

Wie testet man Regler für Reallabore?

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AI4Grids Symposium
Konstanz, 26. September 2023
www.ise.fraunhofer.de

Agenda

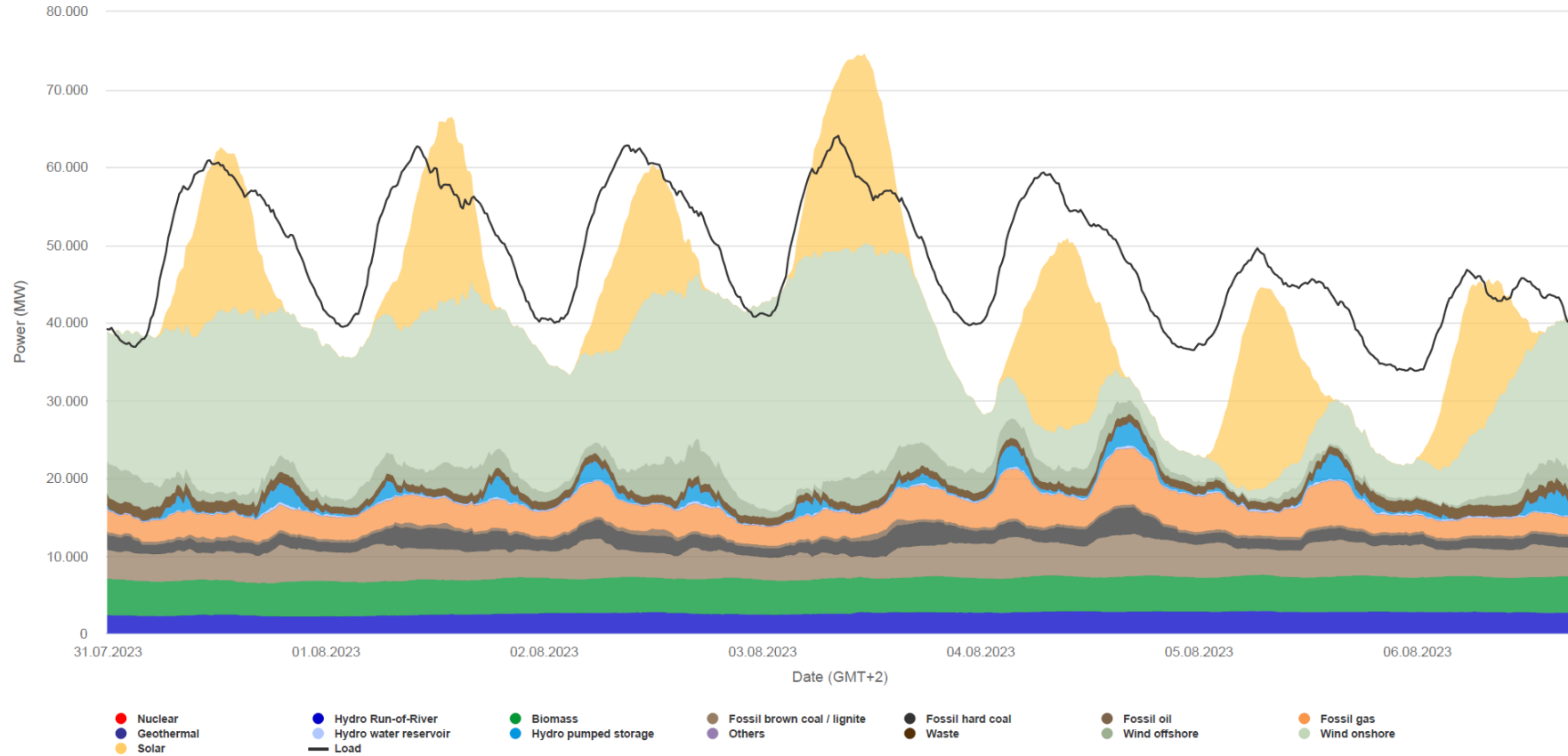
1. Motivation: Why digital grid?
2. Hardware-in-the-Loop Testing
3. Testing Grid Control
4. AI4Grids Test Environment



Motivation - Why Digital Grids?

Motivation

Power Production in Germany week 31 2023



Renewable share:

