Karlsruhe Institute of Technology

ENERGY LAB 2.0

Power Hardware In the Loop infrastructure at KIT

M. Hiller [a]
S. Waczowicz, F. Wiegel, V. Hagenmeyer [b]
S. Hubschneider, T. Leibfried [c]
S. Karrari, W. T. B. de Sousa, G. De Carne, J. Geisbüsch, M. Noe [d]

Institute of Electrical Engineering (ETI)[a] | Institute for Automation and Applied Informatics (IAI)[b]
Institute of Electric Energy Systems and High-Voltage Technology (IEH)[c] | Institute for Technical Physics (ITEP)[d]

KIT and Energy Lab 2.0

- Karlsruhe Institute of Technology
  - > 9000 employees, > 24000 students
  - 4 institutes working in research field of **(Power) Hardware-in-the-Loop**

“PHIL research experience at KIT”

…also presented at RT20

- Energy Lab 2.0
  - **Research infrastructure** located at KIT Campus North
  - Total invest: ~ 23 million EUR
  - Finalisation of the construction in 2020

Energy Lab 2.0

Large-scale research infrastructure for investigation of future energy systems based on renewable energy

Mission

Develop technological solutions for the overall energy system in 2050 in order to successfully integrate the ***renewable energies*** into the ***power grid***, especially by conducting technology-oriented research on a demonstrator scale (***PtG***, ***PtL***, ***PtH***) and complementing it with comprehensive ***energy systems analysis***.

HELMHOLTZ
RESEARCH FOR GRAND CHALLENGES

Karlsruhe Institute of Technology | DLR | JÜLICH FORSCHUNGSZENTRUM

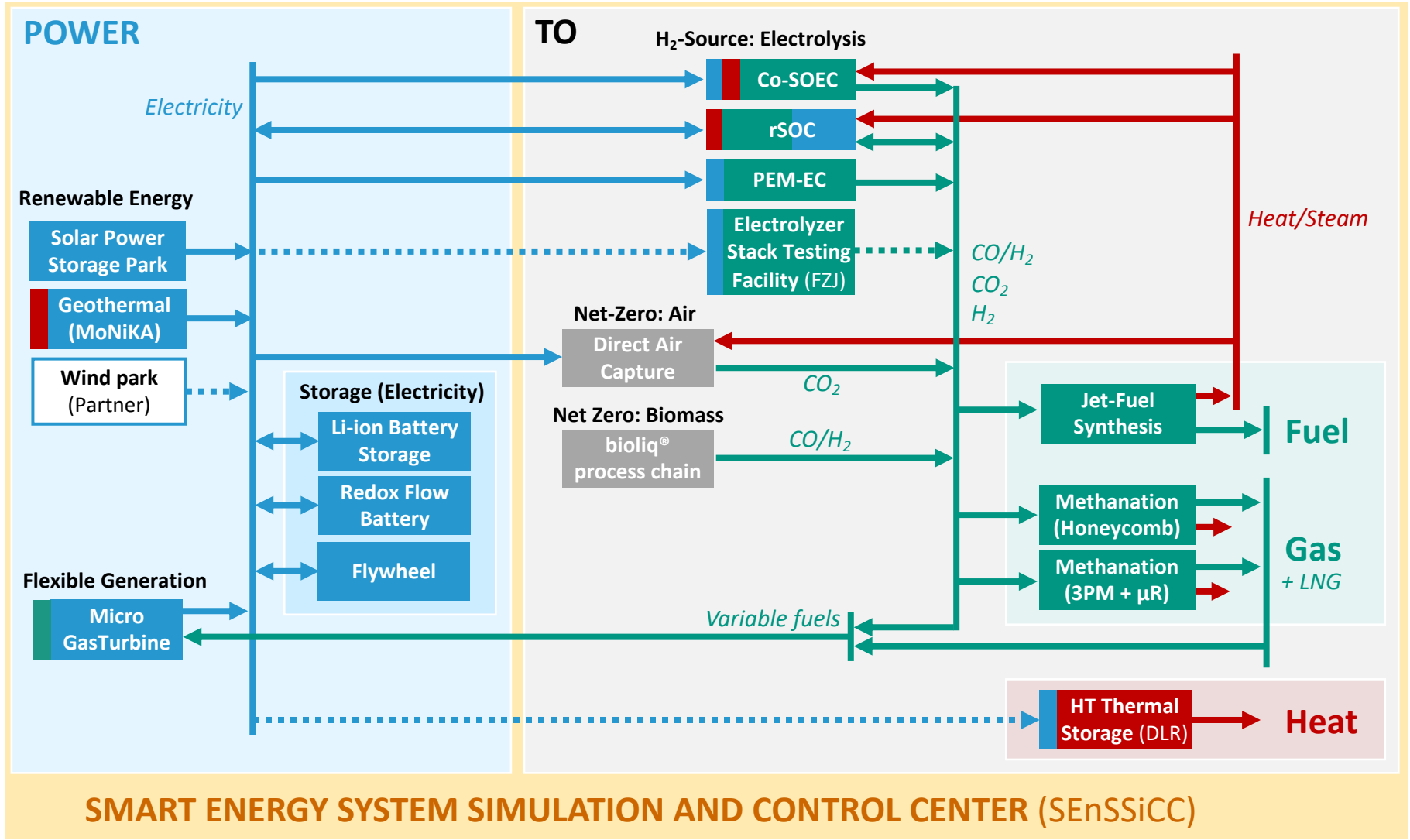
Supported by:

