Holistic Power Distribution System Validation and Testing

The Role of Digital Real-Time Simulation Systems

Thomas Strasser and Georg Lauss

Energy Department – Electric Energy Systems

AIT Austrian Institute of Technology

Session 3 – Insights from ELECTRA / ERIGrid

RTDS® European User's Group Meeting

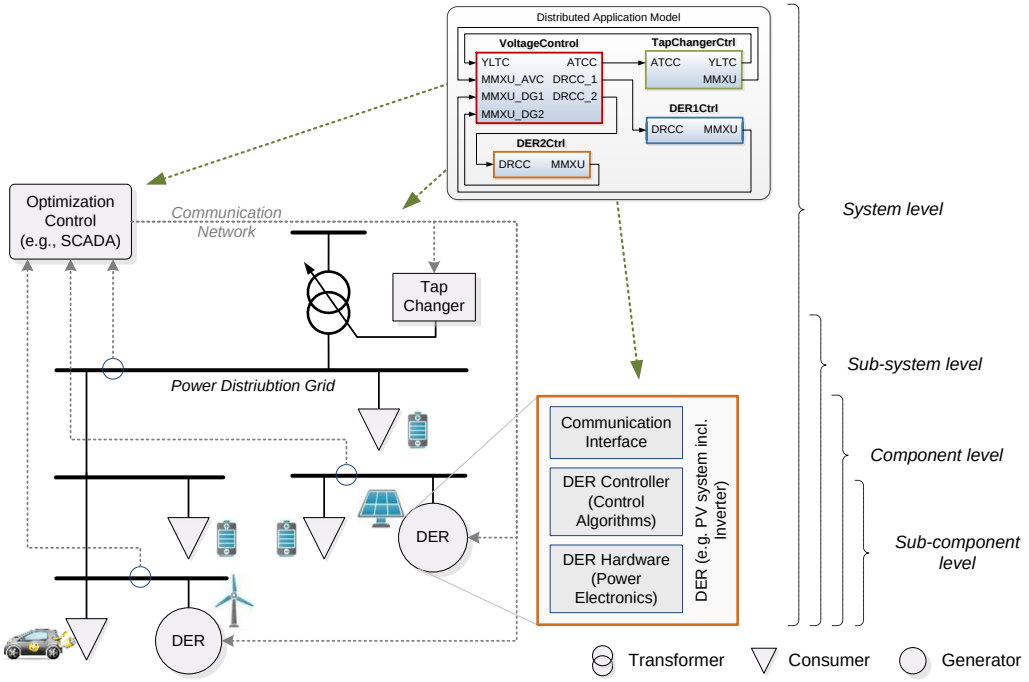
Sept. 15-16, Glasgow, Scotland

Outline

- Background and Motivation
- Needs from the ELECTRA and ERIGrid European Projects
- The Role of DRTS in Smart Grid Design and Validation
- Future Research Directions
- Conclusions

Background and Motivation

- Due to the increasingly higher complexity of smart grid configurations, the aspect of validation will play a major role in future technology developments
- The anticipated large scale installation and roll out of smart grid technologies and solutions requires holistic and integrated validation methods and tools
- An integrated approach for analysing and evaluating smart grid configurations, that addresses the power system as well as information, communication and automation/control aspects is currently still lacking



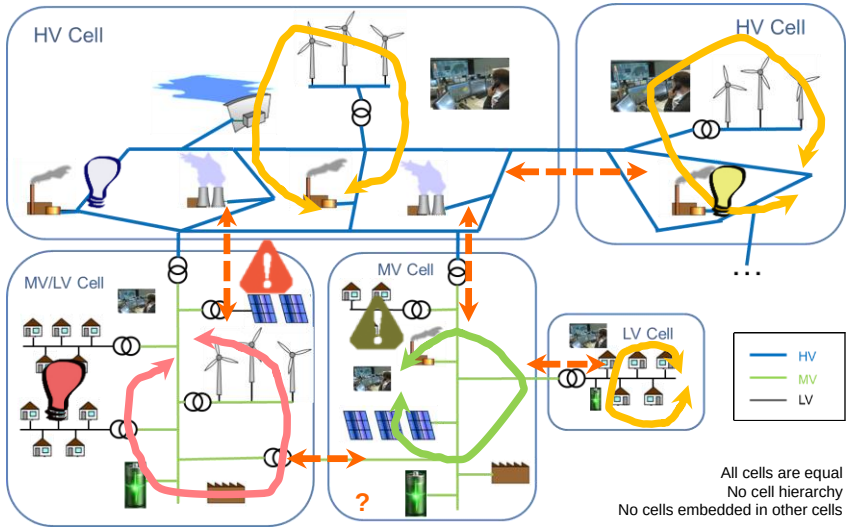
Needs from the ELECTRA and ERIGrid European Projects

