Towards Holistic Testing
–
Development of a Microgrid Controller

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 # European Distributed Energy Resources Laboratories

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Contents

1. Introduction

Holistic Testing – Motivation / Challenges

Motivation

- Pure simulations representing only simplified and user-assumed results
- Pure hardware testing is too complex and costly at innovation and research level
- Current testing capability is limited:
  - Component testing – difficulties in holistic system testing
  - Testing at rigid grid connections – no influence between device-under-test and network dynamics
  - Limitation of high power, missing components, etc.

Objectives

- Development and application of an advanced test chain for smart grid components
- Smoothen transitions between simulation, testing and validation
- Closing the gap between simulation, laboratory and field testing

2. Innovative Testing Chain

Stages of the Testing Chain

1. Simulation-only studies

- Simulation of all required components of a new idea/approach

2. Controller Hardware-in-the-Loop

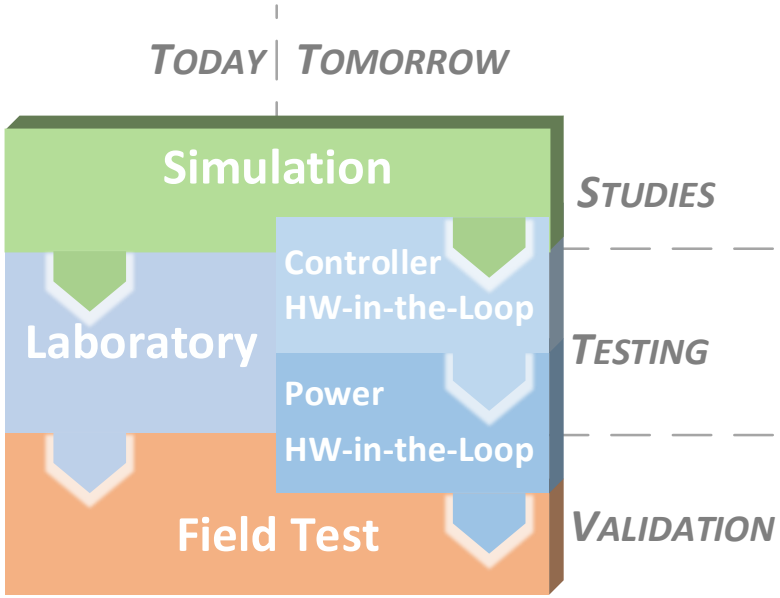
- Real-time simulation of all required components connected to a hardware controller

3. Power Hardware-in-the-Loop

- Replacement of simulated devices by hardware components and real-time simulation of remaining components

4. Field Test (Pure Hardware)

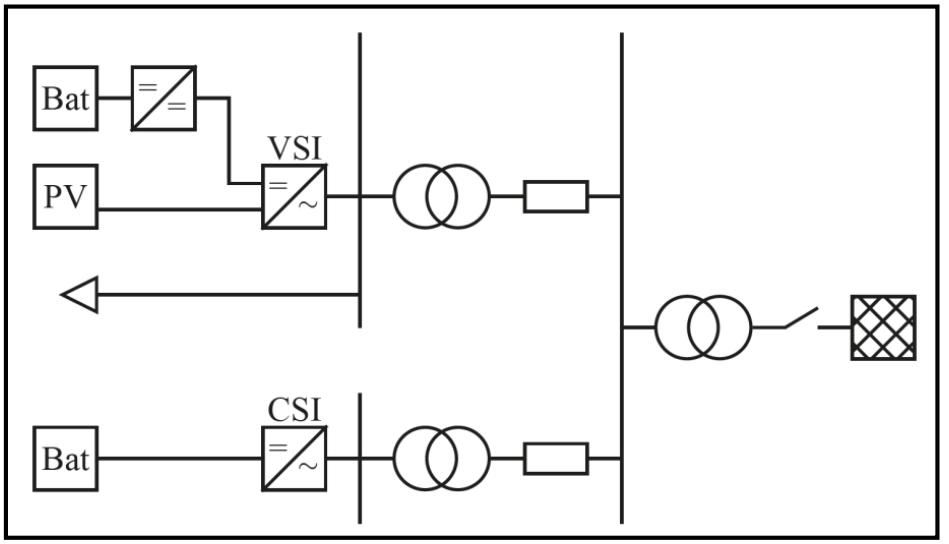
- Field installations with additional monitoring tools



