Karlsruhe Institute of Technology

ENERGY LAB

EGSAL designs and digitalizes future energy grids.

Energy Grids Simulation and Analysis Laboratory

Energy networks (electricity, gas, heat) connect producers, storage facilities and consu-mers. The future electricity grid will play a central role in the integration of all energy forms and networks in the energy transition. Planning, simulation, analysis and optimization of the interconnected grid is therefore essential. EGSAL provides a hardware and software infrastructure for modelling, simulation and analysis of energy grids. The investigated networks range from microgrids (house networks, island networks), over the KIT Campus north power grid, to distri-bution and transmission networks (Karlsruhe city, Baden-Württemberg, Germany, and the inter-connected European grid). State-of-the-art software and self-developed, novel solutions form the basis for the simulation and analysis. EGSAL provides the simulation infrastructure, models and knowledge to develop and investi-gate novel power grid operation concepts. The real-time simulation enables wide scale tests including actual grid components (controllers as well as power hardware) via our integration with the SESCL and PHIL laboratories within the Energy Lab.

- Key hardware component:
  Two fully licensed NovaCor RTDS racks for real-time simulation of large electrical network models
- Broad range of supported for the integration with substation automation protocols and Multi-Domain Co-Simulation (TCP/UPD Sockets, MODBUS, IEC 61850 Sampled Values and GOOSE Messaging)
- Direct fibre-optical connections to CMVC, SESCL and PHIL-Laboratories for Controller and Power Hardware in the Loop studies
- Three FPGA simulation units (GT-SoCv2) for accurate simulation of very fast dynamics (power electronics) and parallel IO of 48 SV-Streams (24 variables each)
- Proven capabilities for geographically distributed real-time simulations with partner laboratories via the VILLAS framework
- GPU-enhanced power workstation used for offline simulation and modelling work running the *e*ASiMOV framework and commercial simulation software

View of EGSAL with the two RTDS systems for real-time simulation of power networks, the visualization monitor, and workstations in the laboratory. EGSAL also provides its resources to KIT and guest researchers through scientific cooperations.

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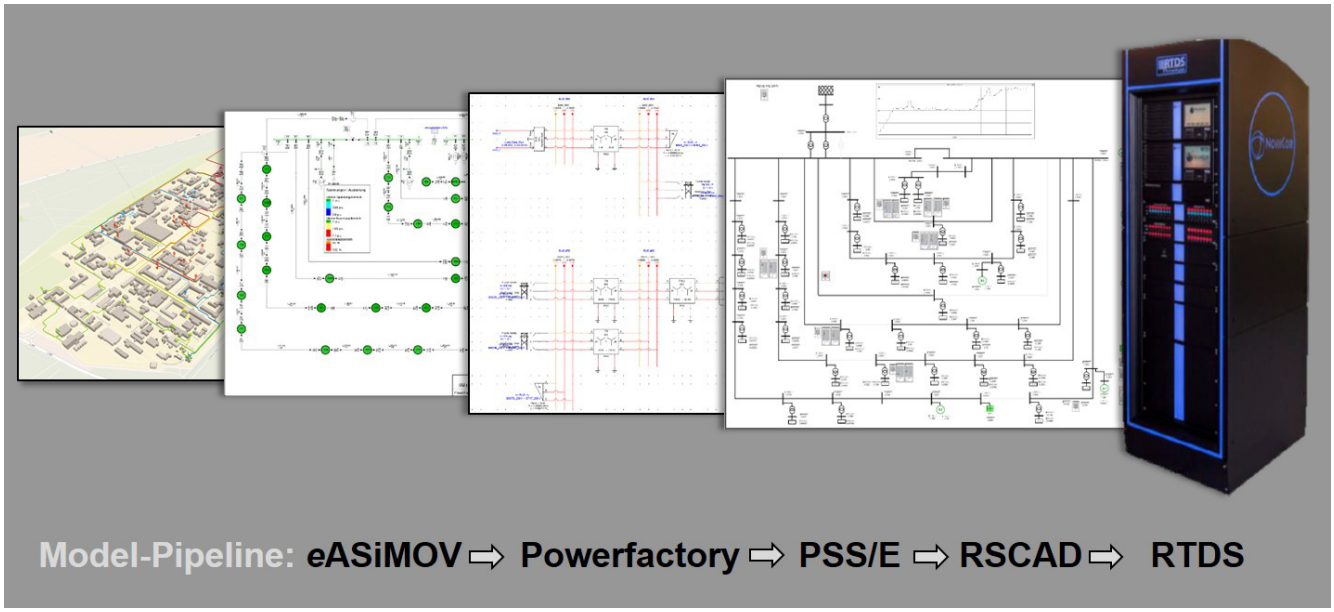

An example of the EGSAL modeling pipeline showing the KIT 20kV campus north network from the model in the eASiMOV framework to the converted model in the RSCAD software for real-time simulation.

EGSAL Specific Scenarios

One scenario is the so-called campus network simulation, consisting of the KIT campus north 20kV network. Combined with the measurement devices installed on the campus, the state of the real network will be fed to the real-time simulated network to form a digital twin of the campus network. This information will be used for online power flow, stability, and security assessment of the network based on the real operating point. The simulated state of the network can be visualized using the methods and infrastructure of the control and visualization center (CMVC).

The interconnection between the measurement hardware, the real-time simulators and the visualization enables research into solutions for future power grid management.

A further scenario is the interconnection of multiple geographically distributed simulators in one real-time simulation via the VILLAS framework.

This connects the Energy Lab with other real-time laboratories to form a combined environment for PHIL and HIL simulation with increased computing power through the combination of multiple simulators.

The EGSAL setup with the real-time simulation is extended with offline-simulations provided by available commercial simulation software and the in-house developed *e*ASiMOV-framework, which among others enables multi-modal energy system analysis in a co-simulation environment.

Richard Jumar
Institute for Automation and Applied Informatics

Hermann-von-Helmholtz-Platz 1
76433 Eggenstein-Leopoldshafen

richard.jumar@kit.edu

Bundesministerium für Bildung und Forschung

Bundesministerium für Wirtschaft und Energie

Baden-Württemberg
MINISTERIUM FÜR WISSENSCHAFT, FORSCHUNG UND KUNST