Validation Infrastructures for Smart Energy Systems: The ERIGrid 2.0 Example

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Expert Workshop
Design and Operation of Digitalized Sector-coupled Energy Systems
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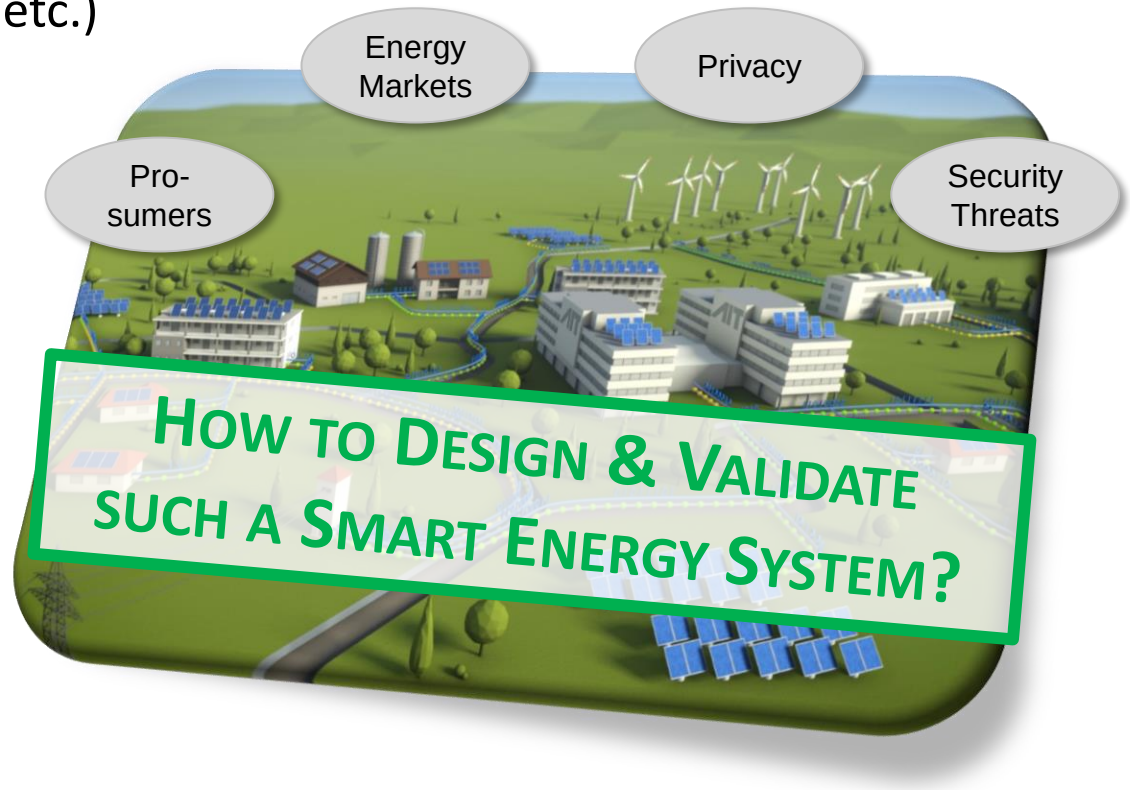
Background and Motivation

- Planning and operation of the energy infrastructure becomes more complex
  - Large-scale integration of renewable sources (Distrib. Energy Res. (DER), like photovoltaics, etc.)
  - Controllable loads (like battery storages, electric vehicles, heat pumps, etc.)
- Trends and future directions
  - Digitalisation of energy infrastructure
  - Sector coupling (linking electricity, gas, and heat grids) for higher flexibility and resilience
  - Deeper involvement of consumers and market interaction



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Needs and Requirements

- Separated design and validation of individual domains (power, ICT, heat, etc.) not sufficient anymore
- Integrated cyber-physical/multi-domain design and validation missing
- Reduction of manual steps necessary to handle complex system configurations
- Reduction of error sources due to manual steps required
- Improvement of application/software quality required
- Faster application development needed due to market behaviour and trends

	Req. & Basic Design Phase	***Detailed Design Phase***	***Implemen-tation and Prototyping***	***Deployment / Roll Out***
Software Simulation	+	++	o	-
Lab Experiments and Tests	-	-	++	+
Hardware-in-the-Loop (HIL)	-	-	++	++
Demonstrations / field tests, pilots	-	-	-	++