3. Development procedure of a Microgrid Controller

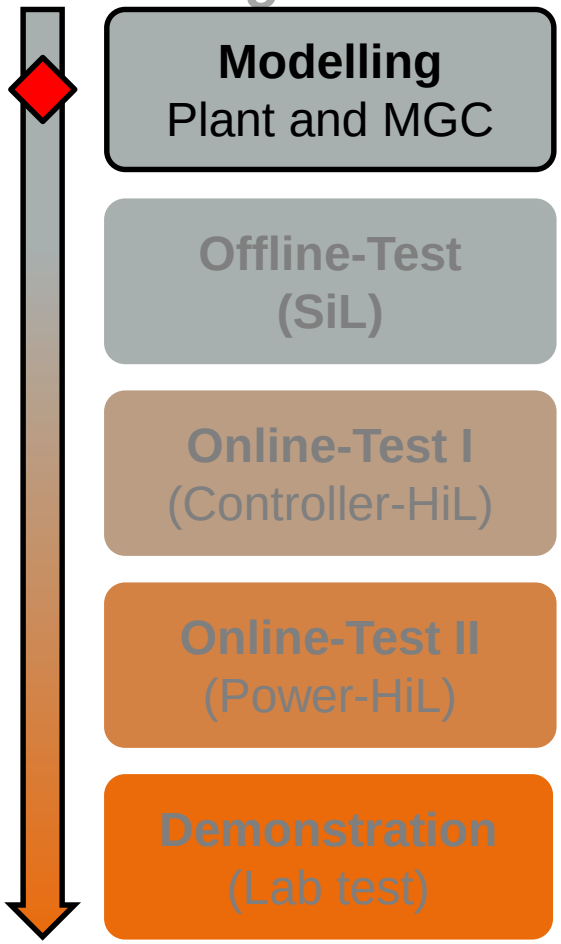
Overview

- Task:
  - Restoration of a purely inverter based Microgrid
  - Grid control and operation control in islanding operation
  - Resynchronization
- Components in the Microgrid:
  - Grid forming inverter with PV and battery (VSI),
  - Aggregated load, 100kVA
  - Commercial available battery inverter (CSI)
  - Transformers, lines, circuit breaker



3. Development procedure of a Microgrid Controller (MGC)

Modelling

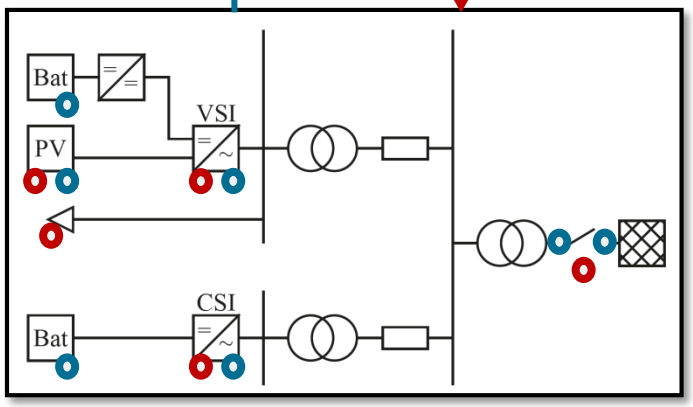


MGC

- Initiation, coordination and monitoring of restoration
- Generator management
- Load management
- PV-curtailment
- Consideration of forecast data
- Adaptive protection coordination

Read measure-ment data

Write control values



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3. Development procedure of a Microgrid Controller (MGC)

