PHIL Architecture for Integrated Thermal-Electric Grids

Dr. Vedran Perić
Head of Research Center for Combined Smart Energy Systems (CoSES)

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Outline

Introduction

Concept of Grid Hardware-in-the-Loop

Opprtunities and challenges of distributed embedded controllers

Conclusions

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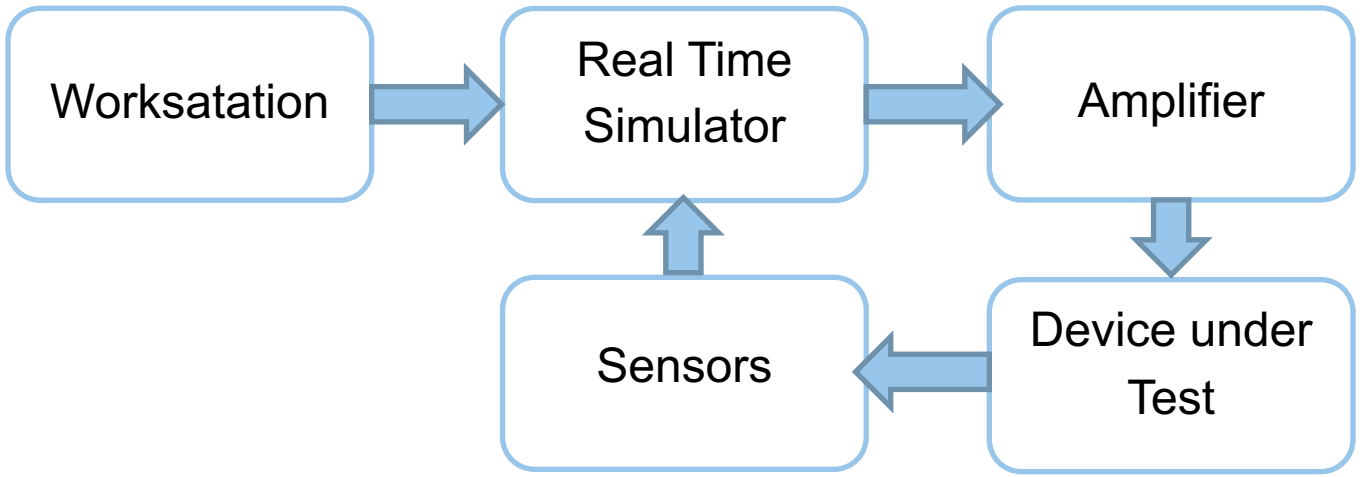
Do we need Hardware-in-The Loop?

- It is useful but sometimes overused
- If the behavior is exactly known, we don't need PHIL
- Hower, it is needed with unfamiliar components
  - Internal controllers
  - High frequency behavior



Quotes

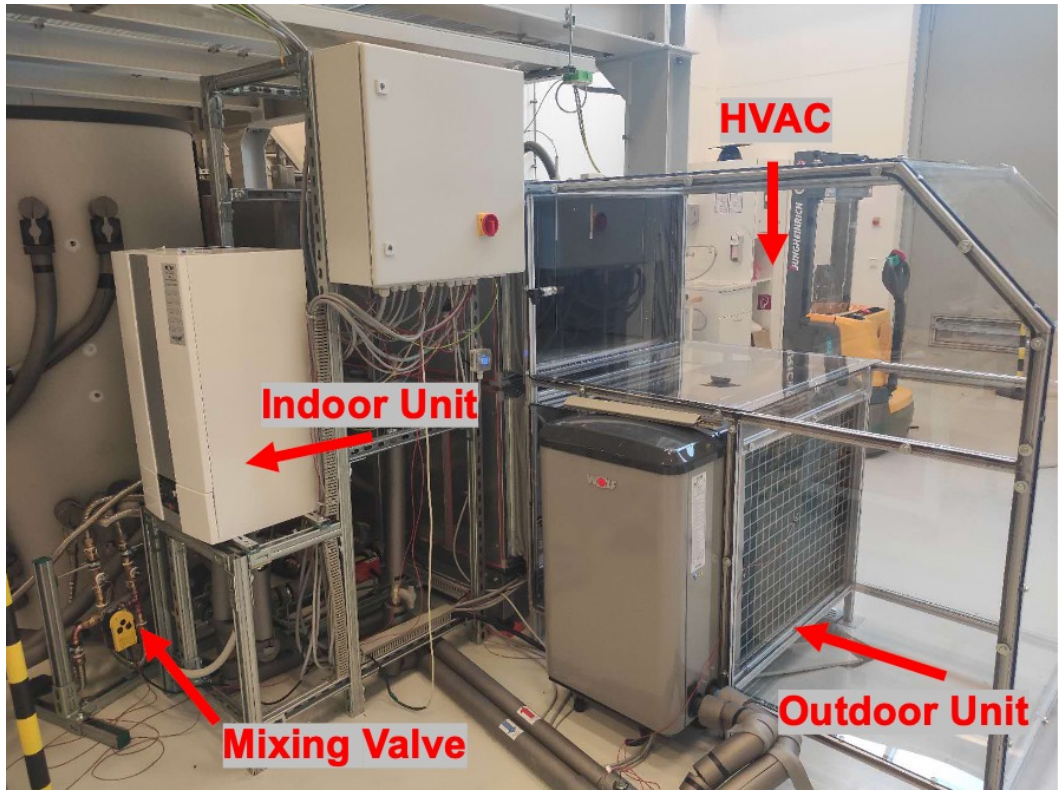
PHIL – The future of electric testing
DNV GL