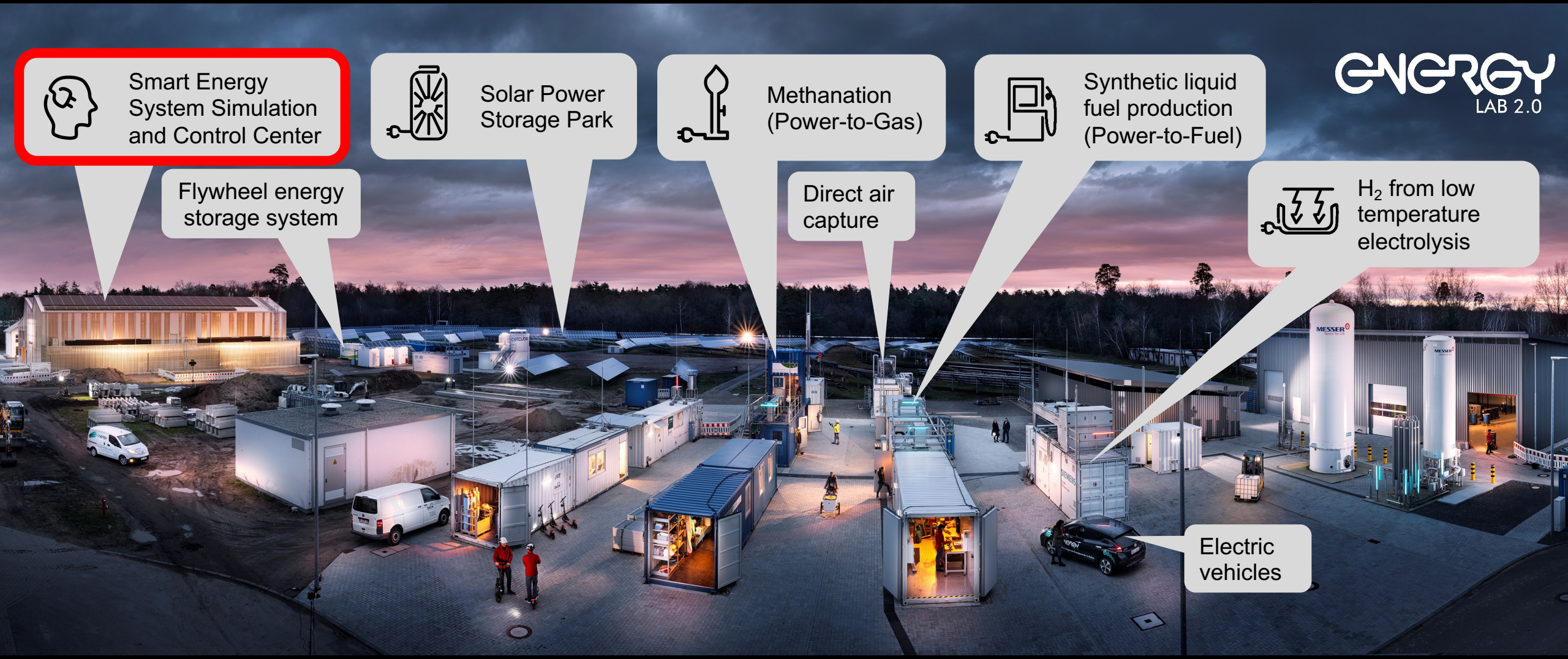
Baden-Württemberg
MINISTRY OF SCIENCE, RESEARCH AND THE ARTS