Offline-Test / Software-in-the-Loop

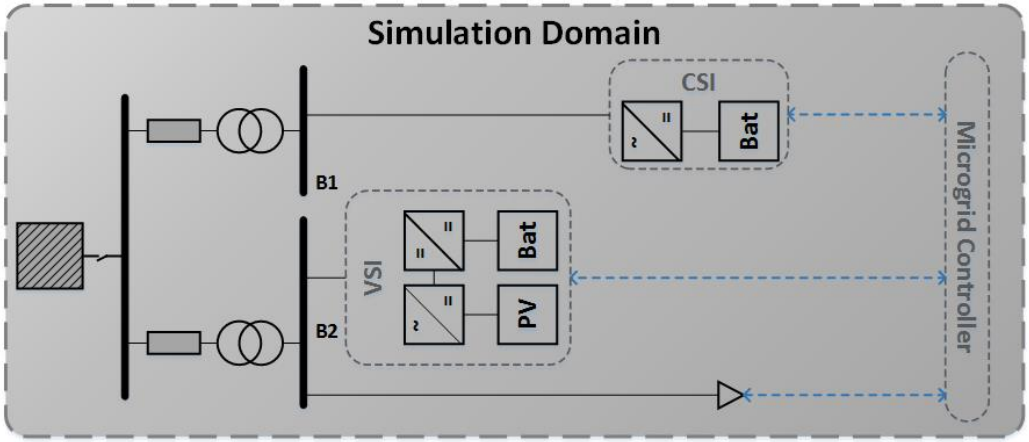
Modelling
Plant and MGC

Offline-Test (SiL)

Online-Test I
(Controller-HiL)

Online-Test II
(Power-HiL)

Demonstration
(Lab test)



Benefits:

- Implementation of all required components and control strategies
- Fast execution of various investigations (short-/long-term aspects)
- Flexibility of investigations and scenarios

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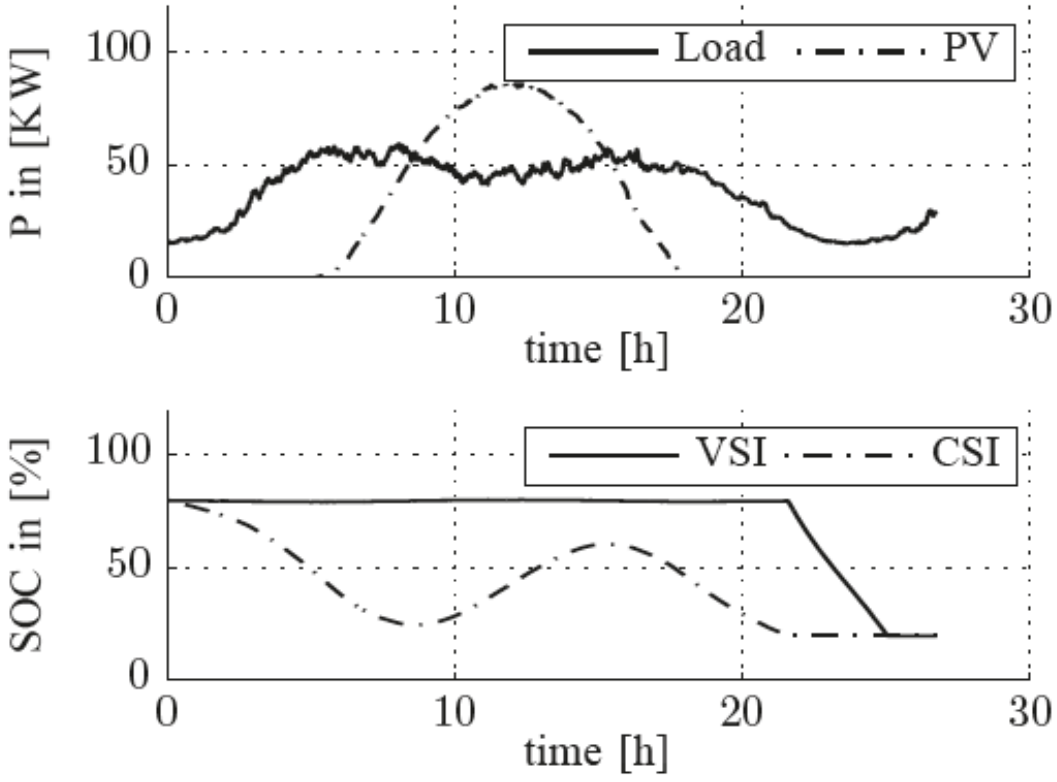
Simulation results (sunny day, summer load)



