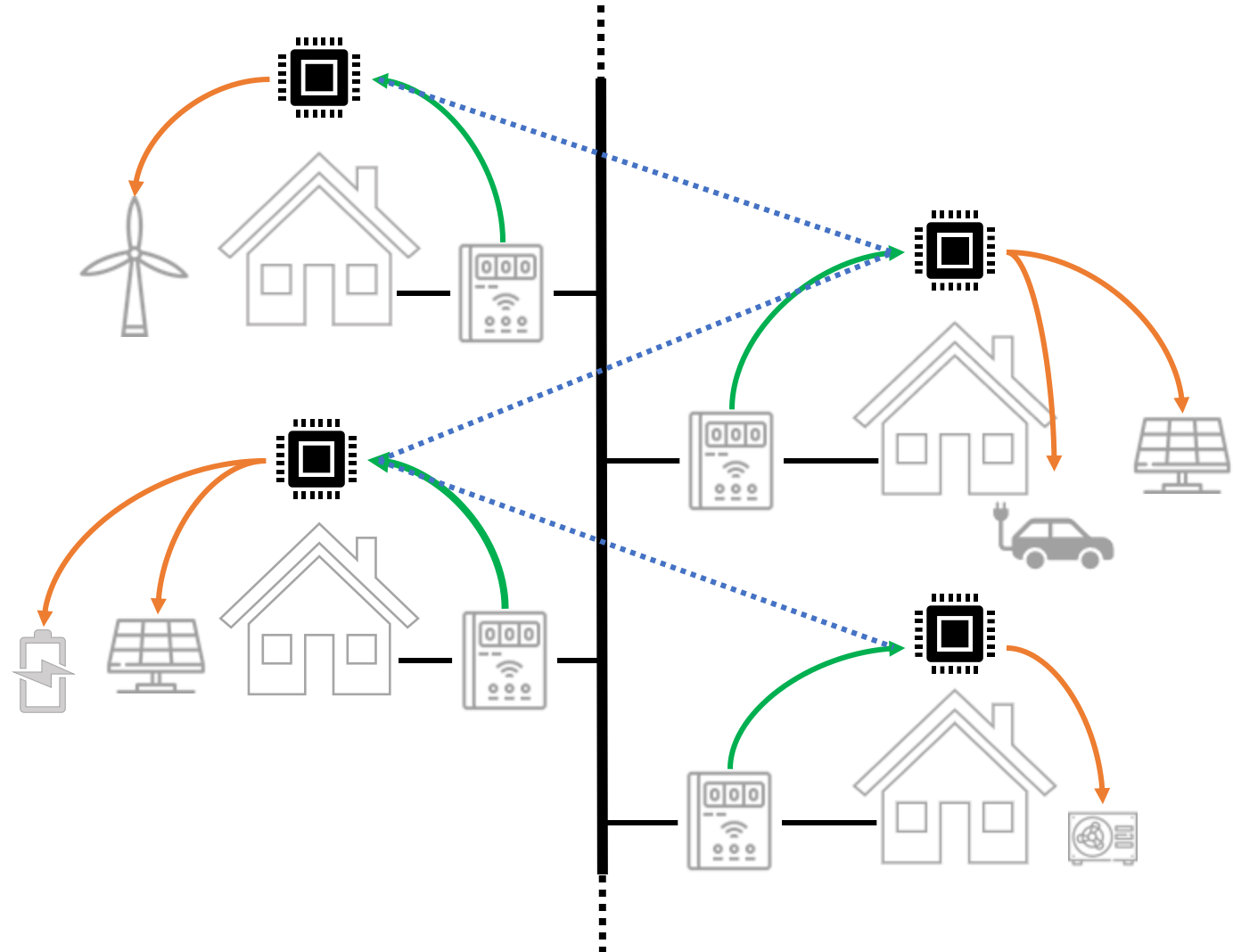




Schematic Overview of Distributed Control

Communication Lines