- ELECTRA IRP
  - European Liaison on Electricity grid Committed Towards long-term Research Activities

- Funding instrument
  - FP7 Integrated Research Programme on Smart Grids
  - Combination of Collaborative Project (CP) and Coordination and Support Action (CSA)
- 21 Partners from 16 European Countries
- 10 Mio Euro Funding from the EC
- ~1000 Person Month

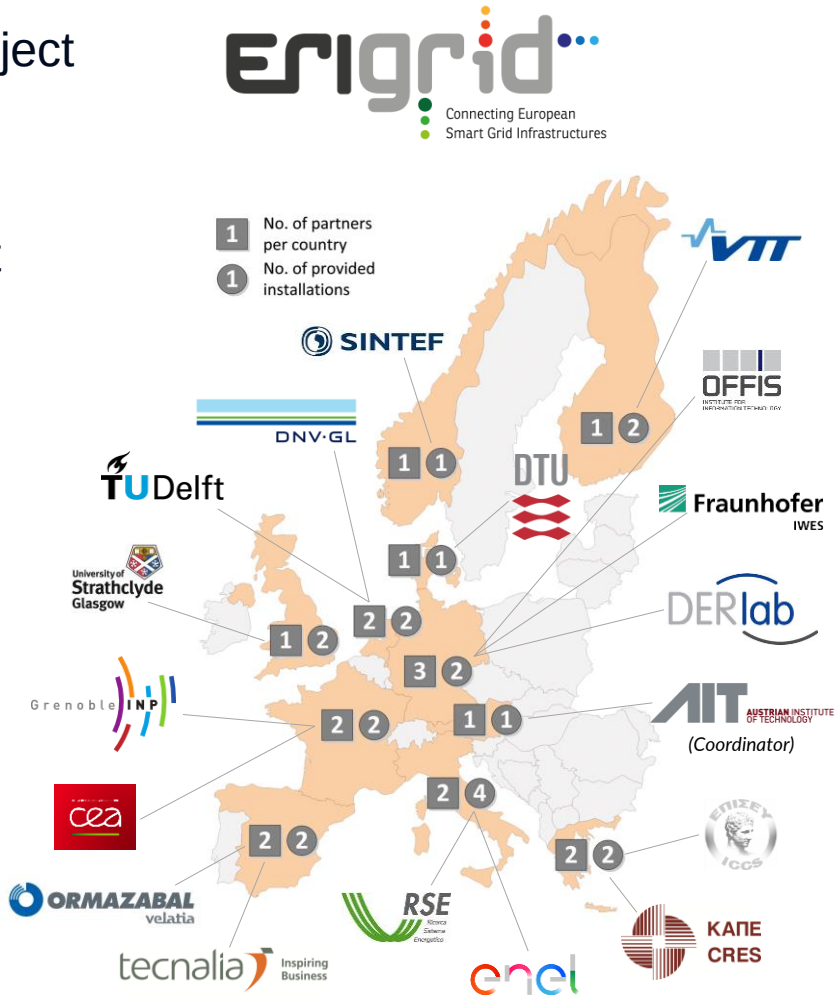
Needs from the ELECTRA and ERIGrid European Projects

- ELECTRA IRP Web of Cells (WoC) Real-Time Operation Approach
  - Power system divided into, locally controllable cells
  - Cell = a group of interconnected loads, distributed generators and storage units, with well-defined electrical and geographical boundaries
  - Cells are connected to neighboring cells via tie-lines (one or multiple)
  - By opening/closing the inter-cells connections, the system is configurable
  - Inter-cell coordination used in order to support system-wide optimized reserves activation
  - Cell have adequate monitoring possibilities and local reserves capacity