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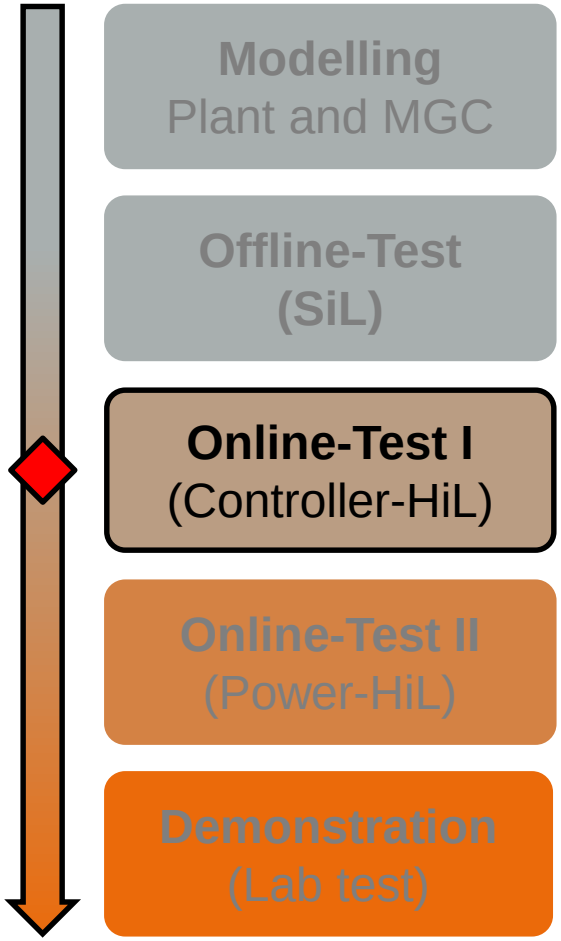
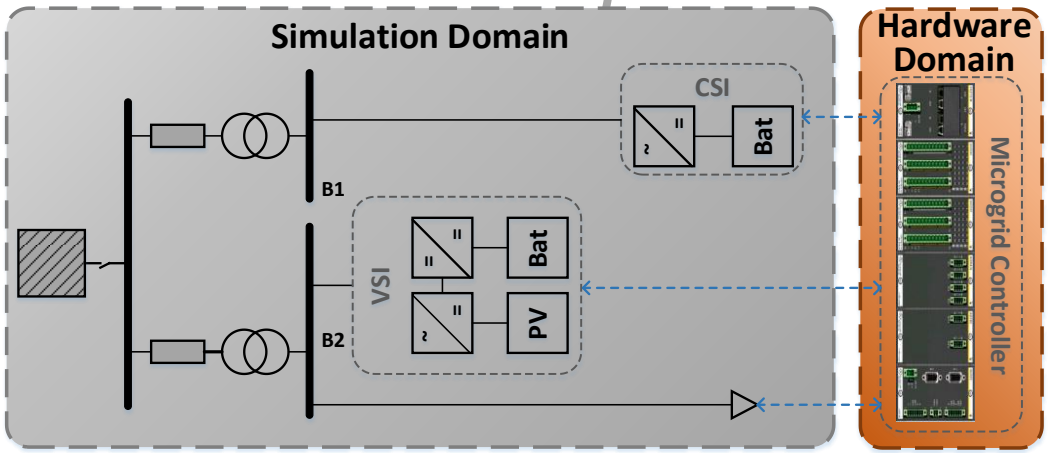
3. Development procedure of a Microgrid Controller (MGC)

Online-Test / Controller Hardware-in-the-Loop





Benefits:

- Transfer of the Microgrid Controller as Device-under-Test (DuT) onto real hardware
- Consideration of all dynamics and interfaces of the DuT
- Testing of controller performance and communication
- Comparative results for stage 1