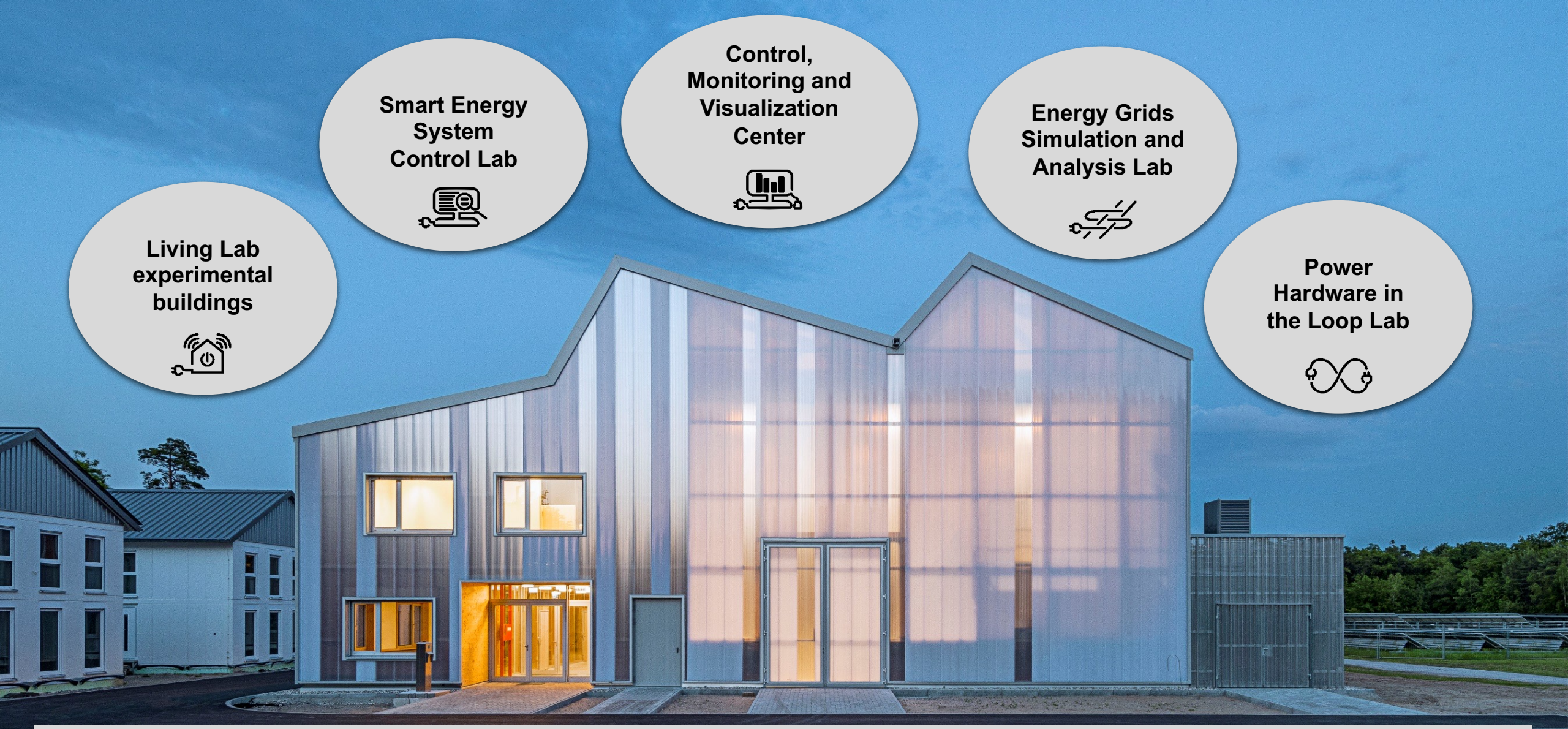
Federal Ministry of Education and Research
on the basis of a decision by the German Bundestag

Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag

Energy Lab 2.0 - Components




Smart Energy System Simulation and Control Center
Flywheel energy storage system
Solar Power Storage Park
Methanation (Power-to-Gas)
Direct air capture
Synthetic liquid fuel production (Power-to-Fuel)
H_2 from low temperature electrolysis
Electric vehicles
ENERGY LAB 2.0
Geothermal energy plant
Living Lab experimental buildings
HT thermal storage
Solid oxid fuel cell
Gas turbines



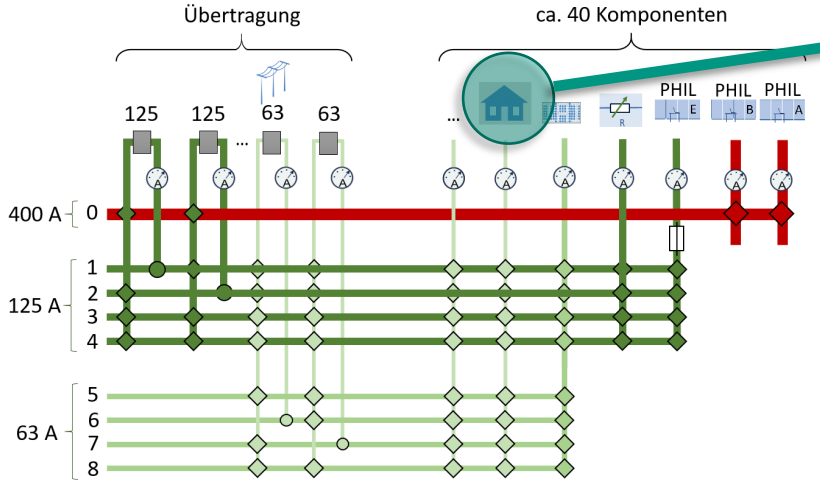
The heart, or rather the "brain" of Energy Lab 2.0 is the **Smart Energy System Simulation and Control Center (SEnSSiCC)**. From here, many of the energy systems can be controlled, all data is collected here, which can then be stored, displayed in a variety of ways and analyzed in detail.