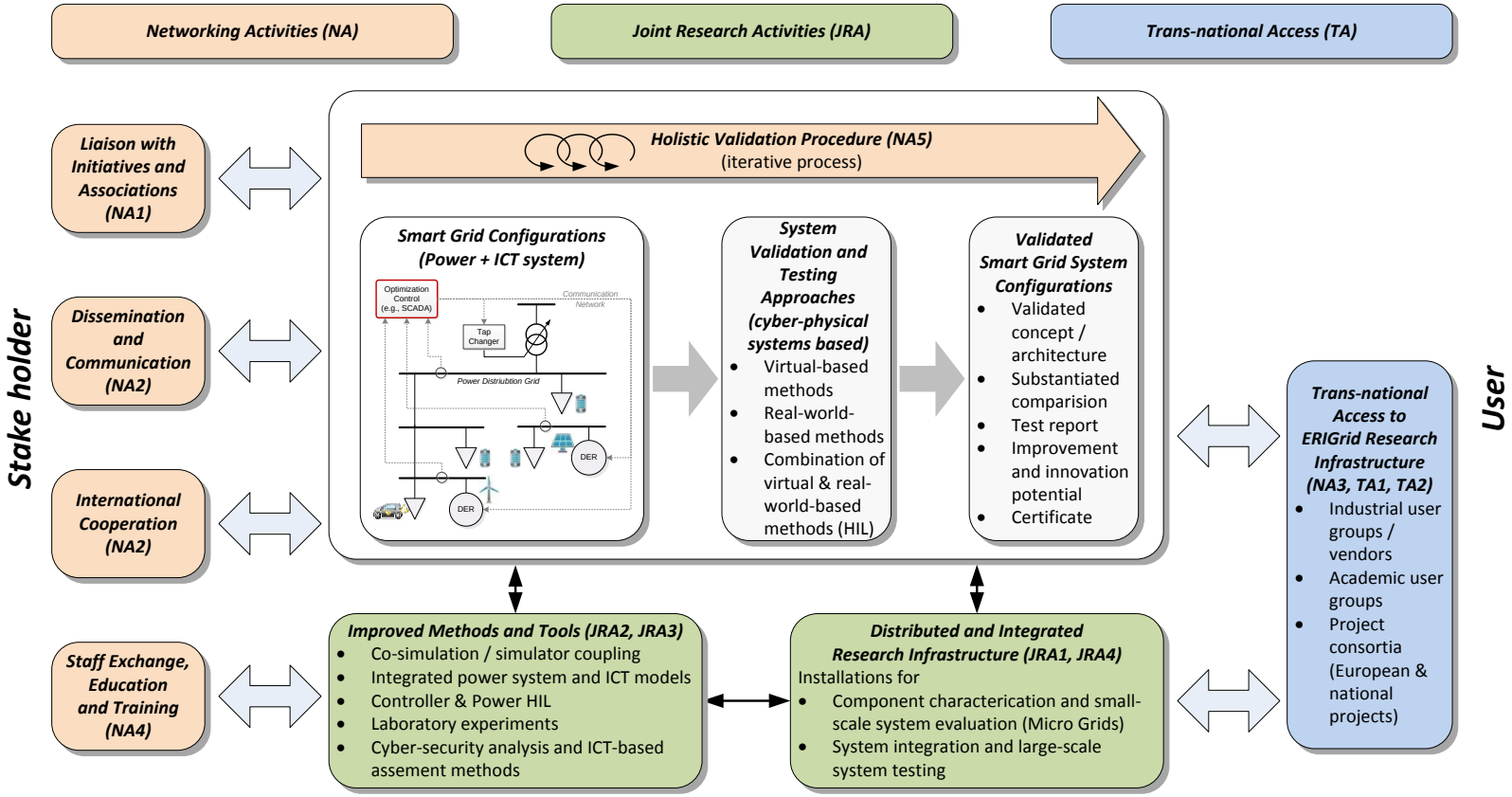
Needs from the ELECTRA and ERIGrid European Projects