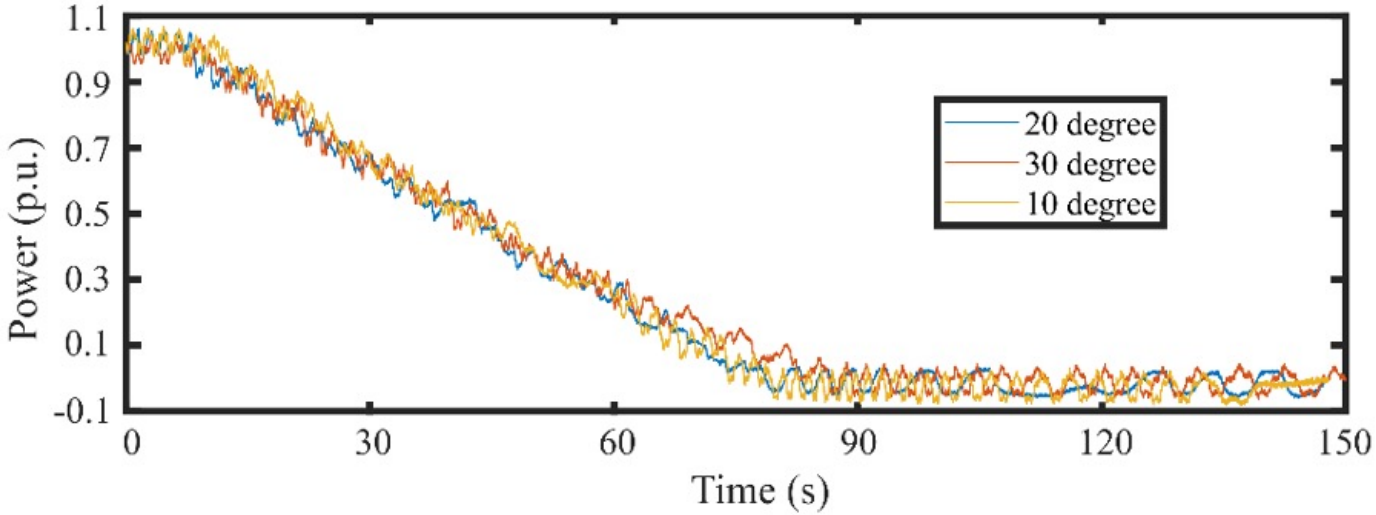
PHIL – A Revolution in the Industry
Opal RT