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

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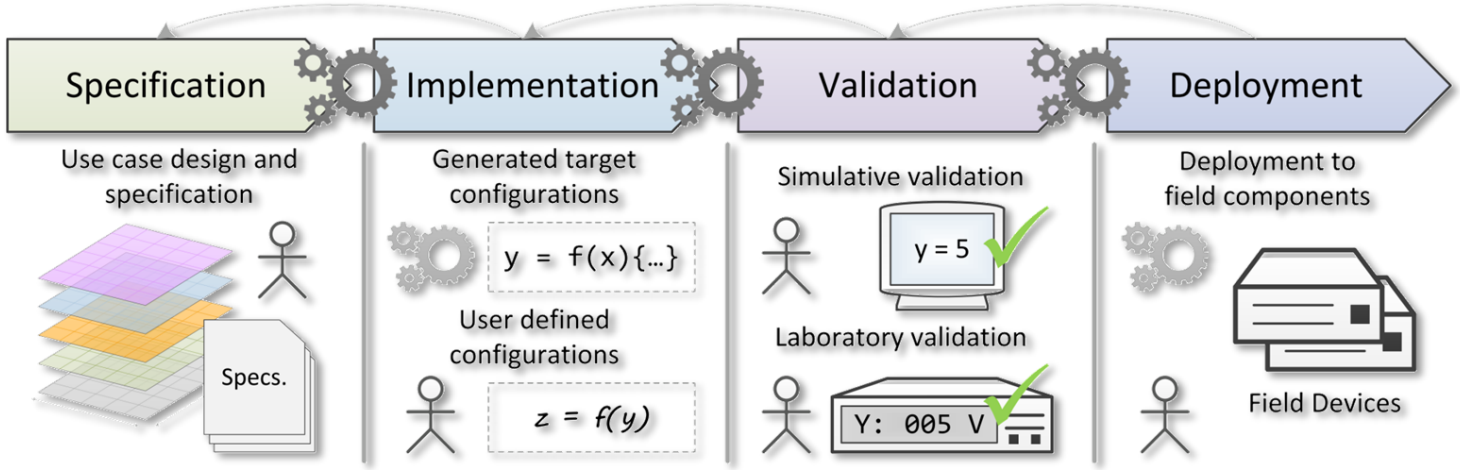
Vision and Research Directions

- Smart energy systems support for integrated …
  - Systems design and implementation
  - Validation and testing
  - Installation and roll-out
- Future research needs
  - Improved development and testing methods/services/tools
  - Extended and advanced research infrastructures and laboratories
  - Well-educated researchers and engineers (“multi-domain understanding”)



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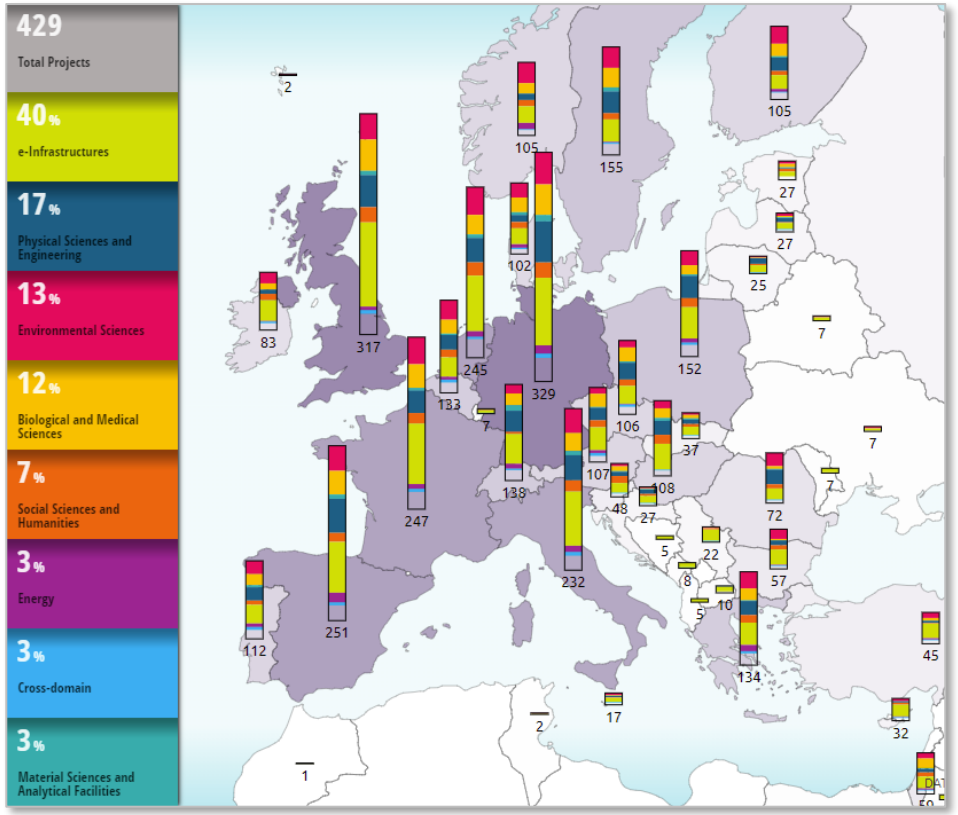
European Research Infrastructures (RI)