- H2020 Research Infrastructure (RI) project
  - Integrating and opening existing national and regional research infrastructures of European interest
- Funding instrument
  - Research and Innovation Actions (RIA)
    Integrating Activity (IA)
- 18 Partners from
  11 European Countries
- Involvement of 21 first class SG labs
- 10 Mio Euro Funding from the EC
- ~1000 Person Month



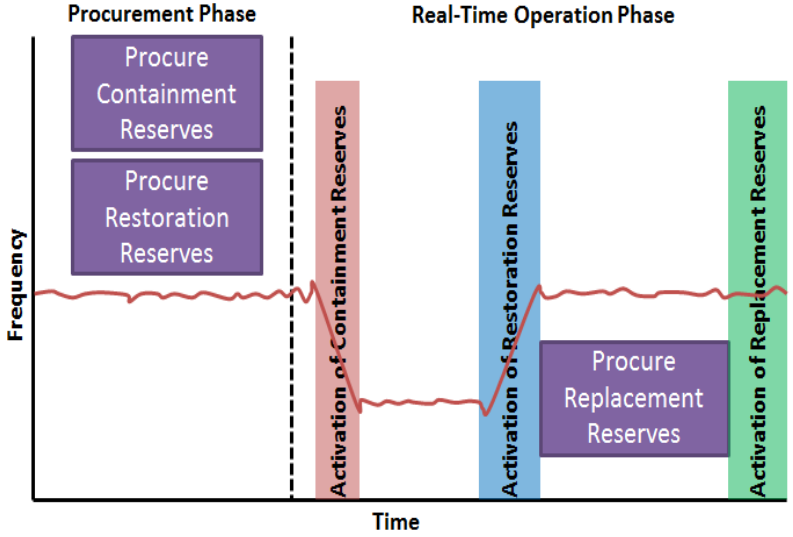
Needs from the ELECTRA and ERIGrid European Projects

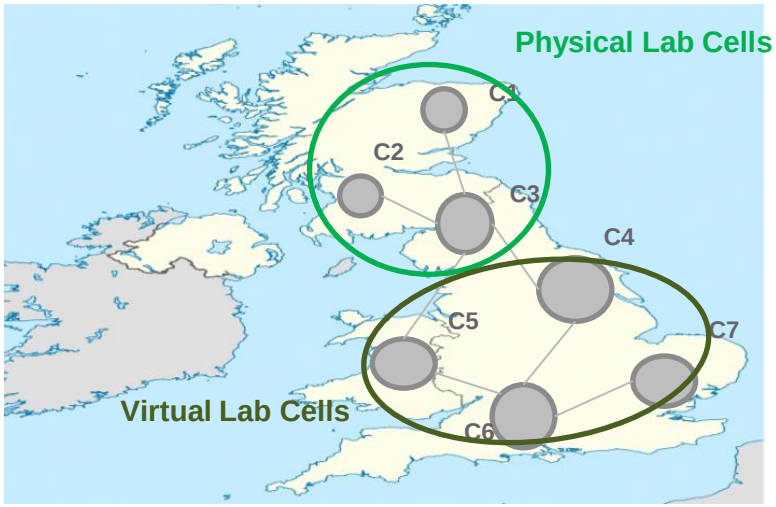
- Leading research infrastructure in Europe for the domain of SG



Needs from the ELECTRA and ERIGrid European Projects

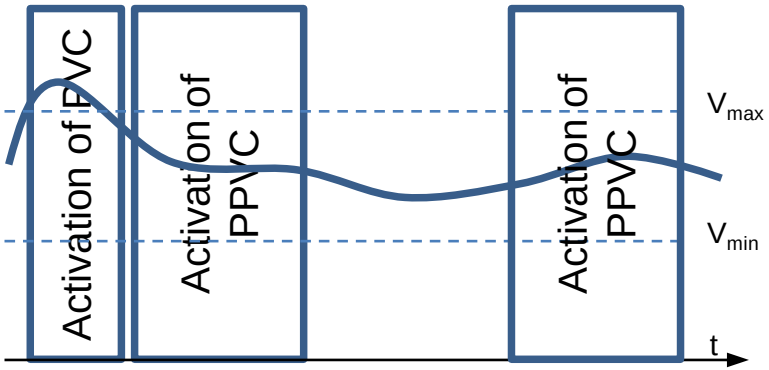
- ELECTRA IRP/ERIGrid: System-level validation of smart grid (ctrl) solutions
  - Example USTRATH: Frequency Containment Control (FCC) + Balance Restoration Control (BRC) + Balance Steering Control (BSC)