2022: 50%

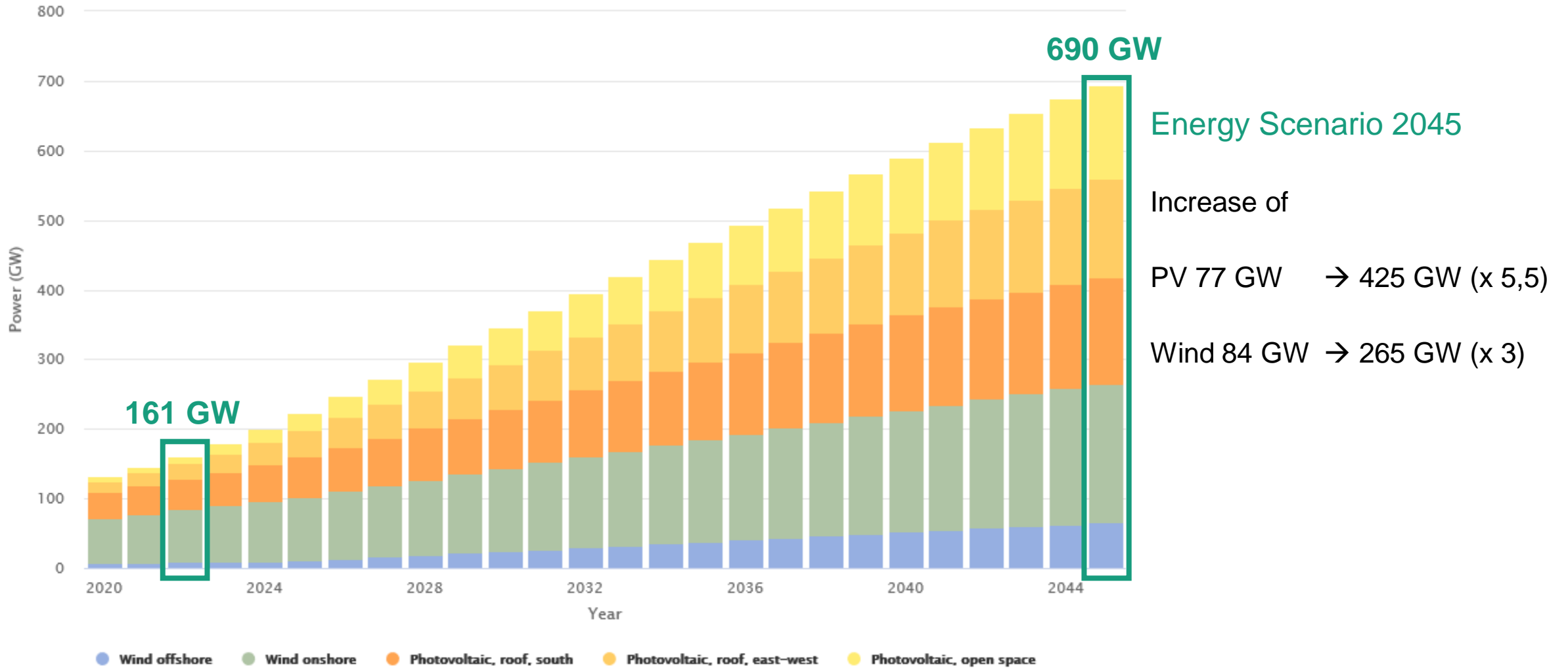
Week 31 2023: 65 – 82 %

Electricity Generation and Consumption must be balanced.

Target is 100% renewable!

Motivation

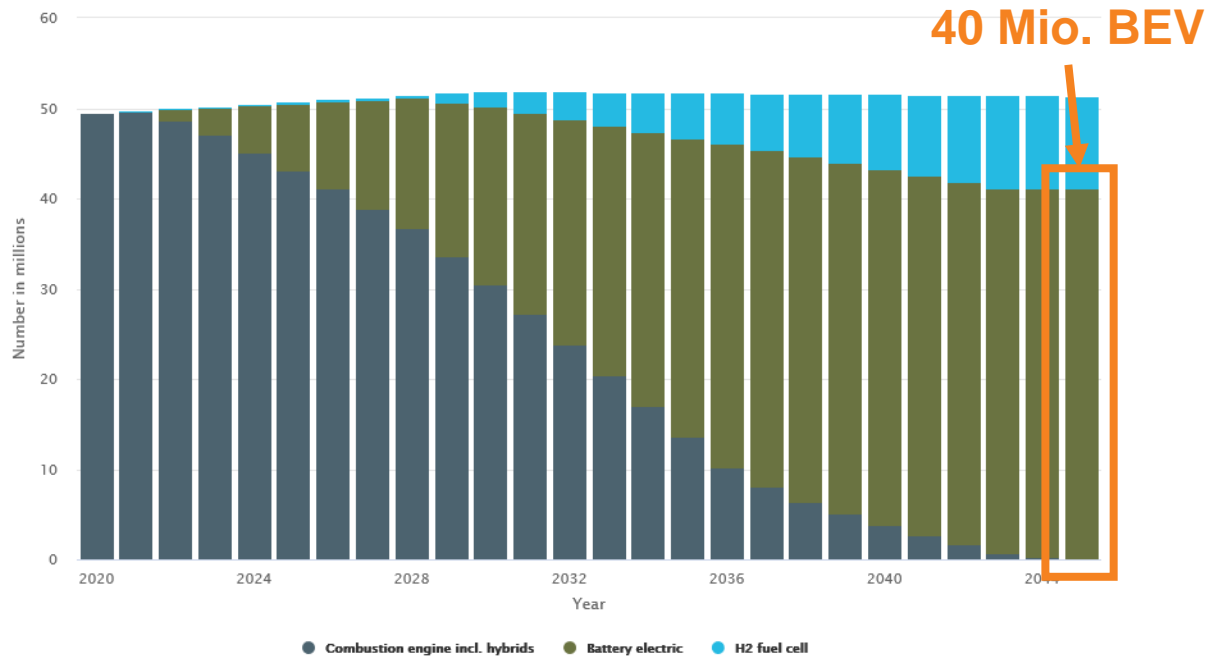
Installed Capacity of variable Renewables