- Provide resources (major scientific equipment) and services to communities
- Conduct research and foster innovation
- Are strategic investments in scientific and technological excellence
- Act as knowledge and innovation hubs (collections, archives or scientific data)
- Essential pillar of the European Science Area

→ ***Only a few cover energy-related topics***



Source: European Commission & RICH2020

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Integrated DER, Smart Grid, and Energy Systems RI's

- Long-term, Pan-European cooperation
- Advanced community

2005

2024

DERlab
European Distributed Energy Resources Laboratories

- GA-ID 5189299
- FP6 NoE (11/2005-10/2011)
- 3 Mio EUR funding
- 12 partners
- Networking of DER labs, pre-standardization

DERri
Distributed Energy Resources Research Infrastructure

- GA-ID 228449
- FP7 RI IA (09/2009-12/2013)
- 5 Mio EUR funding
- 16 partners from 12 countries
- TNA to DER labs, pre-standardization

ERIGRID
Connecting European Smart Grid Infrastructures

- GA-ID 654113
- H2020 RI IA (11/2015-04/2020)
- 10 Mio EUR funding
- 18 partners from 11 countries
- TNA to Smart Grid and DER labs, pre-stand-ardization

ERIGRID 2.0
Connecting European Smart Grid Infrastructures

- GA-ID 870620
- H2020 RI IA (04/2020-09/2024)
- 10 Mio EUR funding
- 20 partners from 13 countries
- TNA & VA to Smart Grid, Smart Energy Systems and DER labs, pre-standardization

Legend:

DER … Distributed Energy Resources
RI … Research Infrastructure
TNA … Trans-national Access
VA … Virtual Access
NoE … Network of Excellence

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Key Facts

- Extended and applied research based on ERIGrid topics and achievements for
  - Smart grid and smart energy systems
  - Digitalization with lab interfacing and data exchange for physical/virtual access
- Tight collaboration of partners
  - 13 European countries involved
  - 20 Partners from research and industry
  - 21 top-class DER, smart grid, and energy systems labs + 8 virtual facilities
  - 10 Mio funding (~900 person months)

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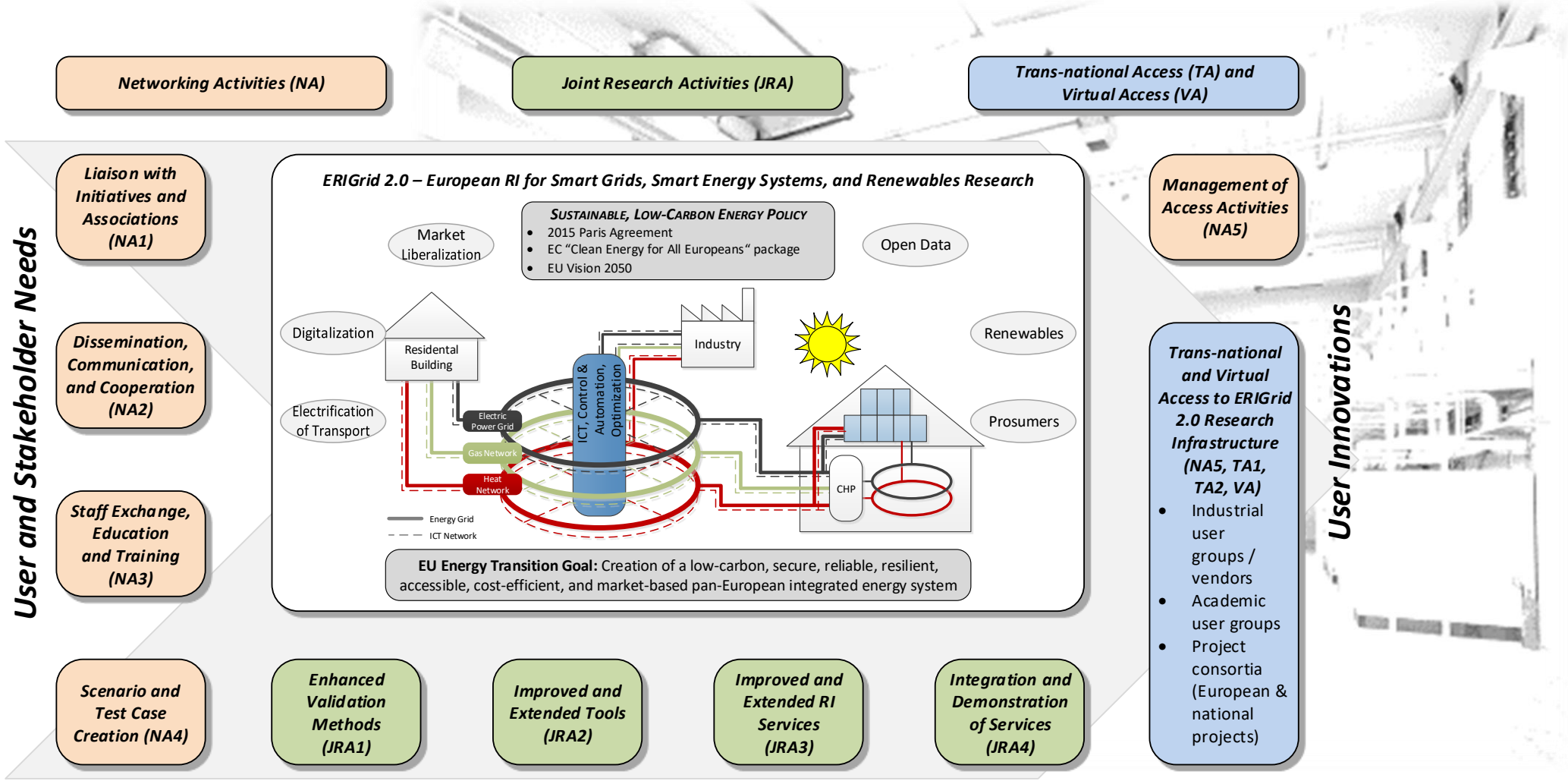
Overall Approach