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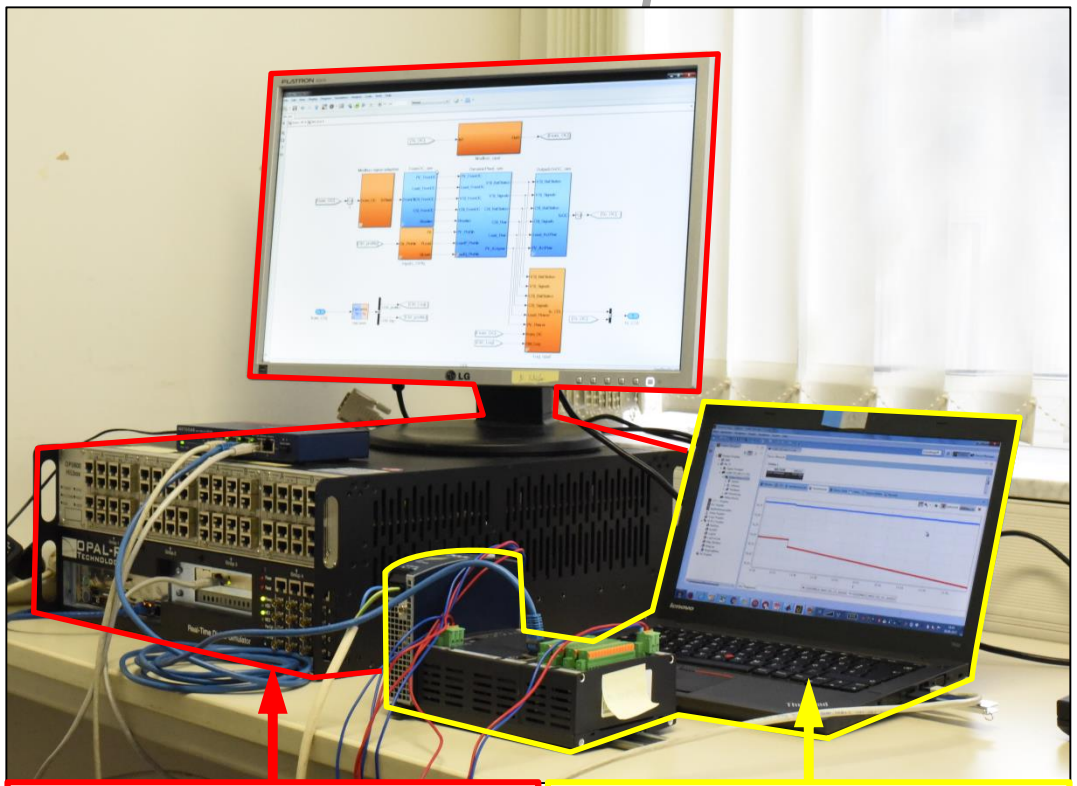