Motivation

Electrification of other Sectors

Technologies in passenger Traffic

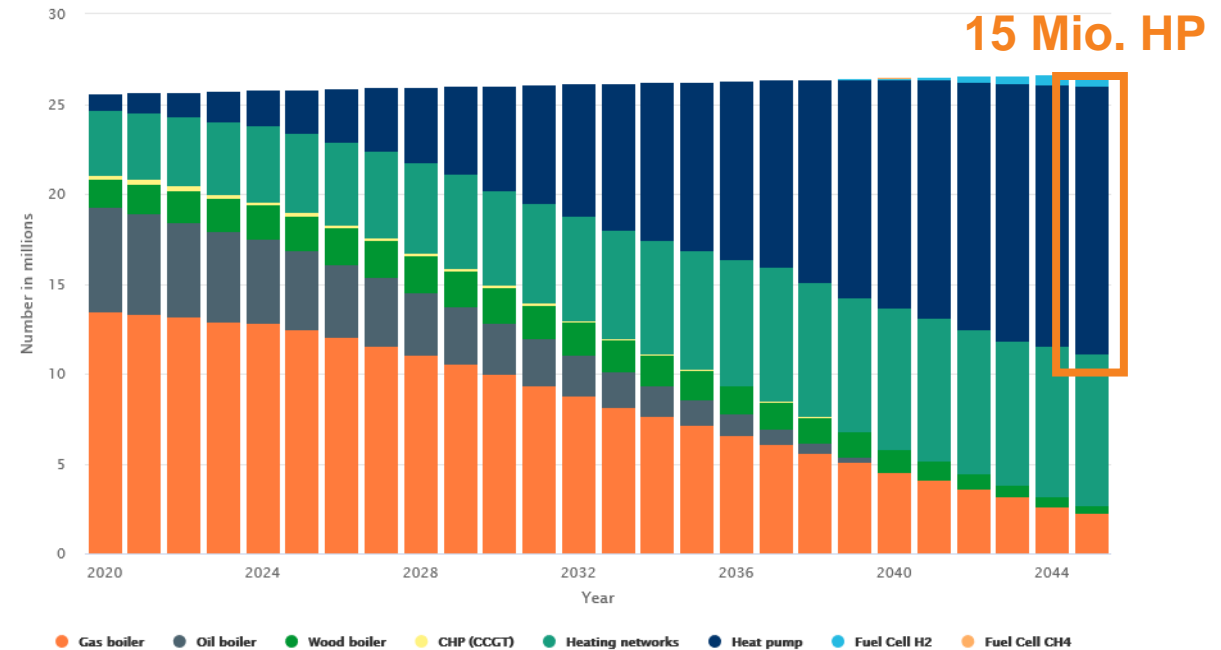


40 Mio. Battery Electric Vehicle (BEV)

x 10 kW = 400 GW connection power

x 50 kWh = 2 TWh battery capacity

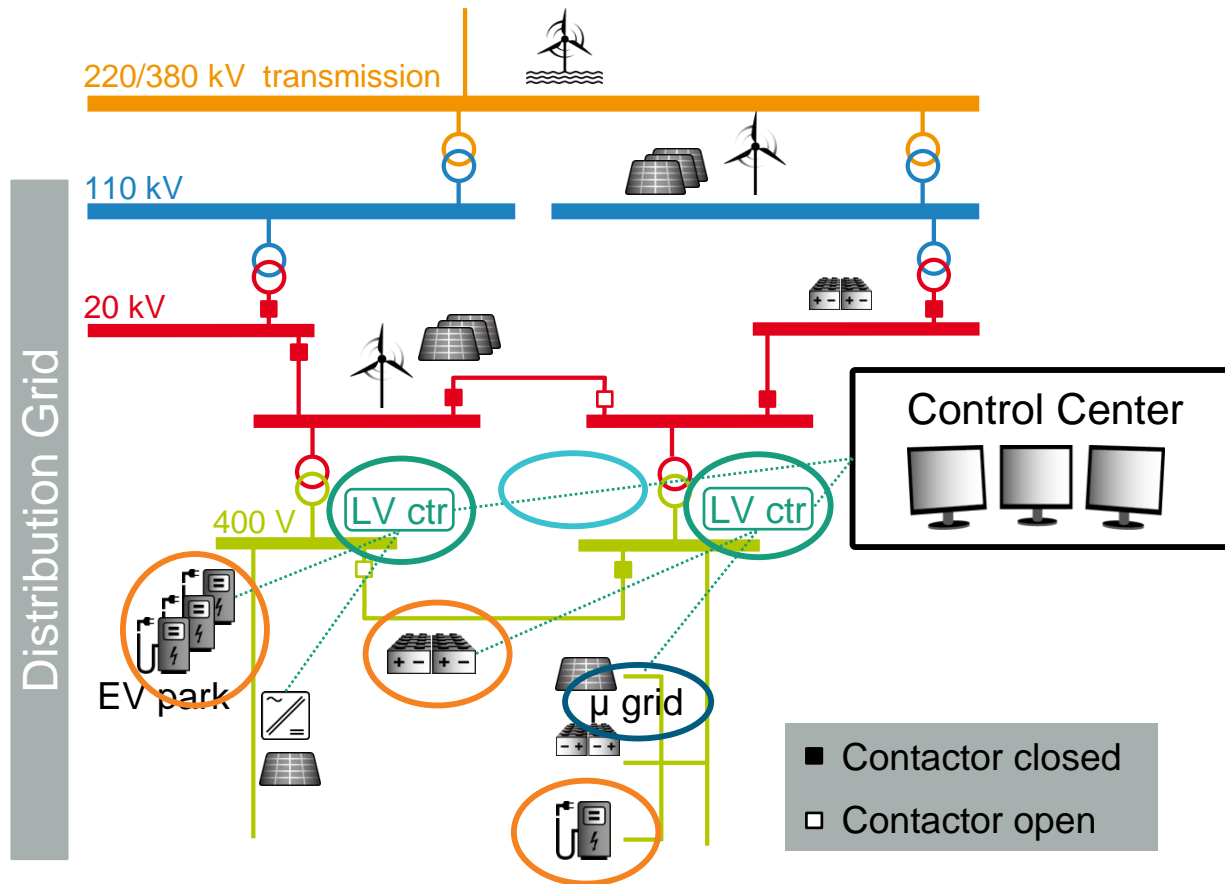
Building Heating Technologies



15 Mio Heat Pumps (HP)

