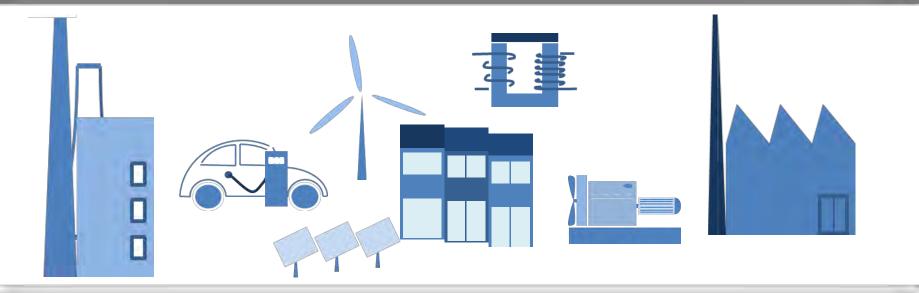


A Concept for the Control, Monitoring and Visualization Center in Energy Lab 2.0

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Overview

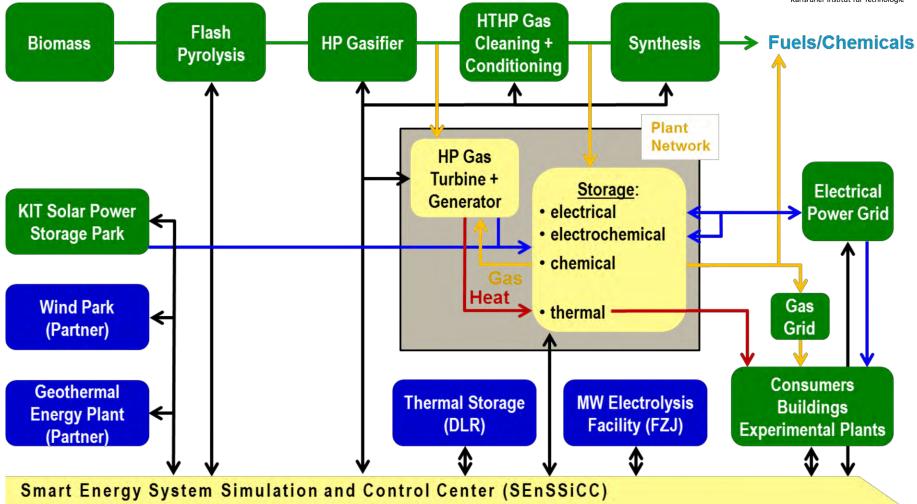
- Motivation / Energy Lab 2.0
- Smart Energy System Simulation and Control Center (SEnSSiCC)
- Basic Concepts of the Control, Monitoring and

Visualization Center (CMVC)

Summary and Outlook

Energy Lab 2.0 – Components





- Smart Energy System Control Laboratory
- Energy Grids Simulation and Analysis Laboratory
- Control, Monitoring and Visualization Center

Smart Energy System Simulation and Control Center (SEnSSiCC)



Main parts

- Smart Energy System Control Laboratory with
- Power hardware in-the-loop test facility
- Energy Grids Simulation and Analysis Laboratory
- Control, Monitoring and Visualization Center

Cross-Cutting Topics

- Big Data
 (Data management and analysis)
- Smart control algorithms
- Security, Safety, Controllability

Smart Energy System Laboratory (Grid Lab) – Planned Equipment (1)



- ∑ 3 Smart houses
- Σ 10 Consumers:
 - RLC load
 - Asynchronous machine with oscillating weight
 - DC motor with PWM interface
 - Car charging station
 - Power to Heat
 - Hardware in the loop consumer