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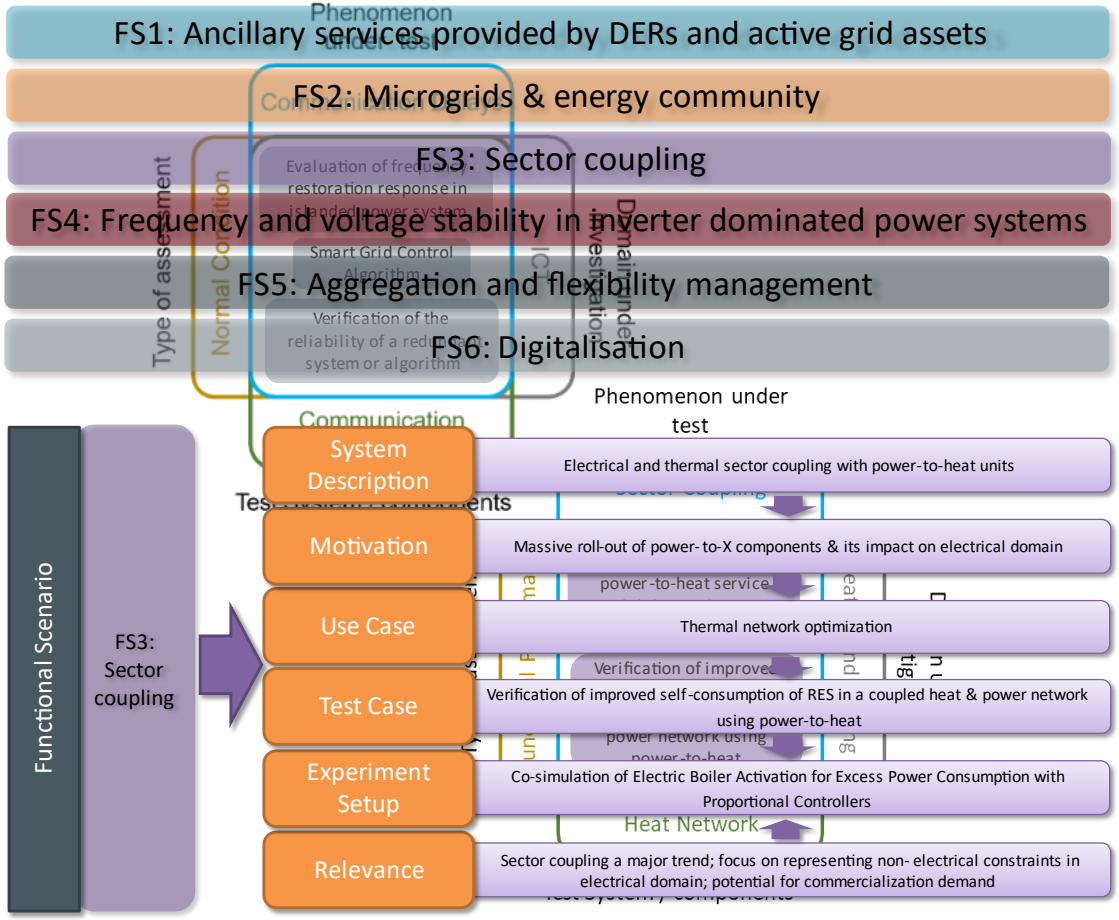
Identification of Scenarios and Test Cases