x 5 kW = 75 GW connection power

Smart Grid Control Motivation



Low voltage controller

energy management (μ grid)

System Component

e.g. EV Supply Equipment, Battery Systems

Communication Interfaces

e.g. Smart Meter, Electric Vehicle



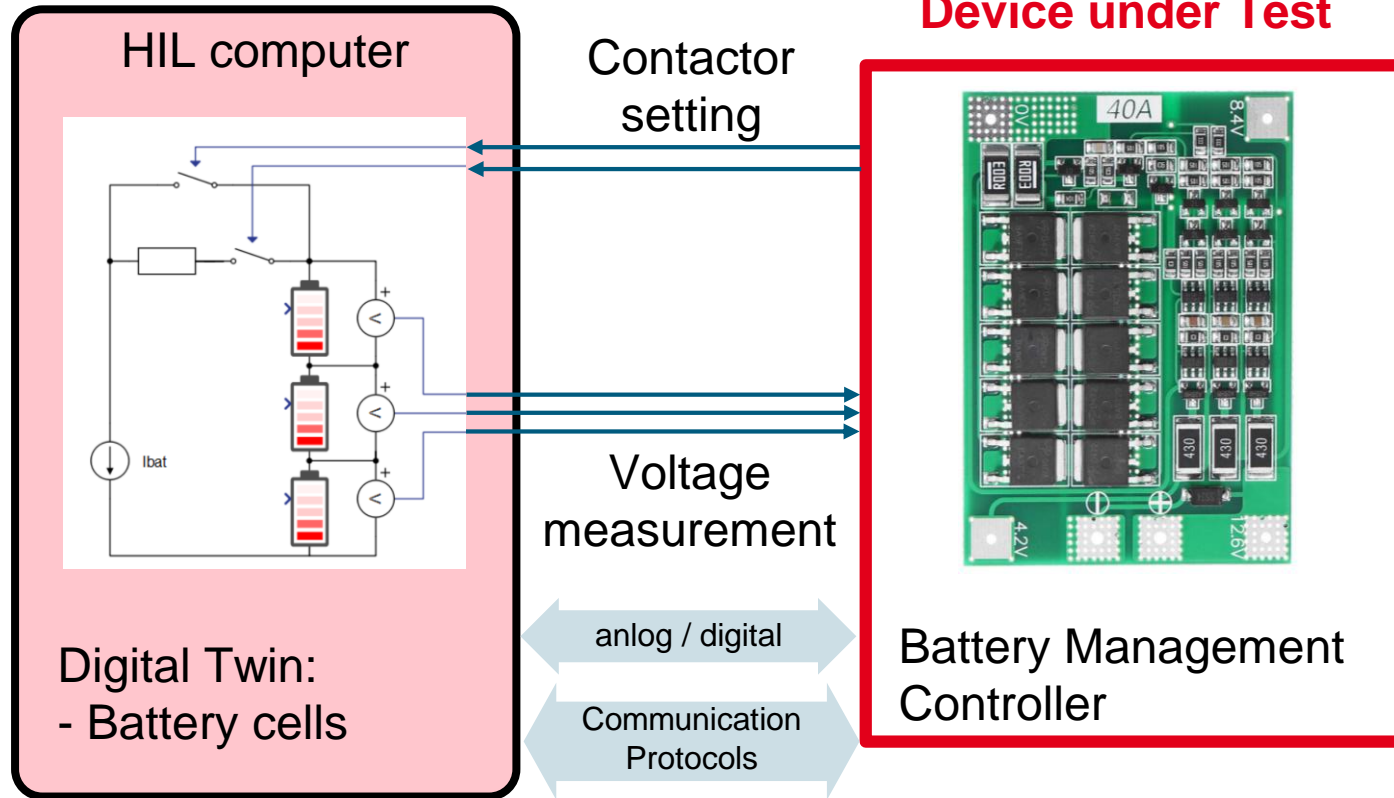
Digital Grid:
Loads must be controlled system oriented!