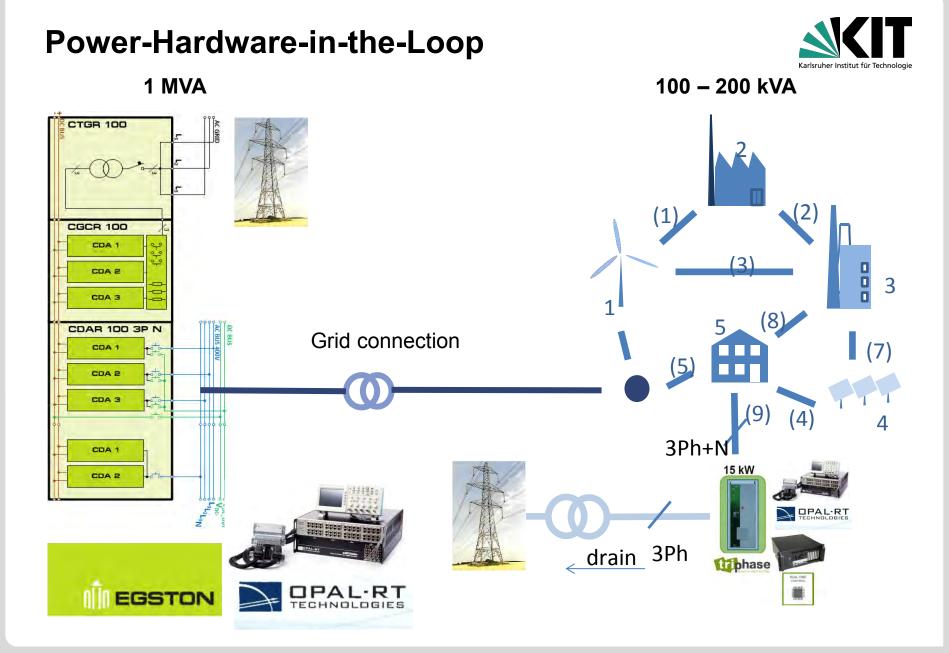
- **Σ** 10 Generators:
 - Diesel/Gas generator
 - Micro co-generation plant
 - Photovoltaic system
 - Smaller wind turbine
 - Power amplifier
 - $\sum 5$ Prosumer :
 - Supercaps
 - Battery storage
 - Storage power station

Smart Energy System Laboratory (Grid Lab) – Planned Equipment (2)



- $\sum 5$ "Reactive power components":
 - Capacitors
 - Inductors
 - Phase shifters,
 - FACTS (Flexible AC Transmission System): e.g. SVC (Static Var Compensator), UPFC (Unified Power Flow Controller), STATCOM (Static Synchronous Compensator)
- ∑5 Other:
 - Passive nodes (Connectors for wiring)
 - Grid connection components (Transformer/RONT)
 - Measurement equipment and programmable IEDs

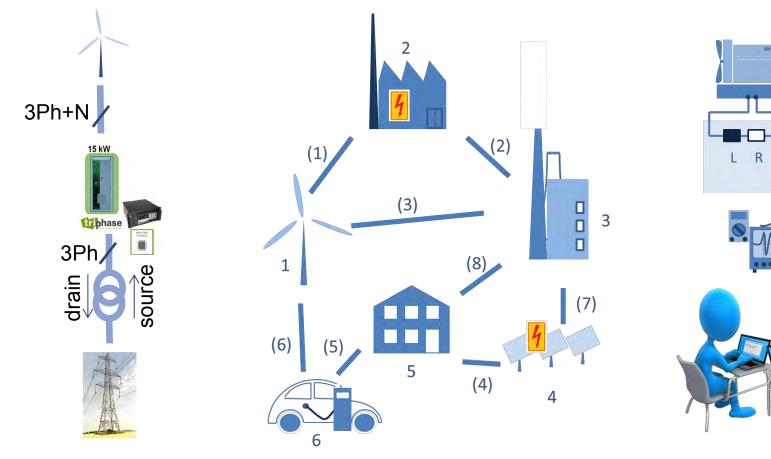
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Grid Lab Research and Usage



C



- 1. Develop flexible components, control algorithms and IEDs for smart grid applications
- 2. Provide a test laboratory, where solutions can be tested under critical conditions
- 3. Hands-on laboratory for (PhD) students

Energy Grids Simulation & Analysis Laboratory



Grid and technical plant modelling (generators, consumers, prosumers); simulation with co-simulation framework

Physical view

Generation

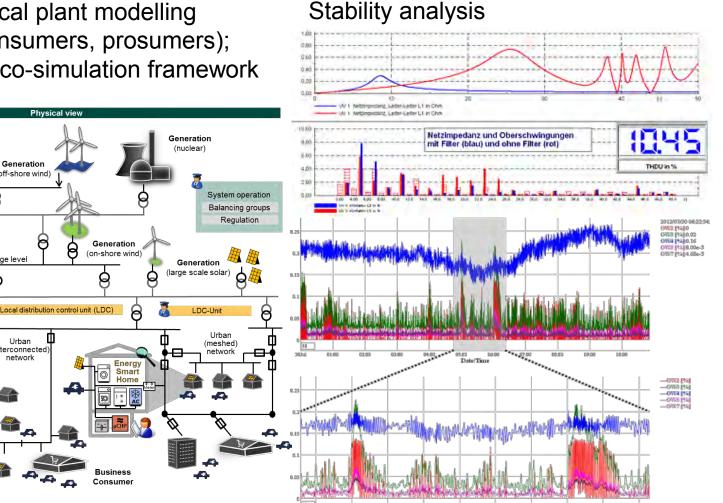
(off-shore wind)