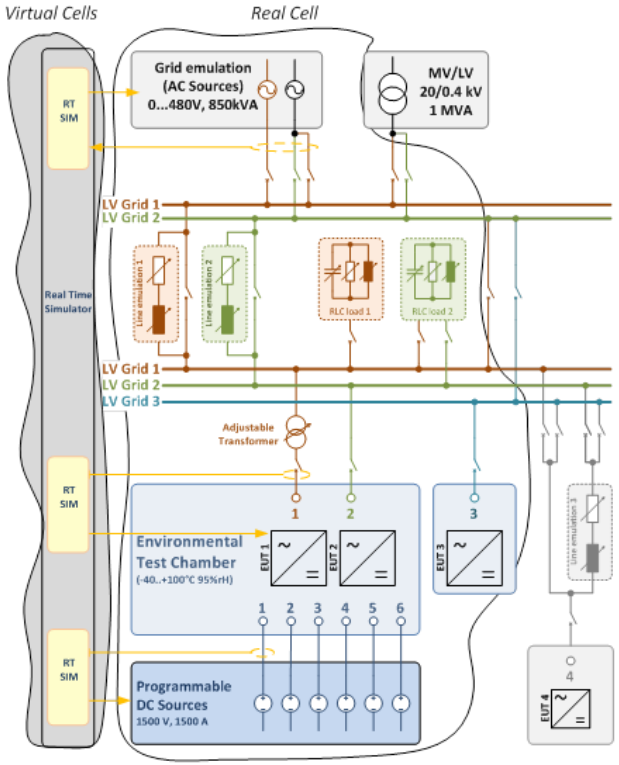




Needs from the ELECTRA and ERIGrid European Projects

- ELECTRA IRP/ERIGrid: System-level validation of smart grid (ctrl) solutions
  - Example AIT: Post Primary Voltage Control (PPVC) + Primary Voltage Control (PVC)





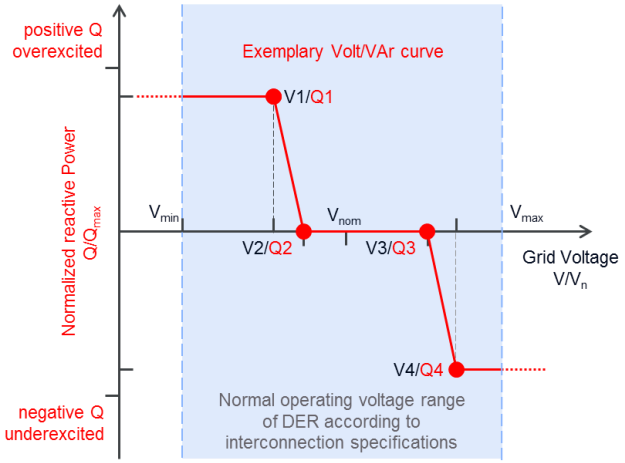
The Role of DRTS in Smart Grid Design and Validation