Hardware-in-the-Loop Test

Hardware-in-the-Loop (HIL)

Example Battery Management System



Device under Test

Prototype controller board

HIL Computer

Model (digital twin) of power part

Emulation of measurements

Evaluation real time signals

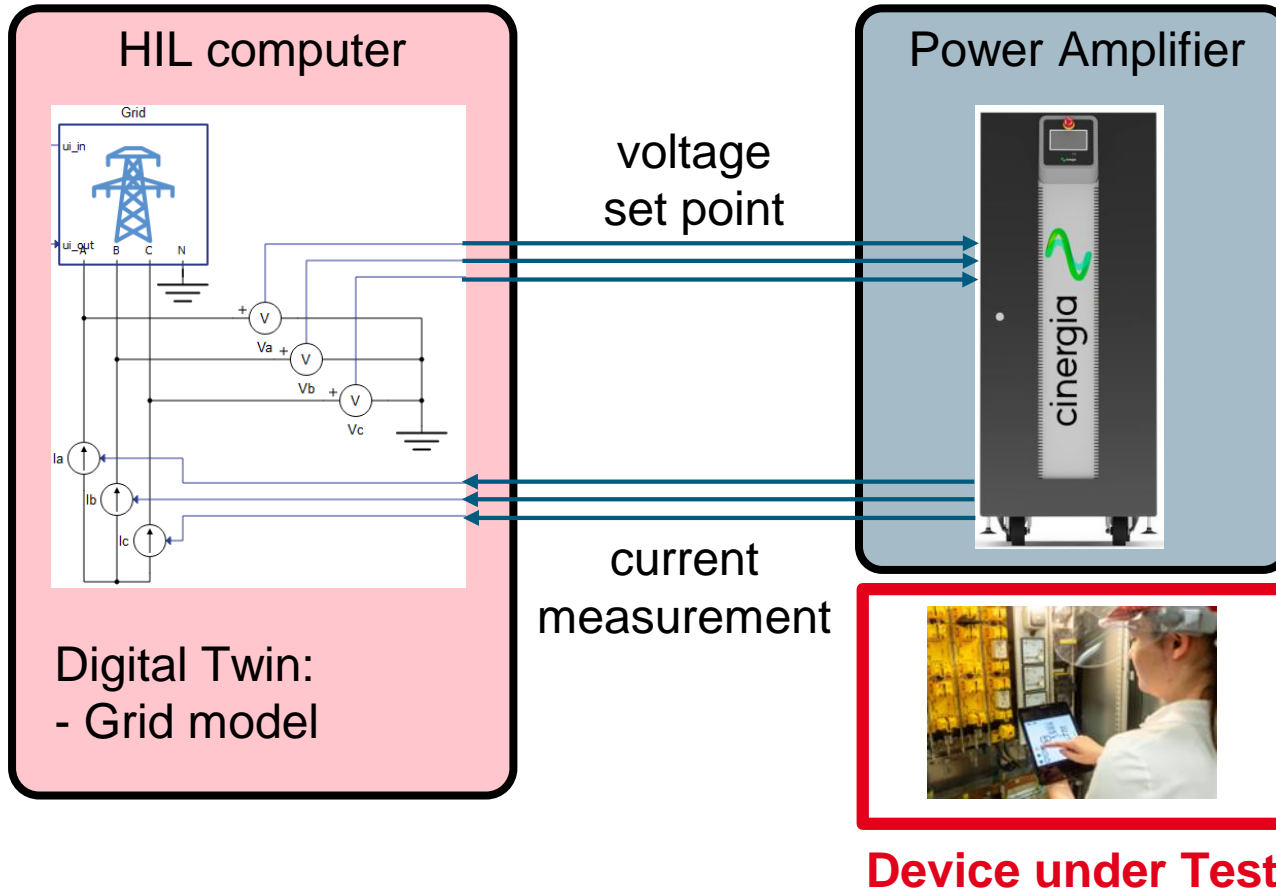
Benefit

Testing without risk

Faster development

Power Hardware-in-the-Loop (P-HIL)

Example Grid Emulation



Device under Test

Real hardware (prototype)