Urban

network

nterconnected)

High voltage level



05:30

Date/Time

05-40

85:50

Business

Prosumer

Generation (coal/gas/water)

Energy

Storage

(water)

Extra-high voltage level

Medium voltage level LDC-Unit

Low voltage level

8

Rural

(radial)

network

CA

9 Private

Prosumer

06-11

06/28

Control, Monitoring and Visualization Center



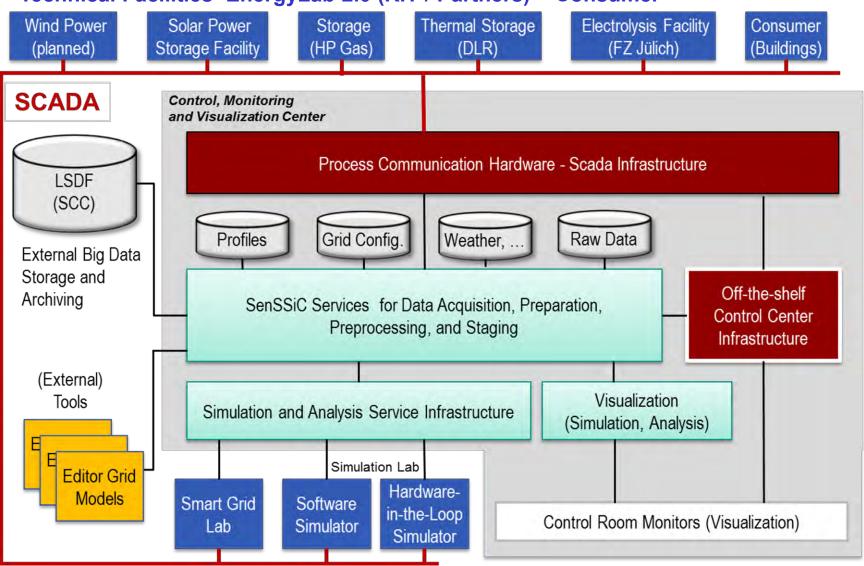
- Combines own research solutions for monitoring, control and visualization of grid simulations with commercial control center software and a SCADA communication infrastructure
- Integrates grid lab hardware and external Energy Lab plants
- Should look like a real grid control center for operators
- Research on new control center software components and architectures, newer communication technology and risks, tools for demand side management, demand response, grid utility operations



Control, Monitoring and Visualization Center Components

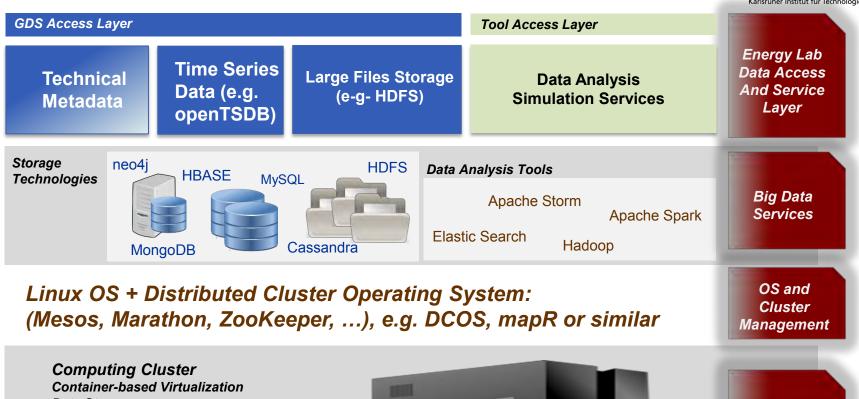
Technical Facilities EnergyLab 2.0 (KIT / Partners) + Consumer