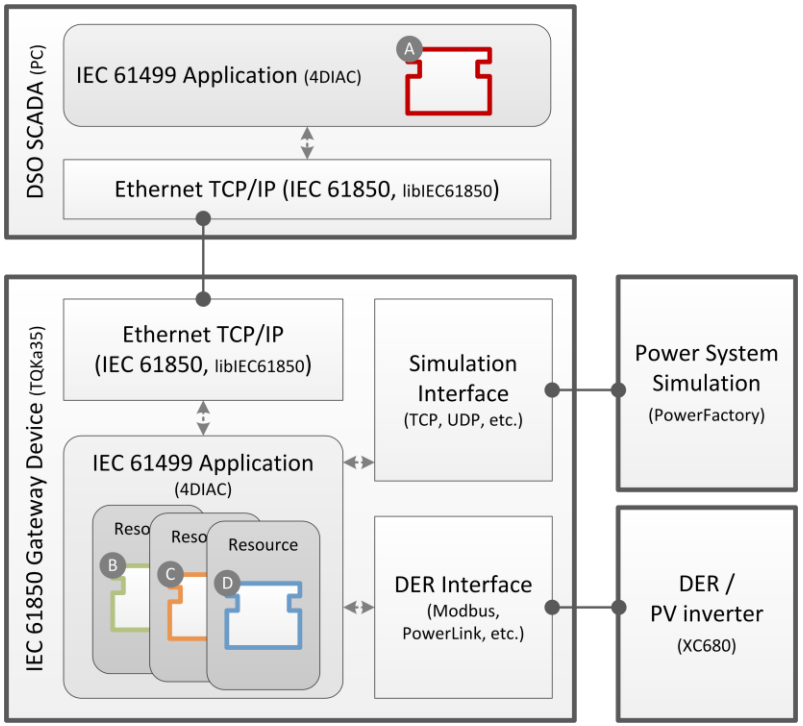
- Brief overview of validation methods

	Req. / basic design	***Detailed design***	***Impl. / prototype***	***Deployment / roll out***
Software simulation (incl. co-sim, SiL)	+	++	o	-
Lab tests	-	-	++	+
Hardware-in-the-Loop (HIL)	-	-	++	++
Demonstrations / field tests / pilots	-	-	-	++

The Role of DRTS in Smart Grid Design and Validation

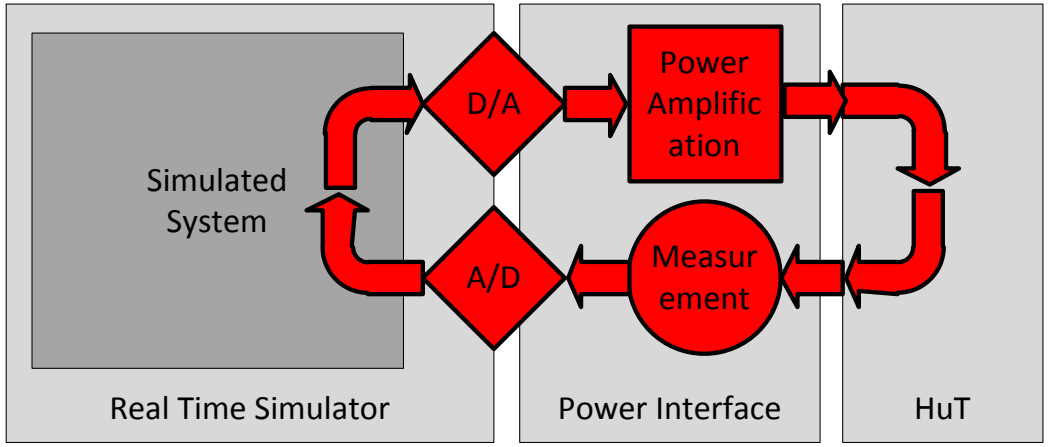
- Controller Hardware-in-the-Loop (CHIL)
  - Suitable for investigations of the control board only (pre-standardisation, communication test procedures, etc.)
  - Highly automated test sequences possible
  - No risk of high power flows