Plant simulation in real time on OPAL RT and host PC

MGC as application on BACHMANN SPS and host PC

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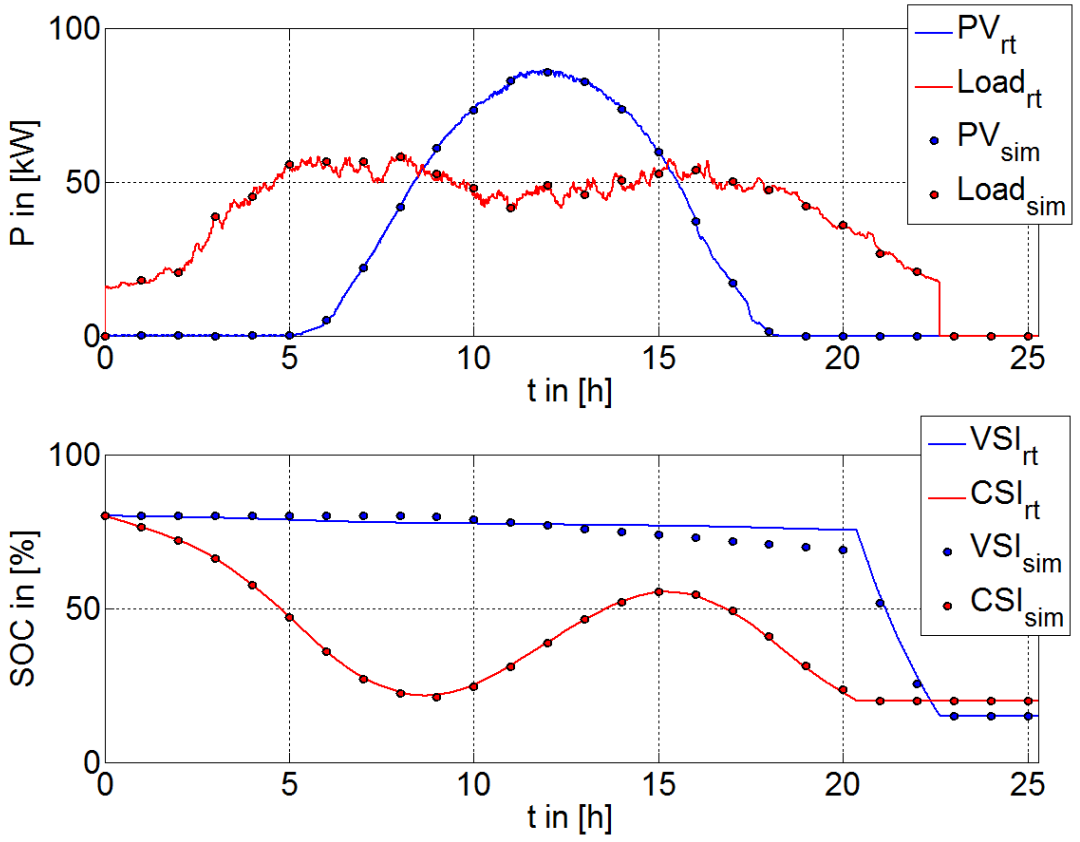
Comparison simulation (sim) and Controller-Hil (rt)



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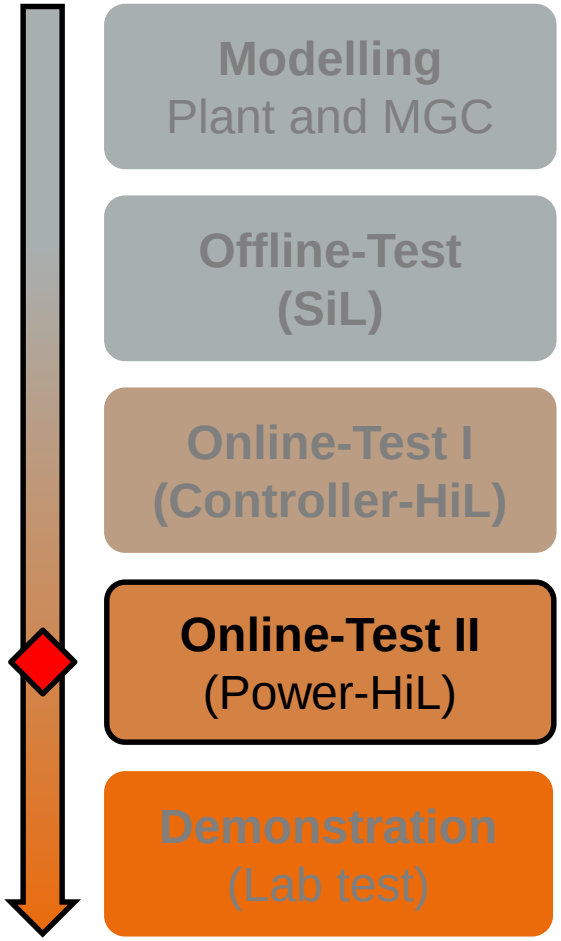