- 25 test cases based on 6 functional scenarios
- Test cases documented with the ERIGrid-1 Holistic Test Description (HTD)

  → Facilitates the implementation at RI level
- Keywords assigned to test cases for the definition of characteristics of technological areas
  - Useful tool for users selecting test cases
  - Test case profiles formed based on keywords
  - Key words focus on 4 dimensions: 1) domain under investigation, 2) phenomenon under test, 3) type of assessment, and 4) test system



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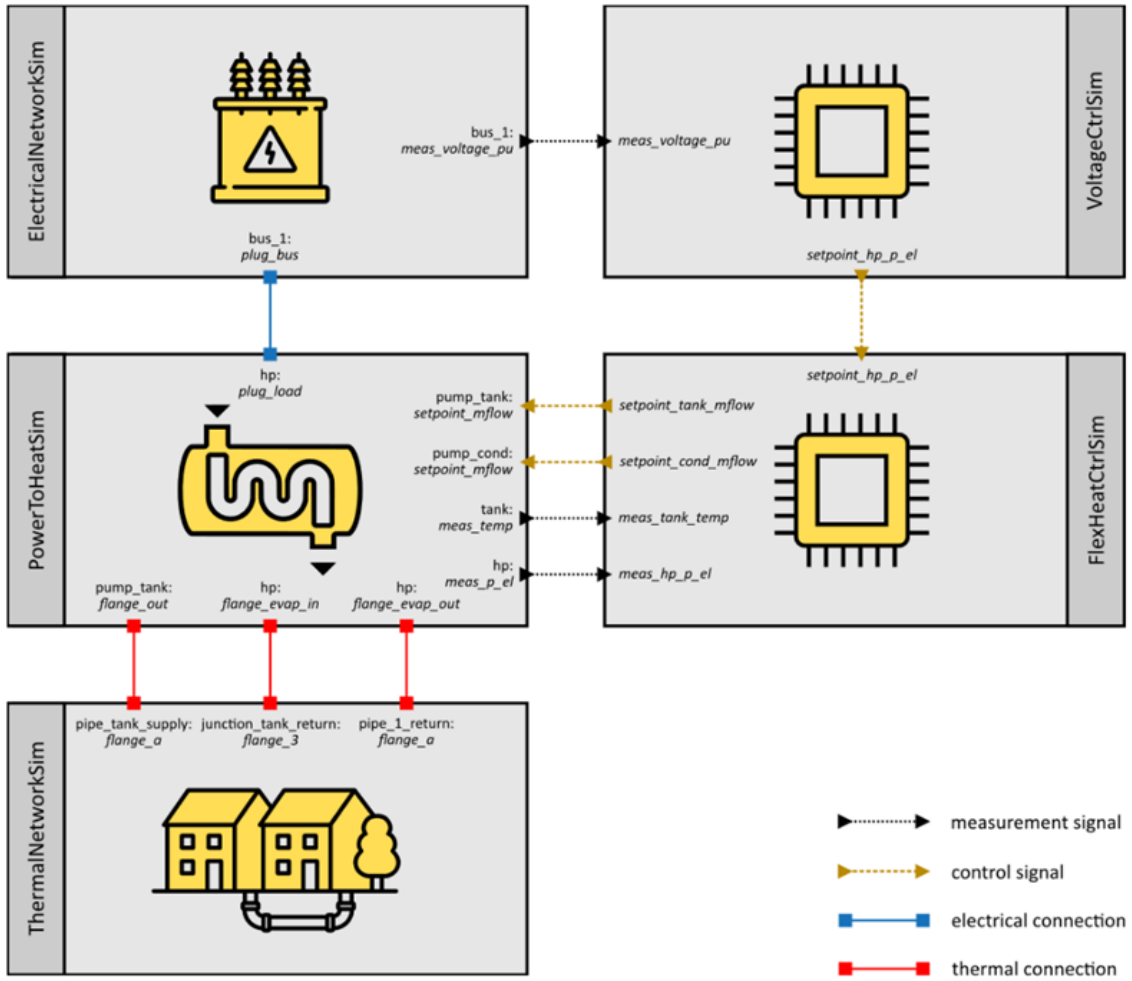
Development of Benchmark Models