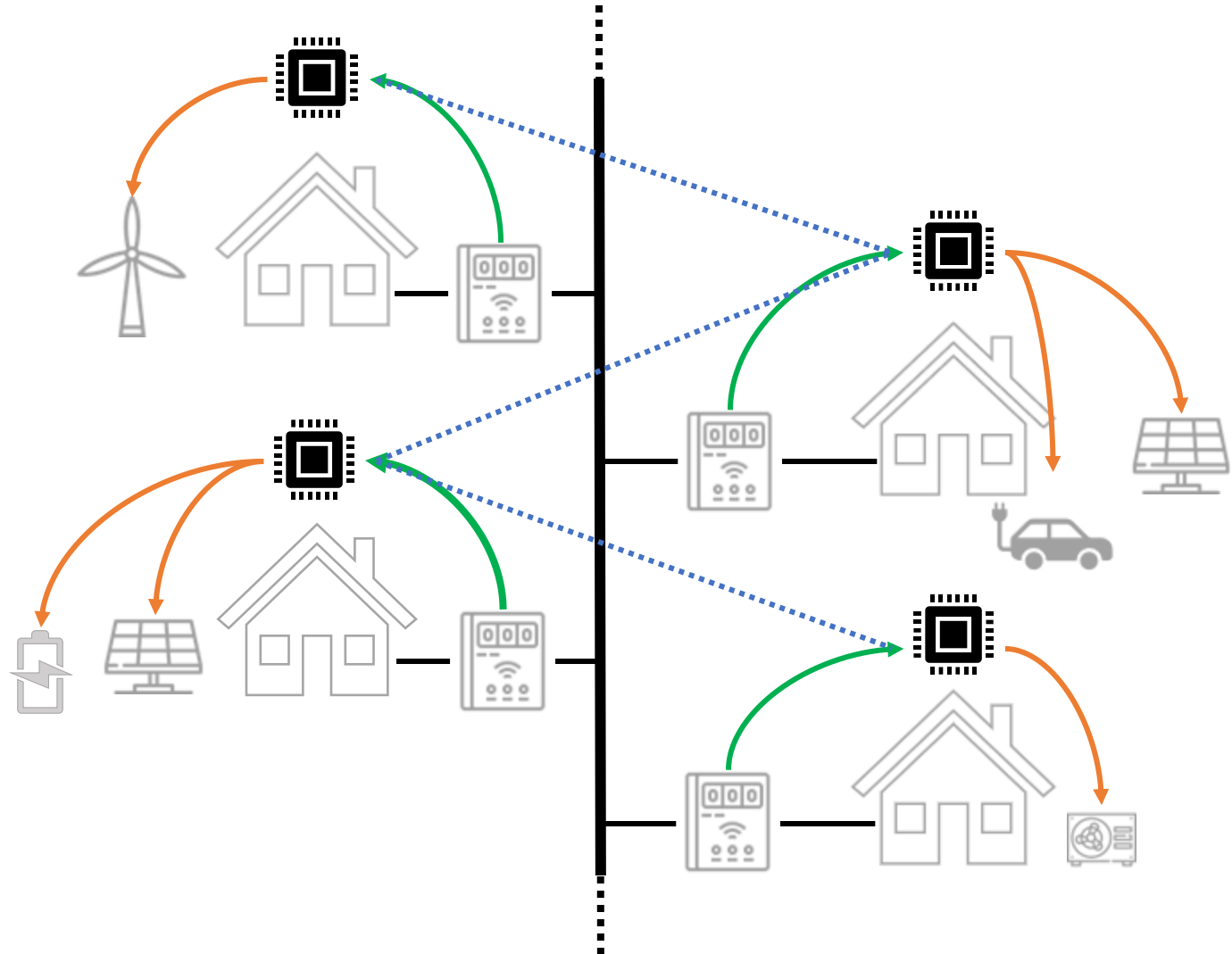
Allow microcontrollers to communicate with each other to reach a consensus





