– An Integrated Pan-European Research Infrastructure for Validating Smart Grid Systems

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Panel Session “Dynamic Long-distance Coupling of Smart Grid Research Infrastructure, Models, and Laboratories for Distributed Real-time Assessment of Cyber-physical Energy Systems”

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Outline

• Motivation and Background
• Status Quo in Validation and Future Needs
• The ERIGrid Research Infrastructure Approach
• Validation and Testing Example
• Conclusions
• Future Activities and Research
Motivation and Background

• Planning and operation of the energy infrastructure becomes more complex
  – Large-scale integration of renewable sources (PV, wind, etc.)
  – Controllable loads (batteries, electric vehicles, heat pumps, etc.)

• Trends and future directions
  – Digitalisation of power grids
  – Deeper involvement of consumers and market interaction
  – Linking electricity, gas, and heat grids for higher flexibility and resilience
Motivation and Background

Key elements of future integrated smart grids for mastering the increasing requirements and system complexity are:

- Power electronics
- Advanced communication, automation and control systems
- Smart algorithms
- Monitoring and data analytics
- Customer integration and market participation

How to design and validate such an Integrated Cyber-Physical Energy System?
Status Quo in Validation and Future Needs

- In the past individual domains of power and communication systems have been often designed and validated separately
- Available methods and approaches are

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<th>Req. &amp; Basic Design Phase</th>
<th>Detailed Design Phase</th>
<th>Implementation &amp; Prototyping</th>
<th>Deployment / Roll Out</th>
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<td>Software Simulation</td>
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<td>Lab Experiments and Tests</td>
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<td>Hardware-in-the-Loop (HIL)</td>
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Legend:
- ... less suitable,  o ... suitable with limitations,  + ... suitable,  ++ ... best choice
Status Quo in Validation and Future Needs

- Promising validation approaches
  - Co-simulation: coupling of domain-specific simulators
  - Hardware-in-the-Loop (HIL) experiments
    - Controller-HIL (CHIL)
    - Power-HIL (PHIL)

Analysing the dynamic charging of electric vehicles with co-simulation

Analysing remote control of inverter-based DER with CHIL
Status Quo in Validation and 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
- 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
Status Quo in Validation and Future Needs

- Vision: “Providing support from design to implementation & installation”
  - Integrated system design
  - Validation and testing
  - Installation and roll out

Design, development, validation, and deployment chain for smart grid solutions
The ERIGrid Research Infrastructure Approach

- **H2020 call “INFRAIA-1-2014/2015”**
  - Integrating and opening existing national and regional research infrastructures of European interest
- Funding instrument: Research & Innovation Actions (RIA) - Integrating Activity (IA)
- 18 Partners from 11 European Countries + 3 Third Parties involved
- Involvement of 19 first class Smart Grid labs
- 10 Mio Euro Funding from the EC
- ~1000 Person Month
The ERIGrid Research Infrastructure Approach

• Supporting the technology development as well as the roll out of smart grid approaches, solutions and concepts in Europe with a holistic, cyber-physical systems approach

• Integrating the major European research centres with a considerable, outstanding smart grid research infrastructure to jointly develop common methods, concepts, and procedures

• Integrating and enhancing the necessary research services for analysing, validating and testing smart grid configuration

• System level support and education for industrial and academic researchers in smart grid R&D is provided to foster future innovation

• Strengthening the technical leadership of the European Research Area in the energy domain
The ERIGrid Research Infrastructure Approach

• Integration of leading smart grid research infrastructure in Europe
The ERIGrid Research Infrastructure Approach

- Towards formalized validation and testing

"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)

ERIGrid holistic validation approach
The ERIGrid Research Infrastructure Approach

• Cyber-physical (multi-domain) approach, methods, and tools for analysing and validating smart grids on system level

Flexible integration of simulation and lab-based validation methods and tools in ERIGrid
The ERIGrid Research Infrastructure Approach

- Improved validation and testing methods (focus on co-simulation and HIL)

Coupling of simulators and validation tools
The ERIGrid Research Infrastructure Approach

- Coupling of research infrastructures for integrated and joint testing (multi-lab)
The ERIGrid Research Infrastructure Approach

• Free of charge access to best European smart grid research infrastructures
  – Scientists from research, academia and industry are invited to apply for the Trans-national Access (TA)
  – Successful applicants will be provided with free of charge access to ERIGrid research facilities (incl. lab installations)
  – The expenses, including travel and accommodation will be reimbursed under ERIGrid conditions
  – Calls open every 6 month
Power System Control Testing

• Cell-based power systems control
  – FP7 ELECTRA IRP Web-of-Cells (WoC) approach

• Controller analysis and investigation
  – Focus on voltage control of a cell

• Validation goal
  – Testing of the WoC control implementation
Validation and Testing Example

- Formal test case description

Templates for describing test cases, test specifications, and experiment specifications
Validation and Testing Example

- Realized test with
  - PowerFactory Client
  - Simulation Client
  - Typhoon HIL Client
  - InfluxDB Client
  - Synchronization Client

HIL-based co-simulation validation setup
Validation and Testing Example

• Achieved results

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
Future Activities and Research

• Improvement and integration of design and validation tools from different domains (focus on power system and ICT)
• Refinement and testing of the holistic validation procedure
• Development of system level validation procedures and benchmark criteria
• Improvement of research infrastructures supporting system level validation
• Education, training and standardization is also a key factor
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2nd call: 15 March - 15 June, 2017
3rd call: 15 August - 15 November, 2017
4th call: 15 February - 15 May, 2018
5th call: 15 August - 15 November, 2018
6th call: 15 February - 15 May, 2019

erigrid.eu/transnational-access
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