- Three benchmarks
  1. Electrical Network
  2. Multi-Energy Networks
  3. ICT-enhanced Power System
- Extensive documentation following PreCISE approach (based on HTD)
- Current work focuses on
  - Uncertainty representation
  - Validation methods



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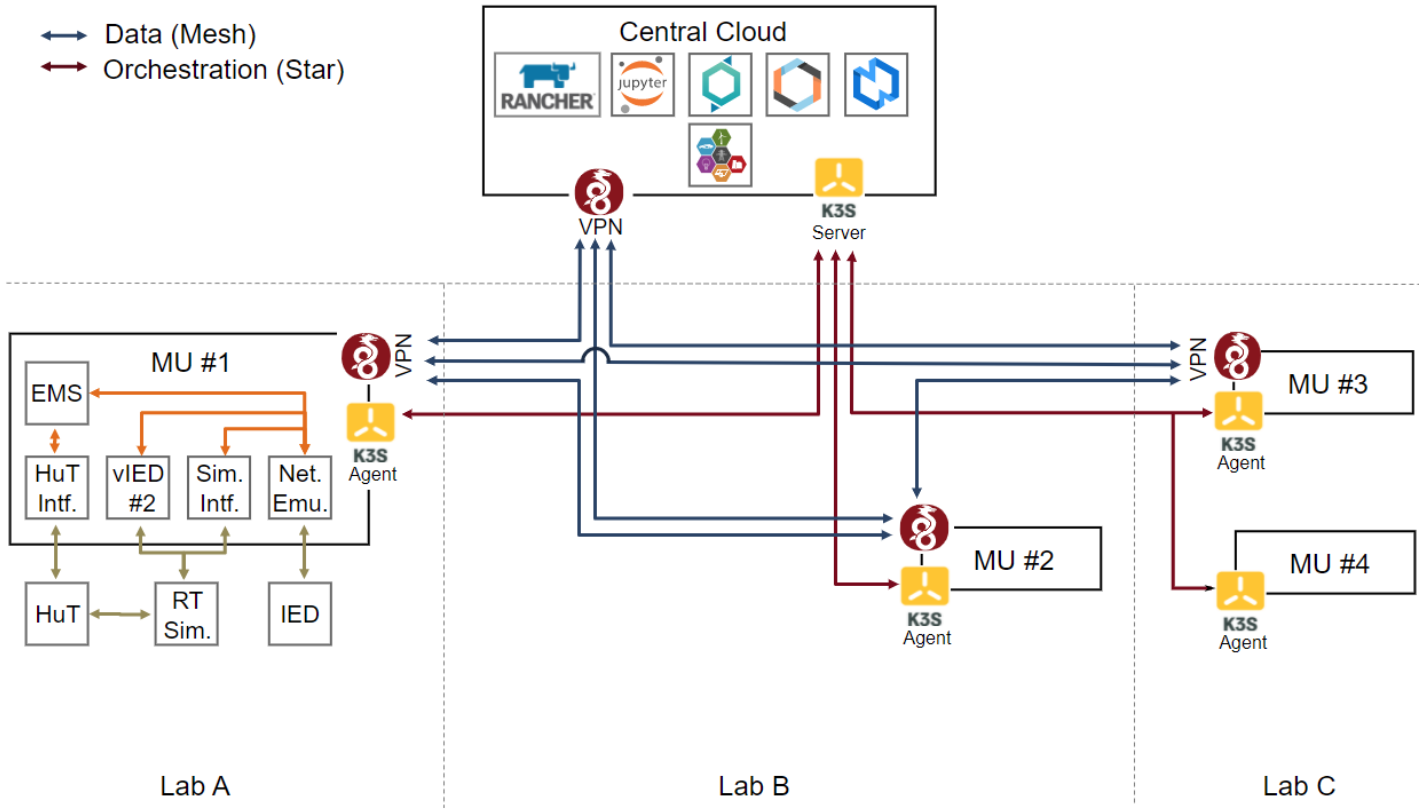
Tools for RI Cooperation

- Accelerating time-to-experiment for remote RI coupling via “RI-as-Code” (RIasC)
  - Prototype set of tools for automated provisioning of distributed mobile compute nodes
  - Enables transparent inter-connection via an overlay network
  - Together with other ancillary services (network monitoring, synchronisation, etc.) these tools provide the basis for a flexible lab middleware