Schematic Overview of Distributed Control

Real time
optimization
allows to deal
with varying
conditions

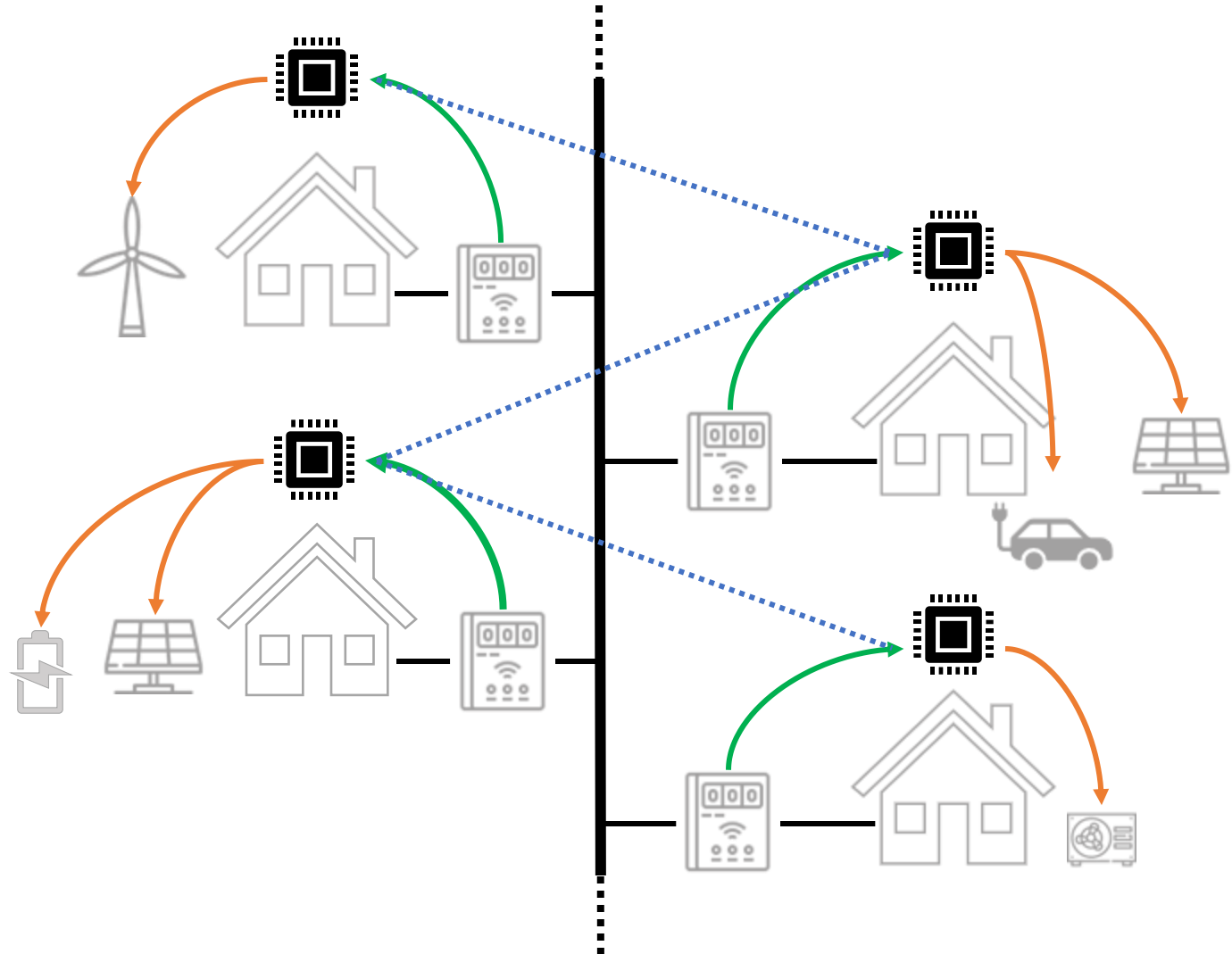




Research Context

Ultimate Objective:

Demonstrate ability of **online distributed controllers** to address operation problems in distribution networks.