The Role of DRTS in Smart Grid Design and Validation

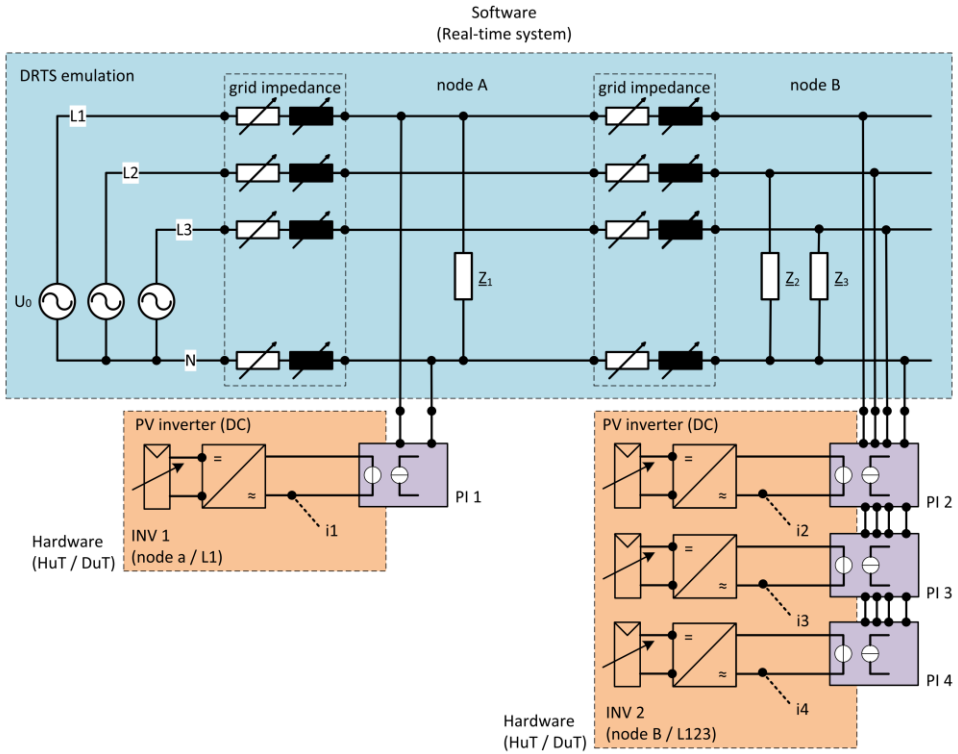
- Power Hardware-in-the-Loop (PHIL)
  - Suitable for investigations on Hardware-under-Test (HuT) with feedback of the true power signals



  - Dynamic behaviour of the Power Amplifier (PA), choice of Interface Algorithm (IA), measurement equipment
  - Stability considerations (Nyquist, Popov, Ljapunow criterion)
  - Measurement equipment used (I/O, transducers)

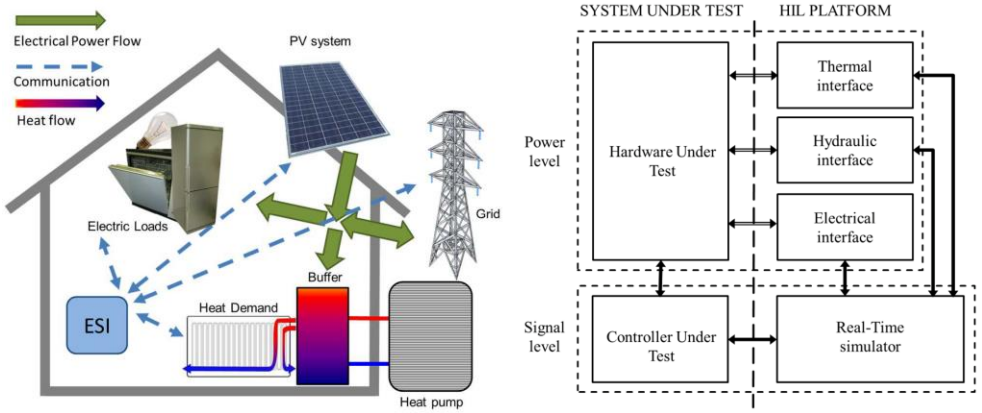
The Role of DRTS in Smart Grid Design and Validation

- Power Hardware-in-the-Loop (PHIL)
  - DRTS-based PHIL simulation test setup of grid-connected PV inverters to investigate active/reactive power controls

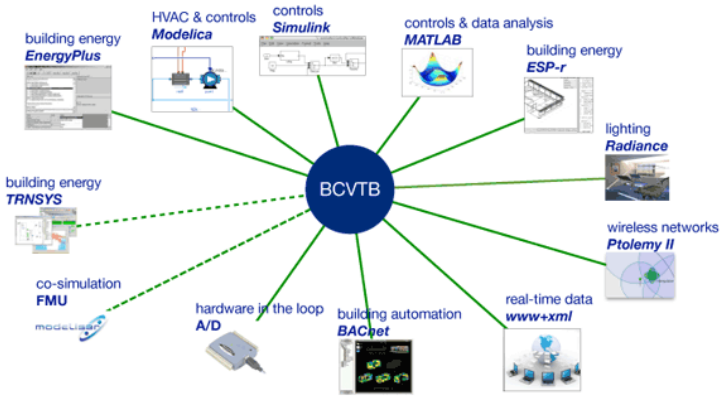


The Role of DRTS in Smart Grid Design and Validation

- Multi-Domain Simulation/Co-Simulation (MD/Co-Sim):
  - Suitable for investigations of various other control/communication circuitry integrated into the test system
  - High degree of flexibility, possibility of integrating various control loops into CHIL/PHIL environment