HIL Computer

Model (digital twin) of power grid

Power Amplifier

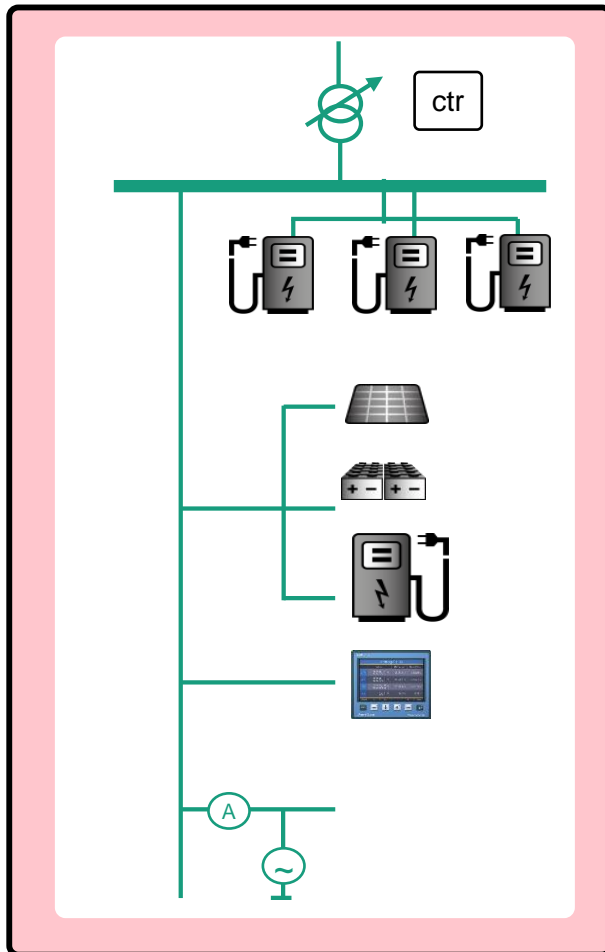
Interface between HIL computer and DuT

Include current measurement into digital twin

Voltage set points to power amplifier

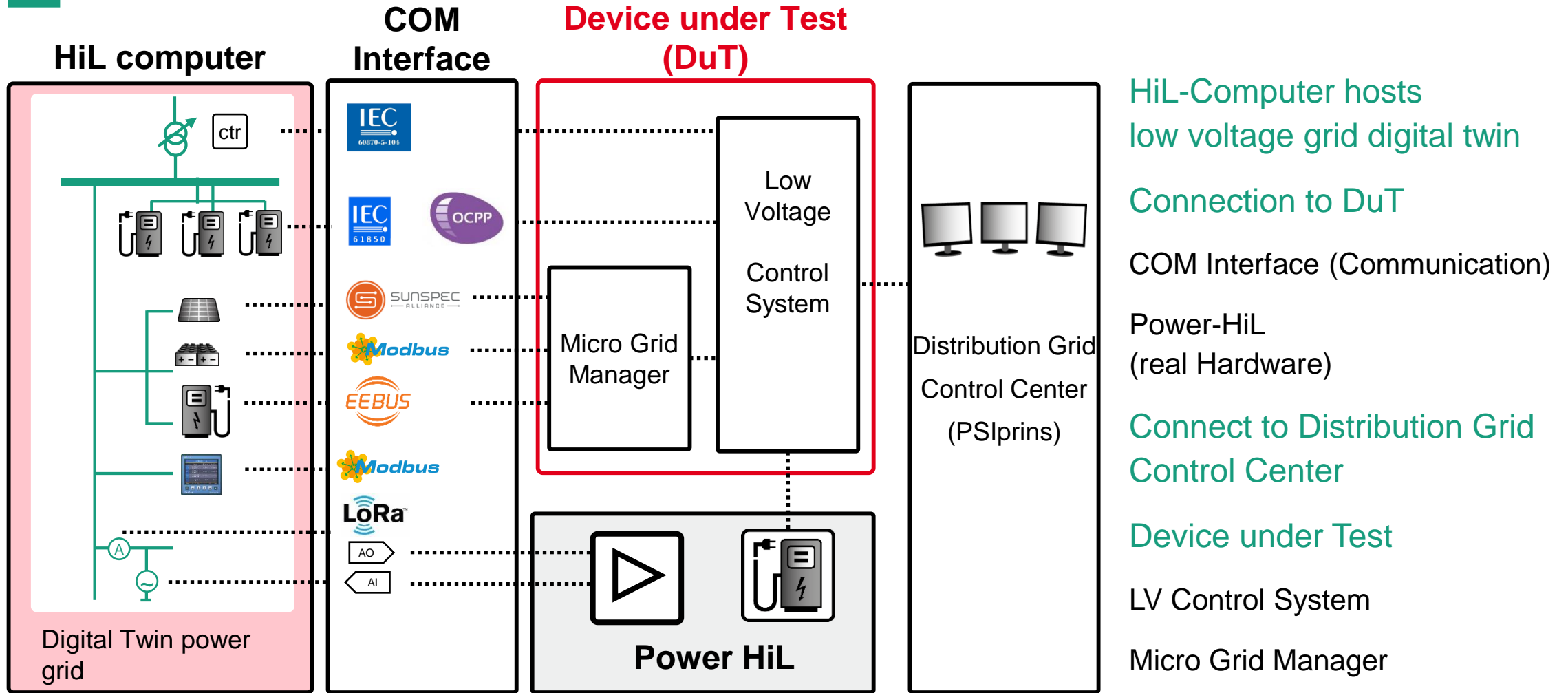
Benefit

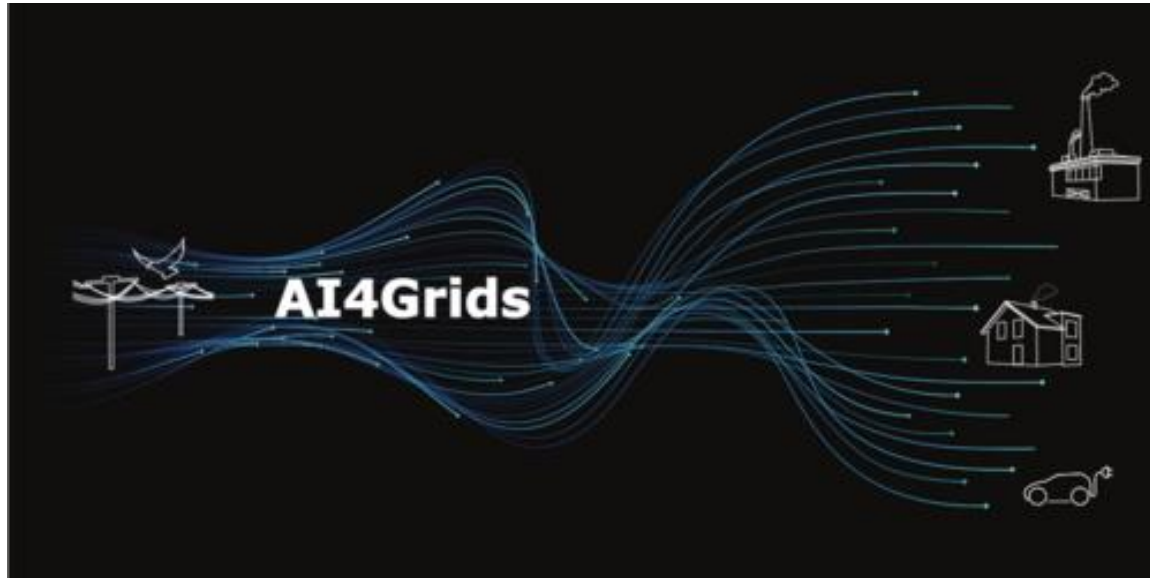
Testing in critical situations