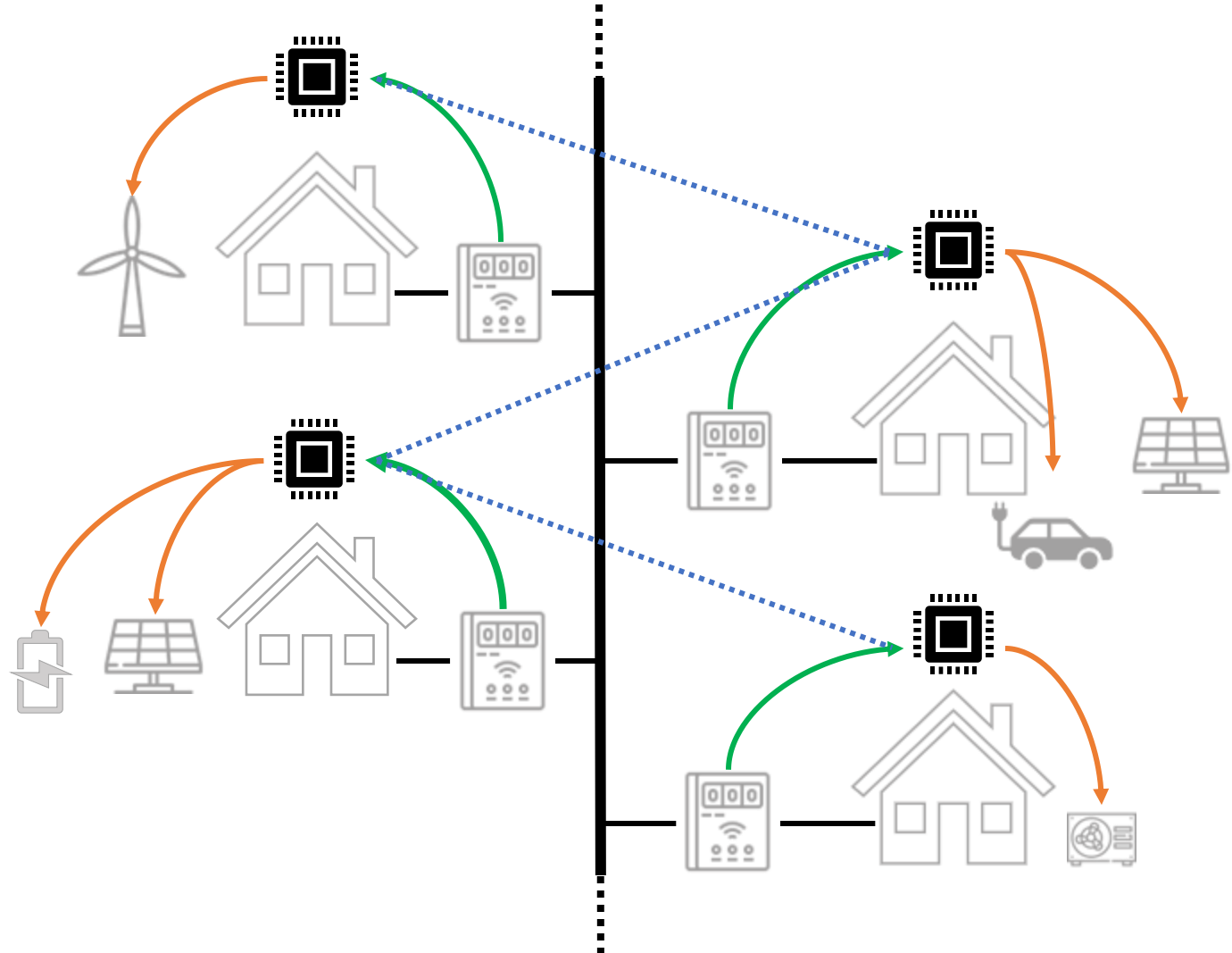


Research Context

Ultimate Objective:

Demonstrate ability of **online distributed controllers** to address operation problems in distribution networks.

→ We need a **large scale and accurate simulation** tool for comparison.





Proposed Architecture