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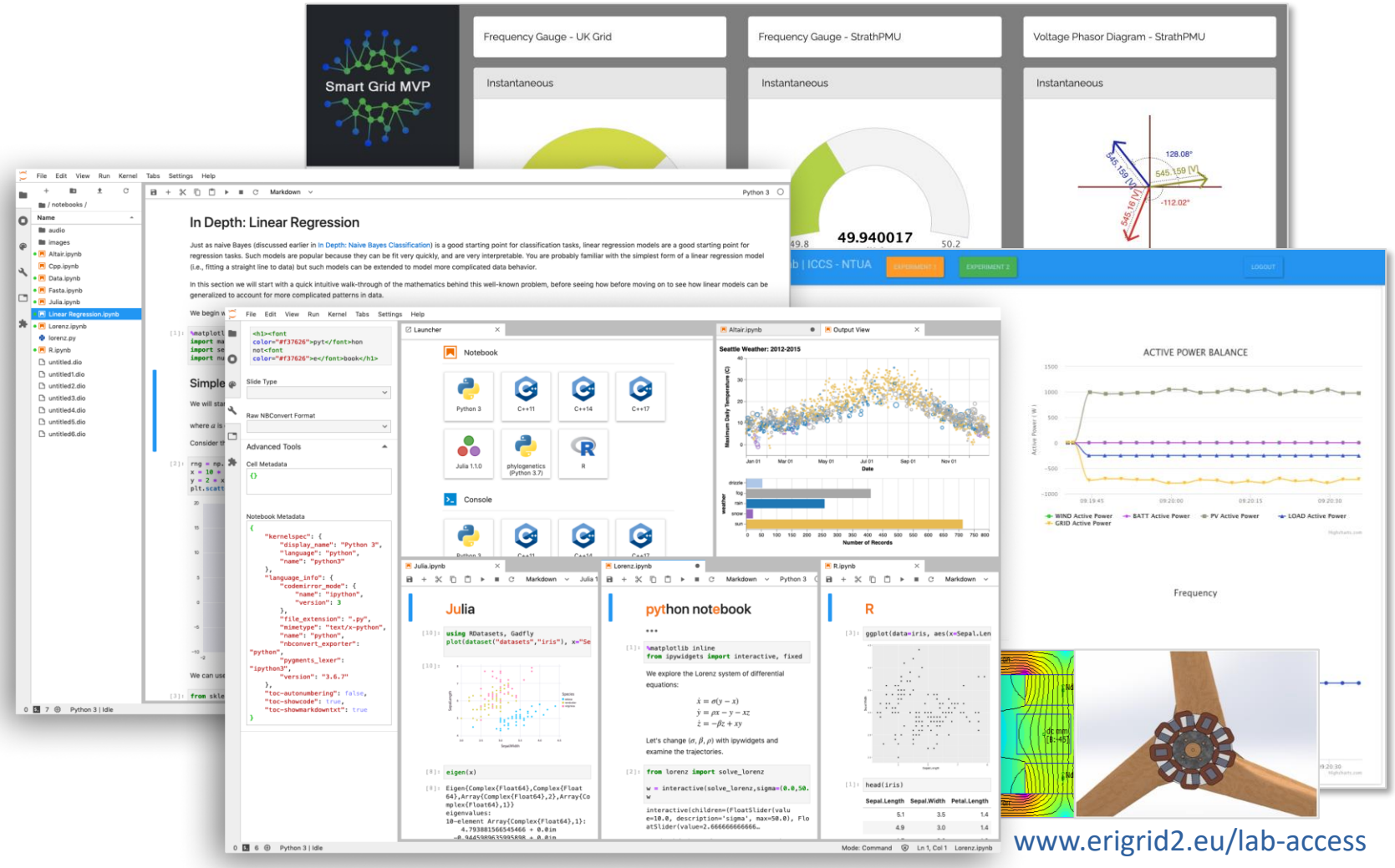
Virtual Services

- Focus on
  - Simulation-as--a-Service (SaaS)
  - Open data, Data- as-a-Service (DaaS)
  - Virtual labs