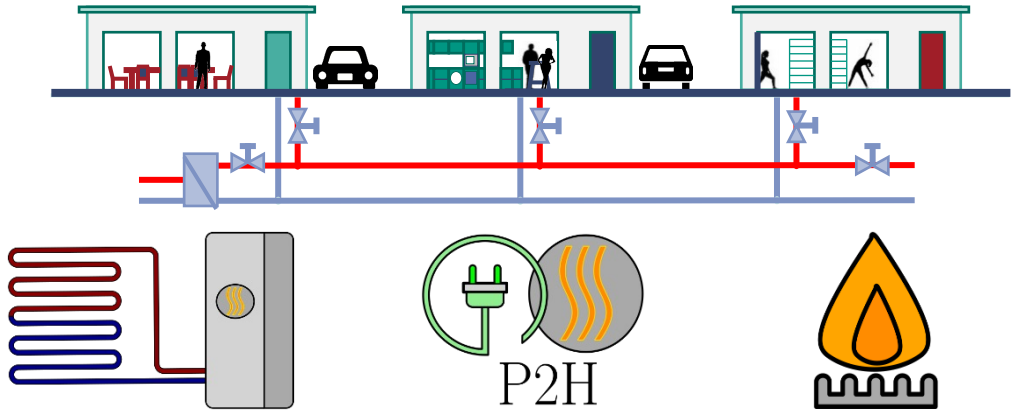
Smart Energy System Control Lab

- **Research Topics:** research platform for experiments, also on the edge of or even beyond stability of the energy systems (generators, consumers, converters, storage technologies, transformers, ...)
- **Research Questions:** autarchy of microgrids, influence of electromobility on distribution networks, optimal electricity affine heat supply in neighborhoods, real-time simulation of microgrids

Living lab experimental buildings

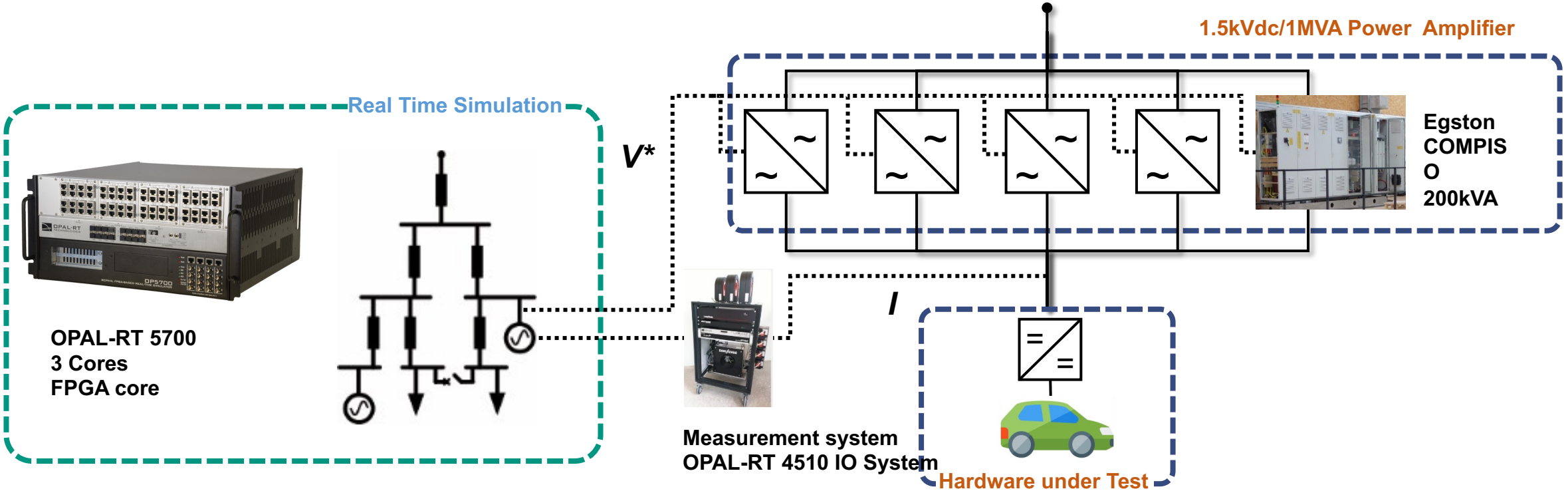
- **Research Topics:** sector coupling, smart home applications, realistic prosumer behavior in smart grid scenarios
- **Networks:** neighborhood system, SESCL
- **Hard Benefits:** generous sensor equipment, flexible energy topology of the neighborhood network (electric and hydronic)
- **Soft Benefits:** immediate and subjective immersion in newly developed smart home applications