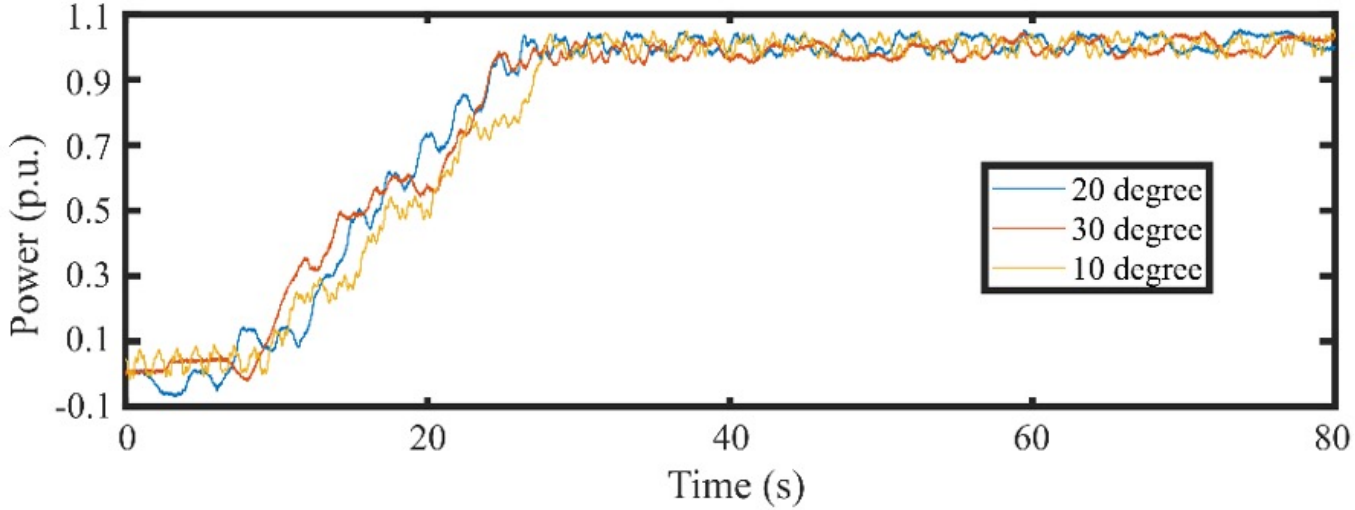
PHIL provides an unparalleled opportunity to characterize the behaviour of power hardware prior to installation in the network
RTDS

Components with unpredictable behavior in multi-energy systems

- In multi-energy systems we have more components with fuzzy behavior







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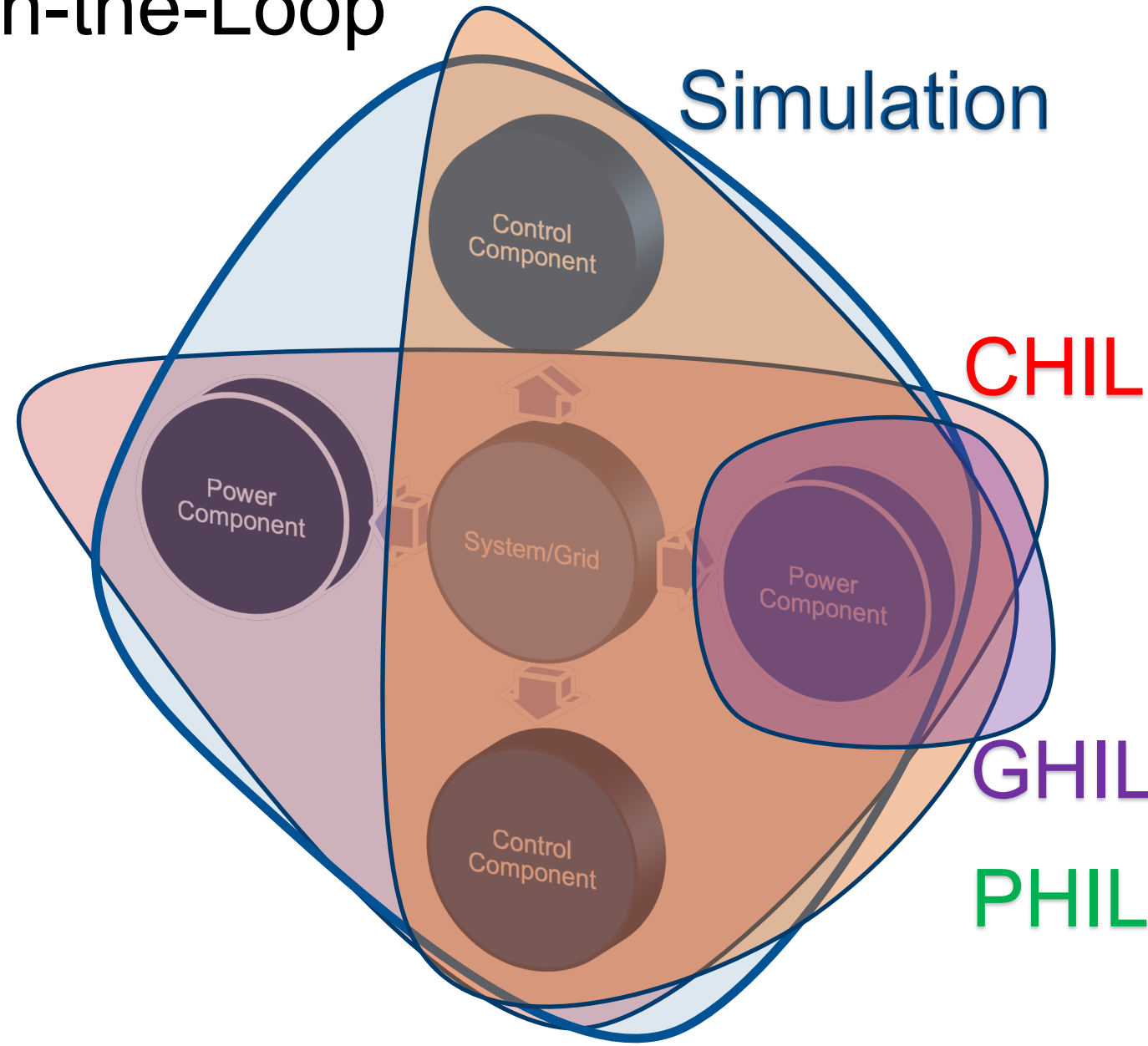
Grid Hardware-in-the-Loop