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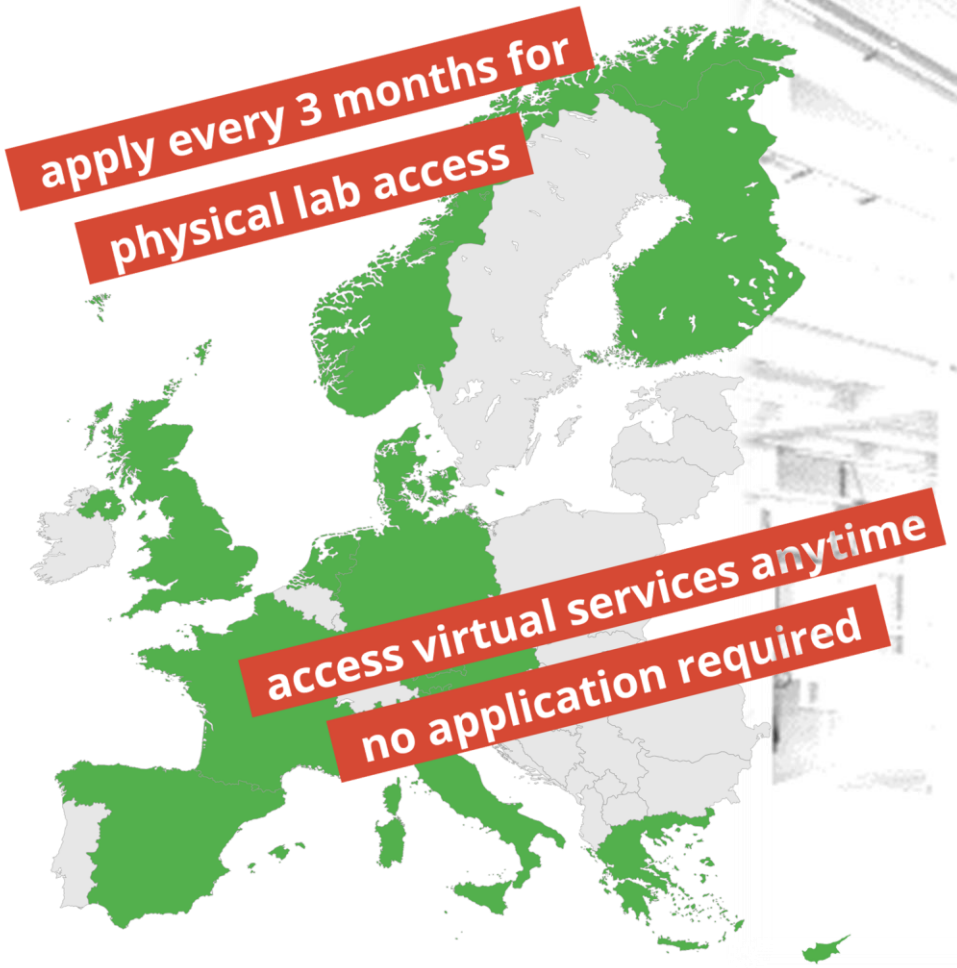
Lab Access Possibilities



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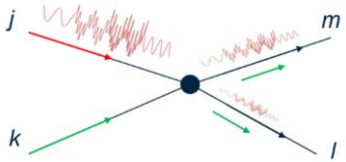
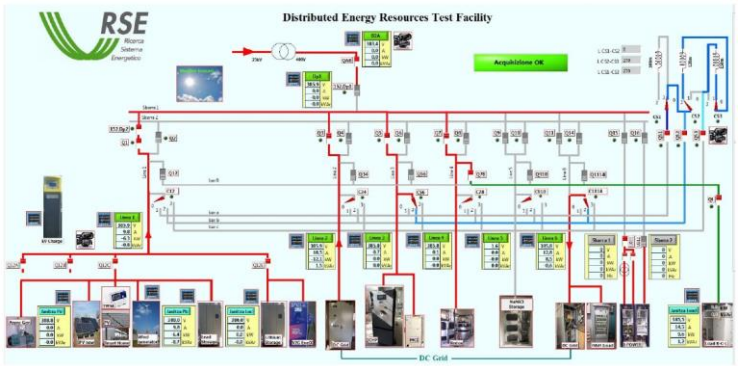
Lab Access Example

University of Glasgow, UK → RSE, Italy

- User project “ColourPower” at the Distributed Energy Resources Test Facility (RSE), Italy
  - Wavelet-transform based signal pro-cessing for the validation of power flow tracing approach
  - Prove the power sharing principle for power flow tracing to determine the share of loses in active distribution grids
  - 183 tests records were obtained





Start date 26/07/2021

End date 06/08/2021

No. of access days 10

No. of stay days 14

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Conclusions

- Integrated analysis and multi-domain, cyber-physical systems based approach needed for mastering the complexity of smart energy systems
- Methods and tools for system-level testing as well as rapid configuration of lab-setups required
- Smart grid, smart energy systems, and DER research and development services (incl. physical labs) are necessary
- Harmonization and standardization necessary (e.g., IEEE P2004 on HIL)
- Multi-domain education and training essential
- RI/lab-collaboration on international basis very beneficial

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@ERIGrid 2.0 Project

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