Testing Grid Control

Low Voltage Grid Control Test Setup

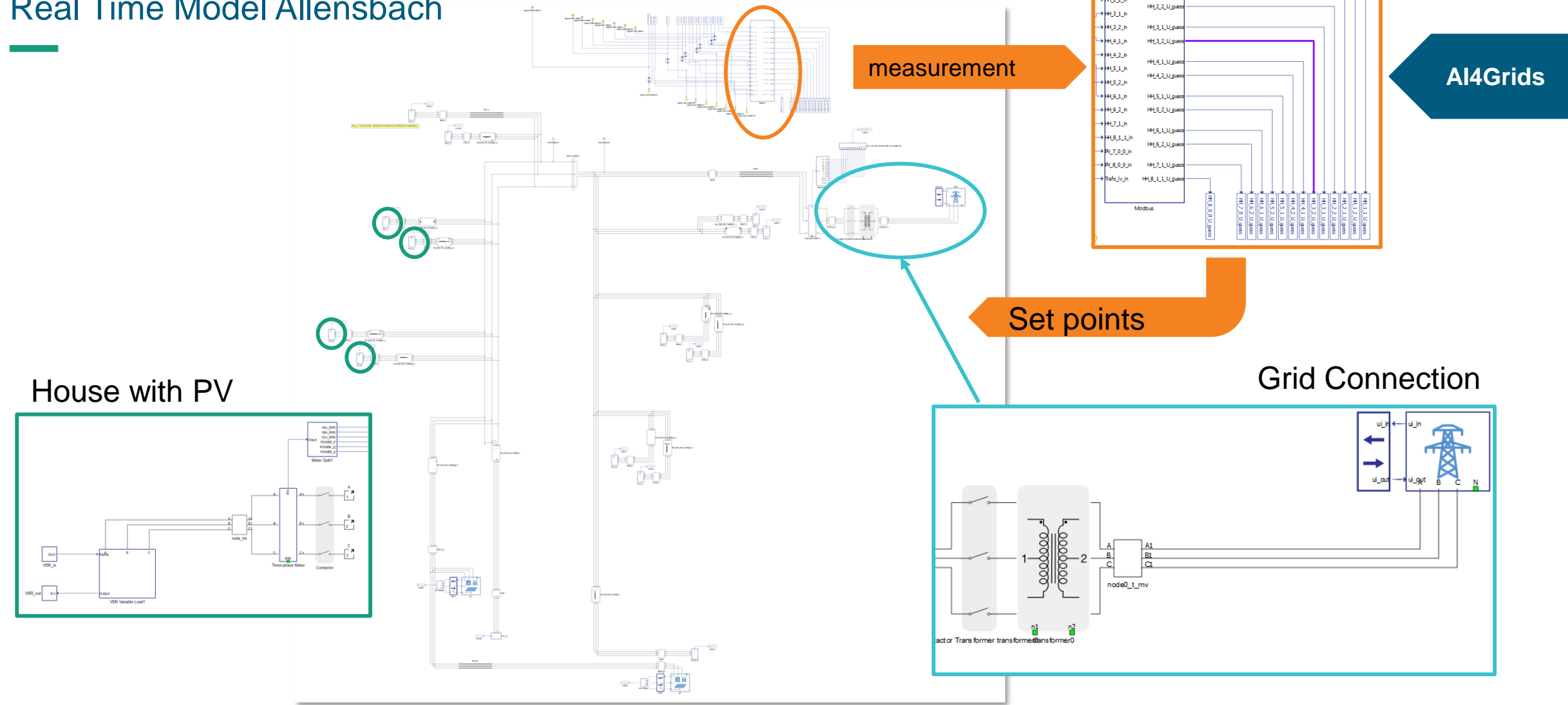




AI4Grids Test Environment

AI4Grids Test Environment

Real Time Model Allensbach



Interface Modbus Control

[UNLOCKED] [ACTIVE] - Alensbach_SCADA_Modbus_Client_vwithPQref_usammengefasstH7-8_nurH1_type2.cus *(unsaved Panel) X