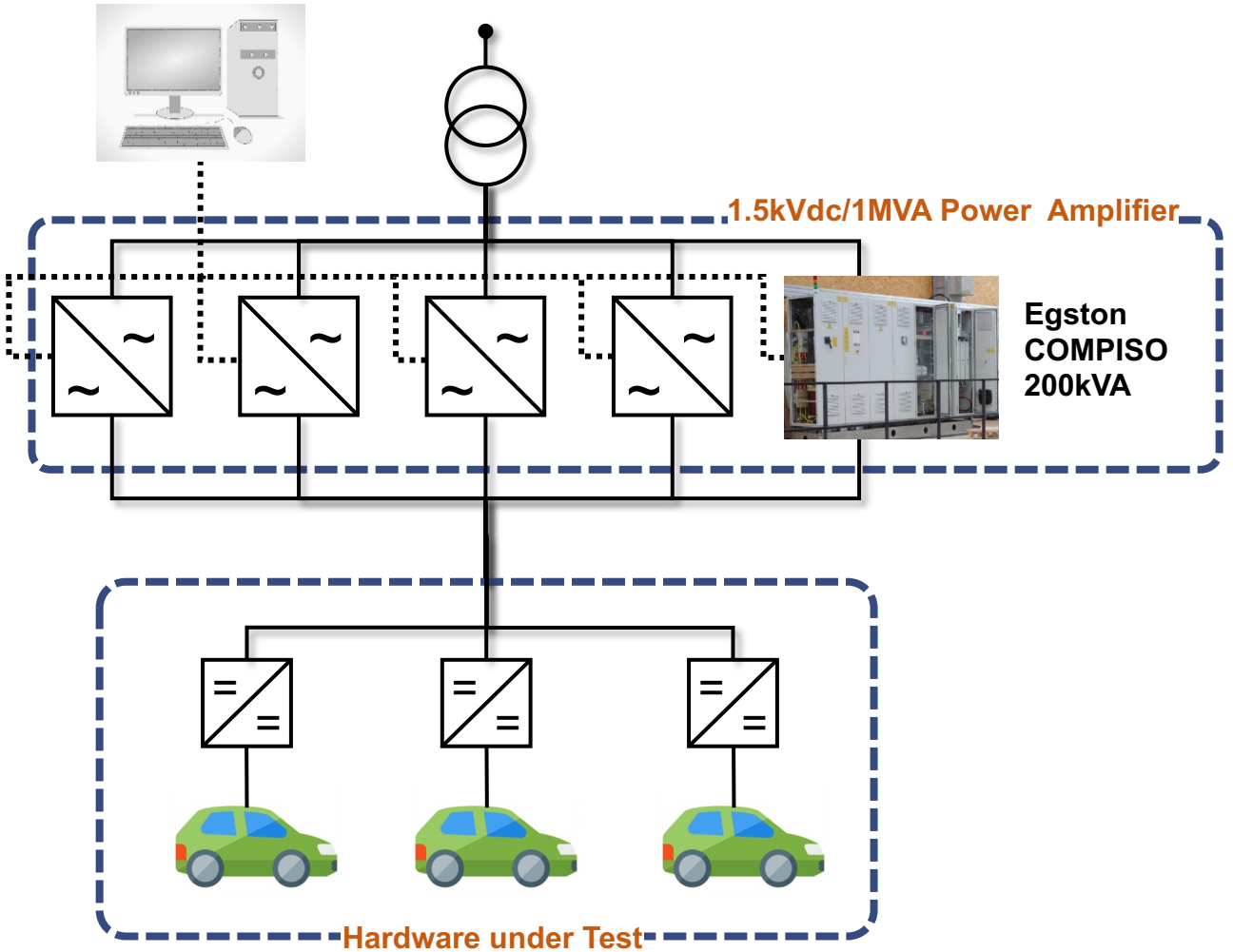
Power Hardware in the Loop Lab

- **Research Topics:** new technology development and testing, grid integration of energy storage systems, multimodal and DC grids experimental validation, superconductive technologies
- **Methods:** Power Hardware In the Loop, Real Time simulation, high power experiments, Digital Twins