- Simulation
- Controller Hardware-in-the-Loop (CHIL)
- Power Hardware-in-the-Loop (PHIL)
- ***Grid Hardware-in-the-Loop (GHIL)***



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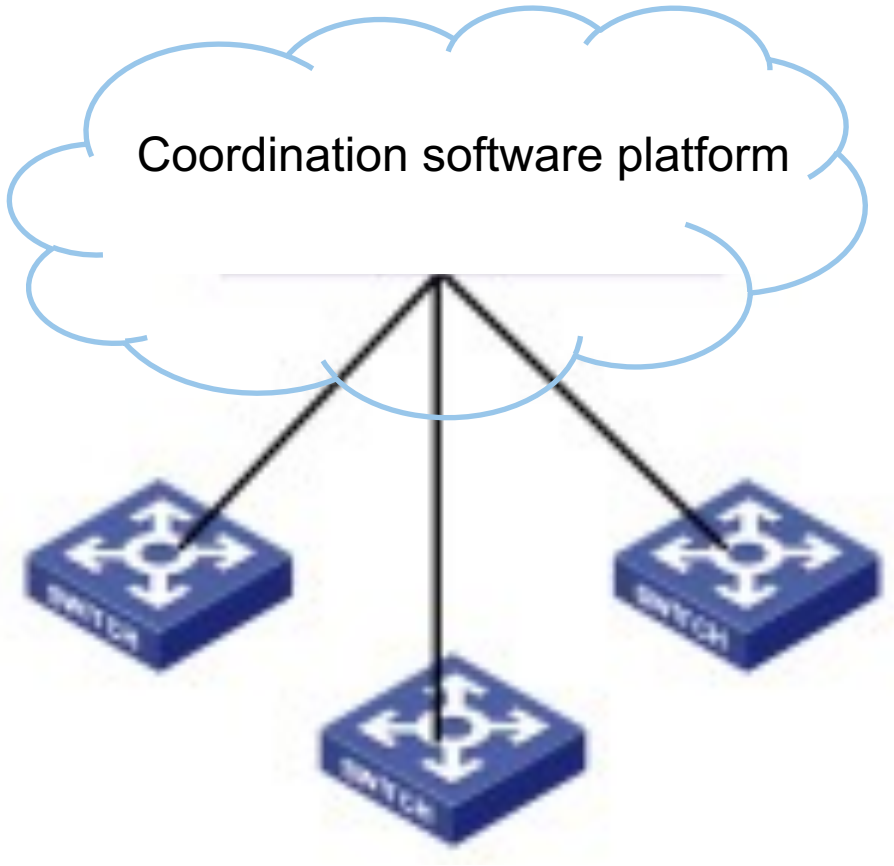
Grid Hardware-in-the-Loop