Model Settings

Lock PANEL ROOT ACTIVE

Trace graph measured active power at nodes 1 [W] [3.0 sec/div]

Trace graph measured active power at nodes 2 [W] [3.0 sec/div]

Trace graph measured active power at low voltage side of trafo [kW] [3.0 sec/div]

Message Log

```

[13:54:04] : [MACRO EXECUTOR] Macro execution finished.
[13:54:15] : [MACRO EXECUTOR] Executing 'set P_PV VBR' embedded macro script
[13:54:15] : [MACRO EXECUTOR] Macro execution finished.
[13:54:19] : [MACRO EXECUTOR] Executing 'set P_PV VBR' embedded macro script
[13:54:19] : [MACRO EXECUTOR] Macro execution finished.
    
```

History View

```

<initial state>
Properties Changed: Trace graph measured active power at nodes 2 [W]
Properties Changed: Trace graph measured active power at nodes [W]
Properties Changed: Trace graph measured active power at low voltage side of trafo [kW]
    
```

TSO WBR 00:00:06:02 STANDALONE SCADA MODE

Interface Realtime Model

[UNLOCKED] [ACTIVE] - Alensbach_SCADA_for_complete_model_vwithPQref_usammengefasstH7-8_nurH1_type2.cus *(unsaved Panel) X

Model Settings

Lock PANEL ROOT > Sub-Panel ACTIVE

of the VBRs according to a provided timeseries file

set P_ref 5000 W set Q_ref 100.0 var set P_PV VBR 7000 W set Q_PV VBR 100.0 var

HH 3_1 nur mit VBR als Residualast

Enable VBR 1 Pref VBR 5000.0 W Qref VBR 100.0 var
P_PV VBR 7000.0 W Q_PV VBR 100.0 var

-1972.52 W **44.46 var** **216.21 V**
active Power VBR reactive Power VBR Vrms VBR

-1845.20 W **214.52 V** **371.55 V**
active Power Meter VLn_RMS Meter VLL_RMS Meter

HH 5_1 nur mit VBR als Residualast

Enable VBR 1 Pref VBR 5000.0 W Qref VBR 100.0 var
P_PV VBR 7000.0 W Q_PV VBR 100.0 var

-1886.38 W **-76.94 var** **216.21 V**
active Power VBR reactive Power VBR Vrms VBR

-1747.05 W **214.37 V** **371.55 V**
active Power Meter VLn_RMS Meter VLL_RMS Meter

HH 3_2 nur mit VBR als Residualast

Enable VBR 1 Pref VBR 5000.0 W Qref VBR 100.0 var
P_PV VBR 7000.0 W Q_PV VBR 100.0 var

-1971.37 W **104.88 var** **216.21 V**
active Power VBR reactive Power VBR Vrms VBR

-1830.91 W **214.48 V** **371.49 V**
active Power Meter VLn_RMS Meter VLL_RMS Meter

HH 5_2 nur mit VBR als Residualast

Enable VBR 1 Pref VBR 5000.0 W Qref VBR 100.0 var
P_PV VBR 7000.0 W Q_PV VBR 100.0 var

-1862.53 W **-31.92 var** **216.21 V**
active Power VBR reactive Power VBR Vrms VBR

-1747.49 W **214.29 V** **371.55 V**
active Power Meter VLn_RMS Meter VLL_RMS Meter

HH 4_1 nur mit VBR als Residualast

Enable VBR 1 Pref VBR 5000.0 W Qref VBR 100.0 var
P_PV VBR 7000.0 W Q_PV VBR 100.0 var

-1877.71 W **-14.28 var** **216.19 V**
active Power VBR reactive Power VBR Vrms VBR

-1757.03 W **221.26 V** **383.23 V**
active Power Meter VLn_RMS Meter VLL_RMS Meter

HH 6_1 nur mit VBR als Residualast

Enable VBR 1 Pref VBR 5000.0 W Qref VBR 100.0 var
P_PV VBR 7000.0 W Q_PV VBR 100.0 var

-1906.46 W **-19.54 var** **216.21 V**
active Power VBR reactive Power VBR Vrms VBR

-1762.82 W **221.31 V** **383.23 V**
active Power Meter VLn_RMS Meter VLL_RMS Meter

Message Log

```

[13:54:19] : [MACRO EXECUTOR] Macro execution finished.
    
```

History View

```

<initial state>
Widget Moved: Sub-Panel
Properties Changed: VBR Pref Macro
    
```

TSO WBR EXC CID SLD AO DTV PSU 00:00:07:16 REAL-TIME MODE



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