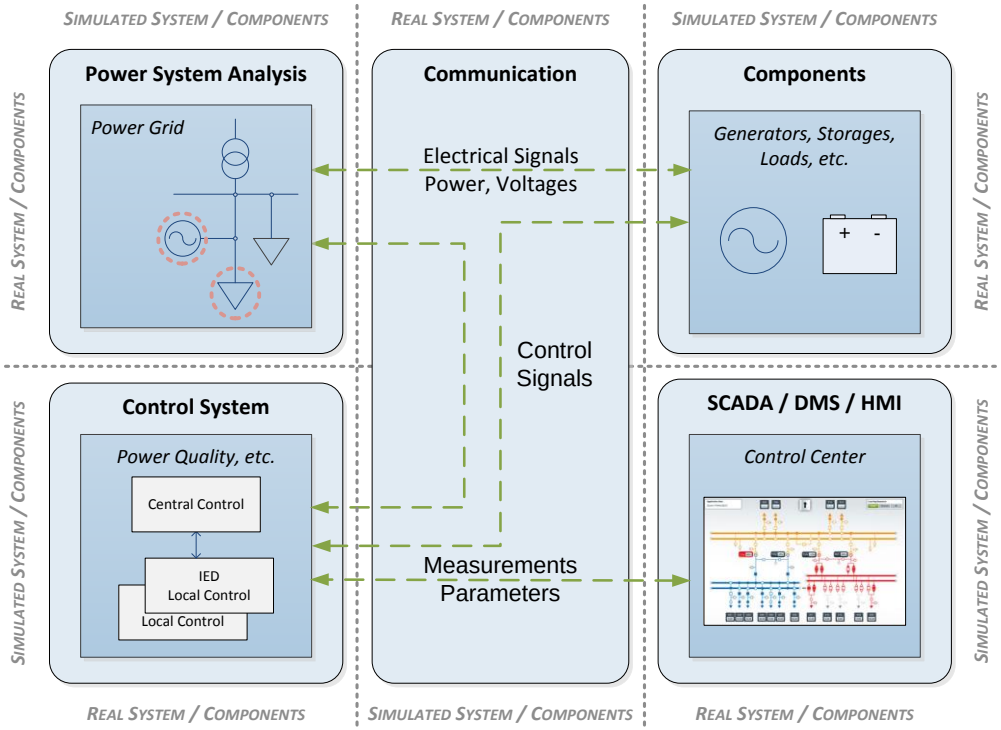
Source: RWTH Aachen



Source: Lawrence Berkley National Laboratories

Future Research Directions

- Integrated methods and tools
- Systems level validation procedures and benchmark criteria
  - A cyber-physical (multi-domain) approach
  - A holistic validation framework
- Development of advanced research infrastructures
- Education and training



Conclusions

- A large-scale roll out of smart grid solutions, technologies, and products can be expected in the near future
- New technologies, suitable concepts, methods and approaches are necessary to support system analysis, evaluation and testing issues
- Flexible integration of simulation-based methods, hardware-in-the-loop approaches, and lab-based testing looks promising for overcoming shortcomings

Researchers Exchange and Free Access to EU SG Labs Submit Now!

Thank you!

Time for discussion

Dr. Thomas Strasser
Senior Scientist
Electric Energy Systems
Energy Department

AIT Austrian Institute of Technology GmbH
Giefinggasse 2 | 1210 Vienna | Austria
P +43(0) 50550-6279 | M +43(0) 664 2351934 | F +43(0) 50550-6390
thomas.strasser@ait.ac.at | http://www.ait.ac.at