CMVC Research IT Infrastructure





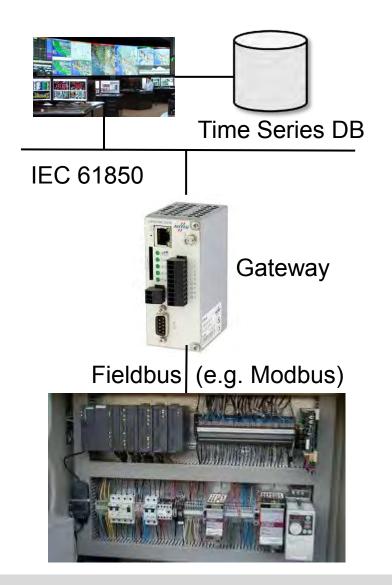
Data Storage

Hardware Level

Interfacing to SCADA and Data Management

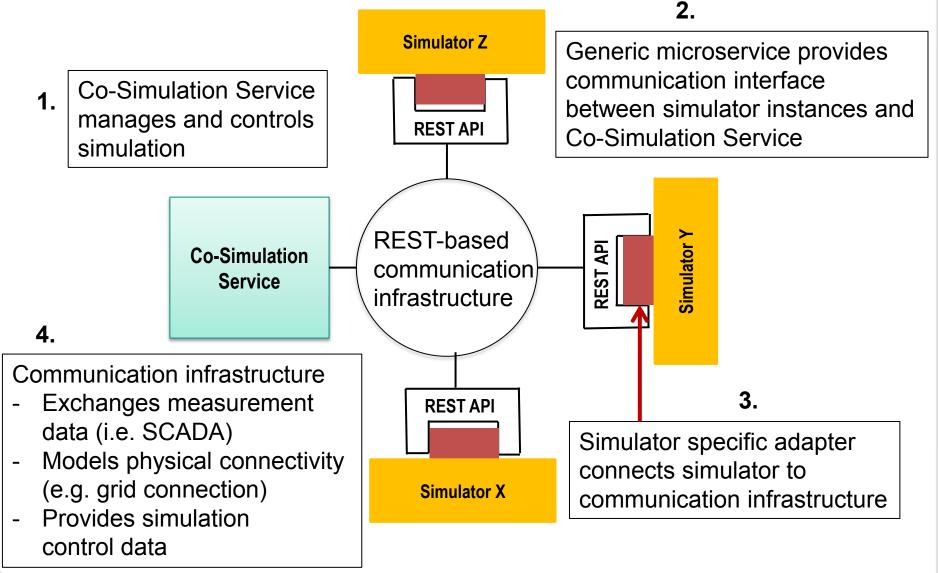


- Gateways will map between
 Fieldbus standards (e.g. Modbus, Profibus, ...) and IEC 618650
- Polyglot and microservice oriented data management, i.e.
 - Use time series database for measurement data
 - Document-oriented database for semantic metadata descriptions
 - Graph database for storing "network structures"
 - Hadoop File System (HDFS) for large chunks of (binary) data
- CIM aware semantic model for information objects, but more document-oriented and less object-oriented



Co-Simulation Framework Architecture

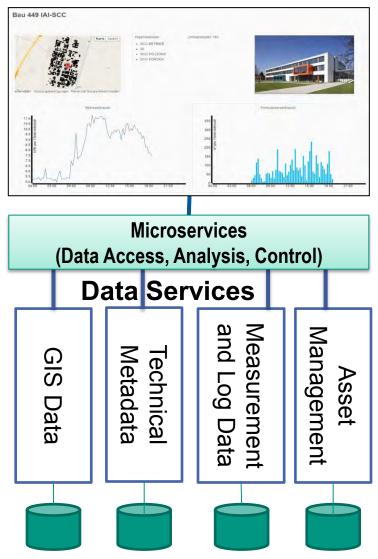




User interface and visualizations



- Primarily based on modern web technologies and microservices
 - Modular parameterized and reusable web-components for data and information display and control actions
 - Modular dashboard and control screens can be composed by using, configuring and arranging such web-components
 - Access the microservices for data access, control and other business logic
 - Integrated Event Bus and Notification system
- The web user interfaces can be augmented by mobile and desktop applications accessing the same services as needed



Status and Outlook



- Some tools are already available for data management, analysis and visualization (based on web and Big Data technologies)
 - Storing and accessing large binary data files in HDFS (i.e. phasor measurement data chunks)
 - openTSDB as primary storage for measurement data and Elasticsearch for combining measurement data and log data for analysis
 - First experiments analyzing energy related (measurement) data with big data tools
 - Generic web framework for data visualization
- IEC 61850 instrumentation of Energy Lab facilities is in the works
- Big Data Development cluster will be setup in the next two months
 - mapR will be evaluated first as cluster operating system
- Co-simulation Service has to be worked out (cooperation with other parties?)