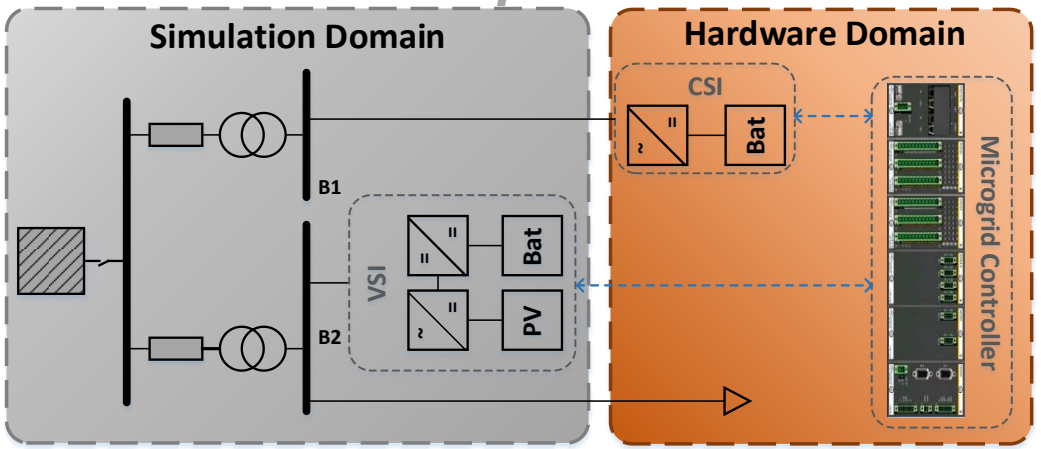

Benefits:

- Partial replacement of simulated models by hardware
- Verification of communication, DuT and power hardware operation and harmonized performance
- Investigation of different scenarios

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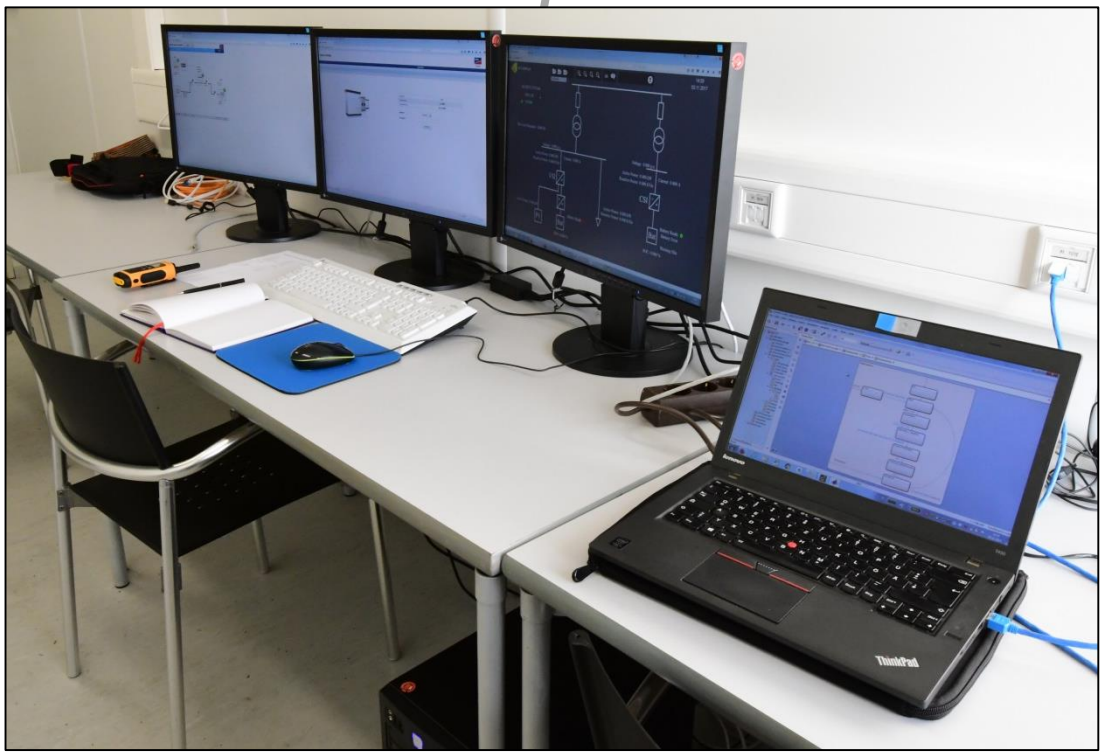

