Is there a need for formalized design & validation methods in integrated energy systems?

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Outline
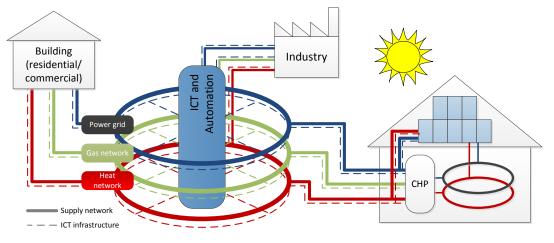
- Background and Motivation

- Status Quo in Design and Validation

- Future Needs

- The ERIGrid Validation Approach

- Conclusions

Background and Motivation

- Higher complexity in planning & operation of power distribution grids due to large-scale integration of distributed, renewable sources & controllable loads

- Advanced ICT and automation approaches and smart algorithms are required to master the steadily increasing requirements

- Communication, automation & control systems, and data analytics are key elements of future, integrated smart grids

- Further trends
    - Deeper involvement of consumers and market interaction
    - Linking electricity, gas, and heat networks for higher flexibility & resilience

→ Integrated, Cyber-Physical Energy System

Status Quo in Design and Validation

- **Past**
  - Individual domains of communication systems and power grids have been often designed and validated separately

- **Available methods and approaches**

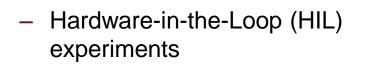|	Req. & Basic Design Phase	Detailed Design Phase	Implementation & Prototyping	Deployment / Roll Out
Software Simulation	+	++	O	-
Lab Experiments and Tests	-	-	++	+
Hardware-in-the-Loop (HIL)	-	-	++	++
Demonstrations / field tests / pilots	-	-	-	++

Legend:
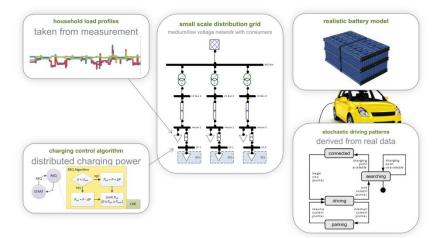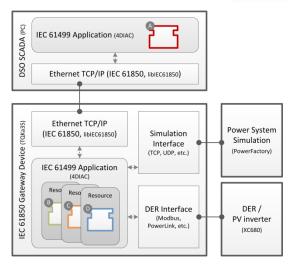- … less suitable,   o … suitable with limitations,   + … suitable,   ++ … best choice

Status Quo in Design and Validation

- Promising validation approaches

  – Co-simulation: coupling of domain-specific simulators

    (example: dynamic charging of electric vehicles)

  – Hardware-in-the-Loop (HIL) experiments

    - Controller-HIL (CHIL)

      (example: remote control of inverter-based DER)

    - Power-HIL (PHIL)
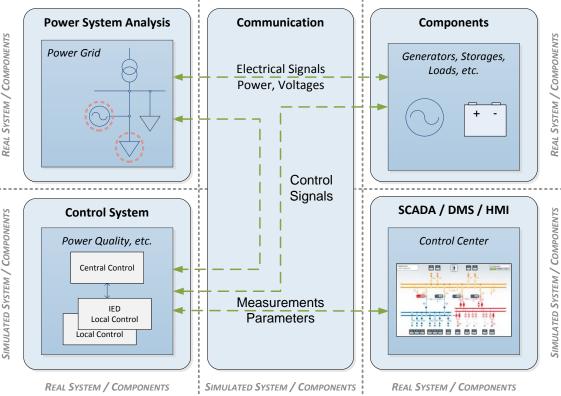
Future Needs

- A cyber-physical (multi-domain) approach for analysing and validating smart grids on the system level is missing today

    – Existing methods focusing mainly on component level issues

    – System integration topics including analysis and evaluation are not addressed in a holistic manner
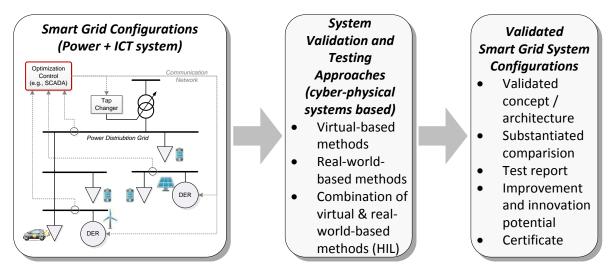
Future Needs

- A holistic validation framework and the corresponding research infrastructure with proper methods and tools needs to be developed

- Harmonized and standardized evaluation procedures need to be developed

- Well-educated professionals, engineers and researchers understanding integrated smart grid configurations in a cyber-physical manner need to be trained on a broad scale
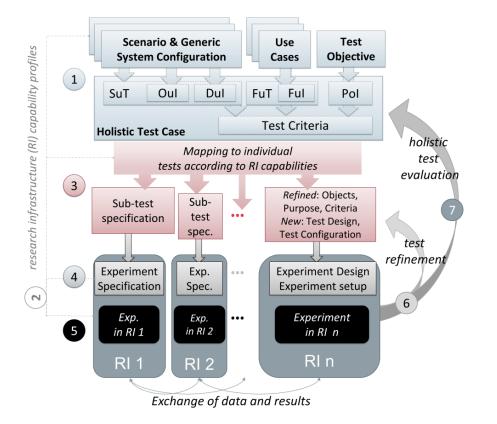
The ERIGrid Validation Approach

- Towards formalized validation

"From validation needs to evaluated integrated smart grid configurations"

Legend:
- System under Test (SuT)
- Object of Investigation (OuI)
- Domain under Investigation (DuI)
- Function(s) under Investigation (FuT)
- Function(s) under Test (FuI)
- Purpose of Investigation (PoI)
- Research Infrastructure (RI)

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 of integrated approaches

- Advanced research infrastructures are still necessary

- Flexible integration of simulation-based methods, hardware-in-the-loop approaches, and lab-based testing looks promising for overcoming shortcomings

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