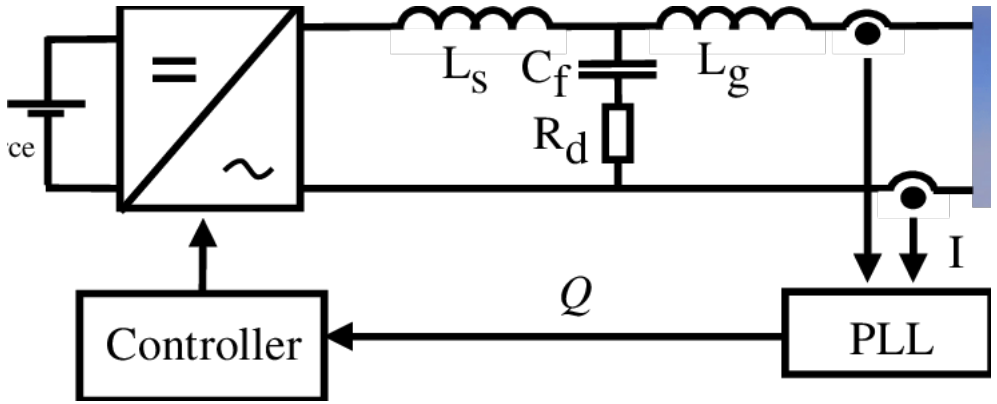
Parallel real-time simulators

- ***Challenges:***
  - Coordination/common point of management
  - Time synchronization
- ***Opportunities:***
  - Shared computation resources
  - Coordinated firmware management (updates, bug fixes)
  - Central monitoring point
  - Integration with other systems
  - Cost saving architecture/ Elimination of redundant measurements

Example: Measurement Redundancy

Each inverter in active distribution grids has:

- Voltage and current sensors/Transducers
- Synchoronization block



Sensors can be shared among multiple inverters

- Therefore, the system has redundant meaurements

P. Pant, F. Ibanez, P. Vorobev, T. Hamacher and V. Peric, "A Simplified Microgrid Architecture with Reduced Number of Measurement Units," *2022 IEEE PES ISGT-Europe*, Novi Sad, Serbia, 2022.

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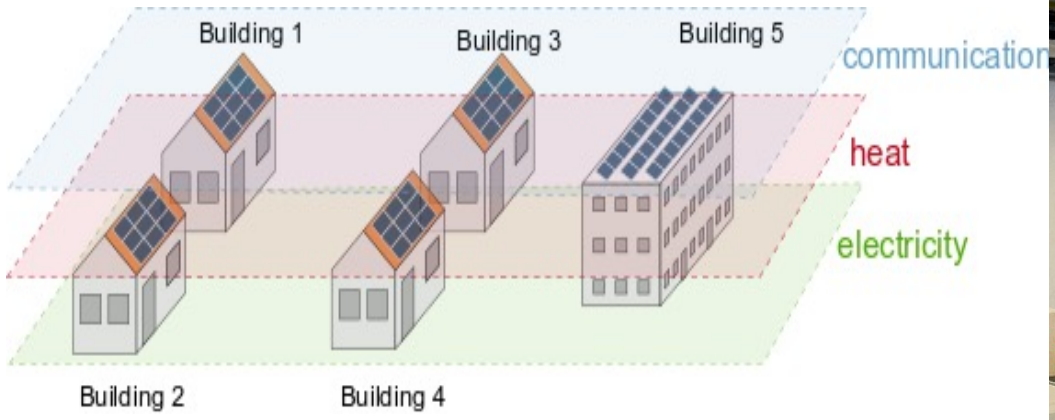

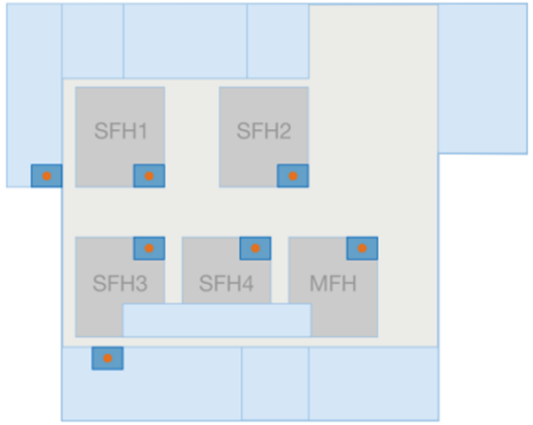

Conlusions

- PHIL is useful but not in every time
- GHIL extends the concept of PHIL with distibuted embedded controllers
- Distributed embedded controllers create new opportunities PHIL
- CoSES laboratory investigates distributed control approaches in multi-energy systems

THANK YOU FOR YOUR ATTENTION

Dr. Vedran Perić

Head of Research Center for Combined Smart Energy Systems (CoSES)

vedran.peric@tum.de
www.vedranperic.de