Control room with LAN access to all components

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RTDS system with power amplifiers

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(Lab test)

Battery inverter with transformer station and battery container

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3. Development procedure of a Microgrid Controller (MGC)

Demonstration / Field Test

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Plant and MGC

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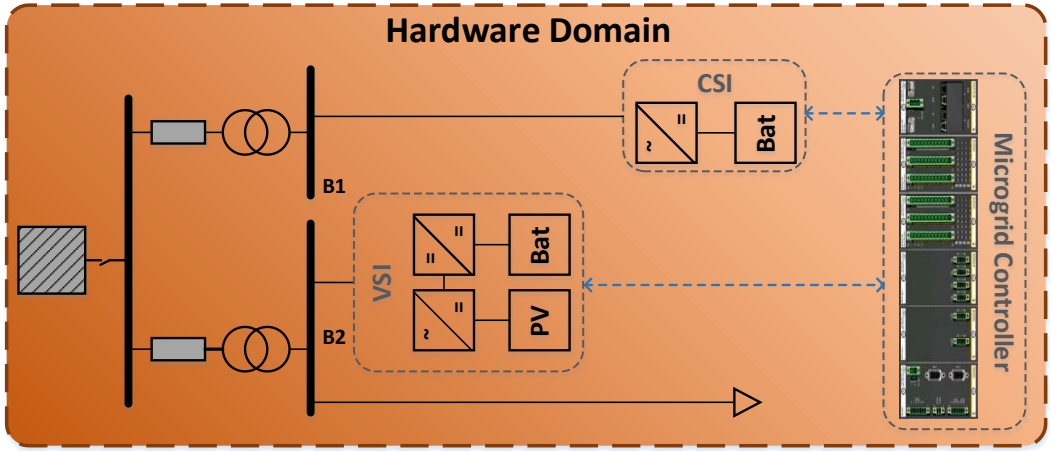
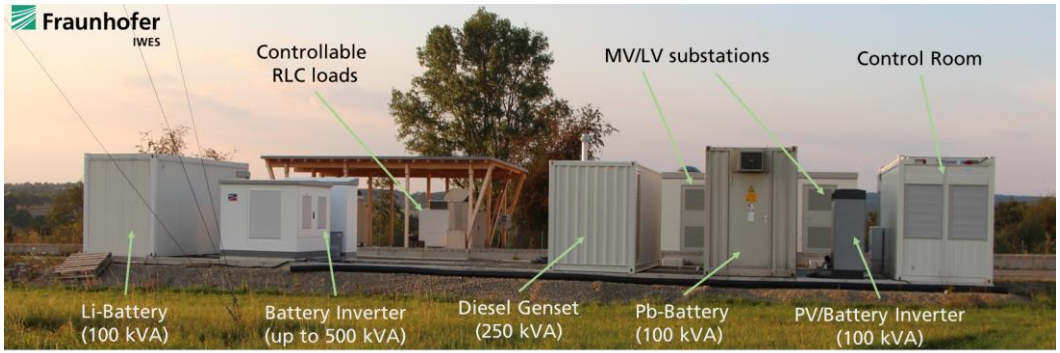
Online-Test II
(Power-HiL)

Demonstration
(Lab test)





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4. Summary of Performed Investigations

Conclusions and Overview

- New testing technologies support the validation of current and prospective research
  - Integrates realistic power system conditions in lab testing
  - Enables holistic testing of prototypes and innovative methods and technologies
- Proof of Concept
  - Support during the design of a Microgrid Controller
  - Step by step testing for controller development
  - Validation of the idea/approach by iterative replacement of simulation models by real hardware

Innovate testing chains de-risk field tests by enabling reality-close testing in controllable/safe laboratory environments

Thanks for your attention!

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