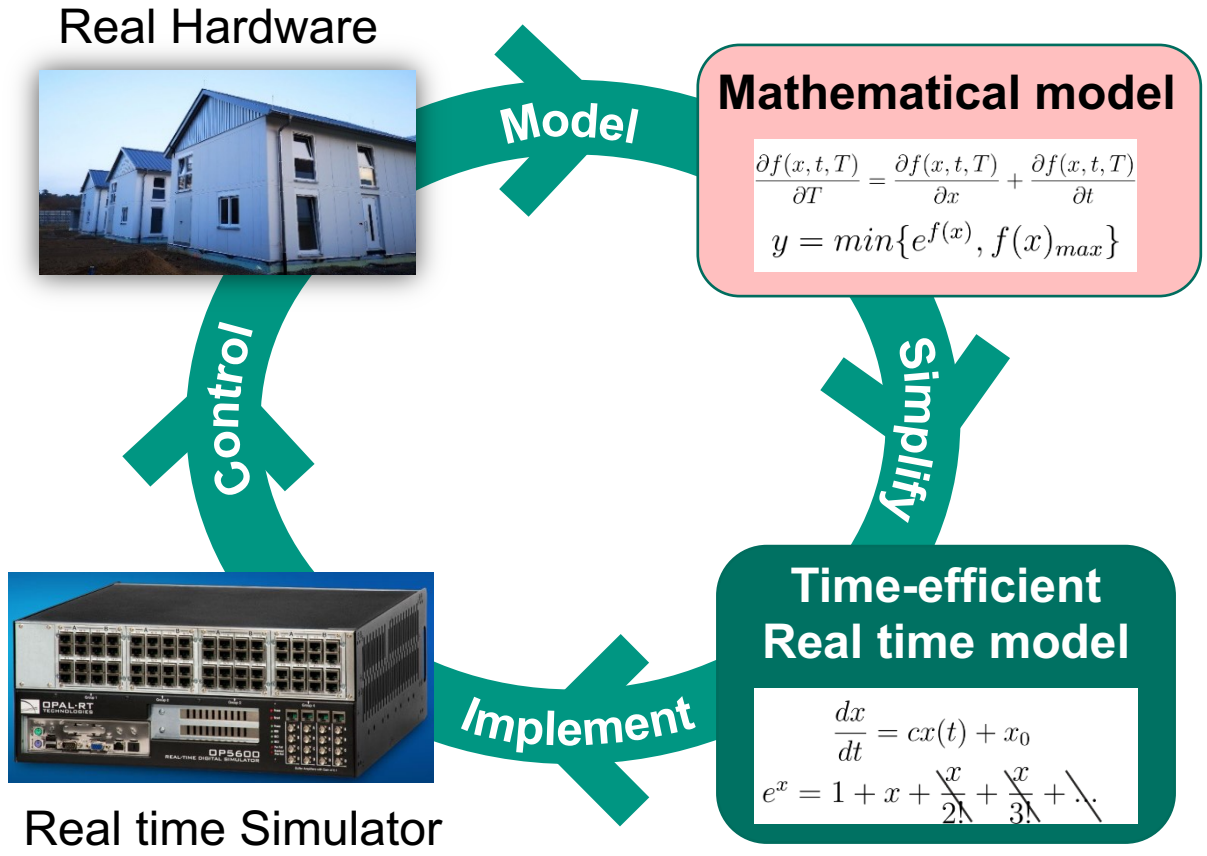
Power Hardware in the Loop Lab

- High Power and High Voltage testing facility
  - 5 x 200kVA Egston COMPISO Modules
  - 400 Vac / 1500 Vdc max Voltage
  - 4500A (@150Vdc) continuous current (6000A short-term)
  - Controllable voltage and current profiles (z.B., LVRT)
- Services
  - Electric vehicle charging station validation
  - Test types for new technologies
  - Breakers and fault limiters testing



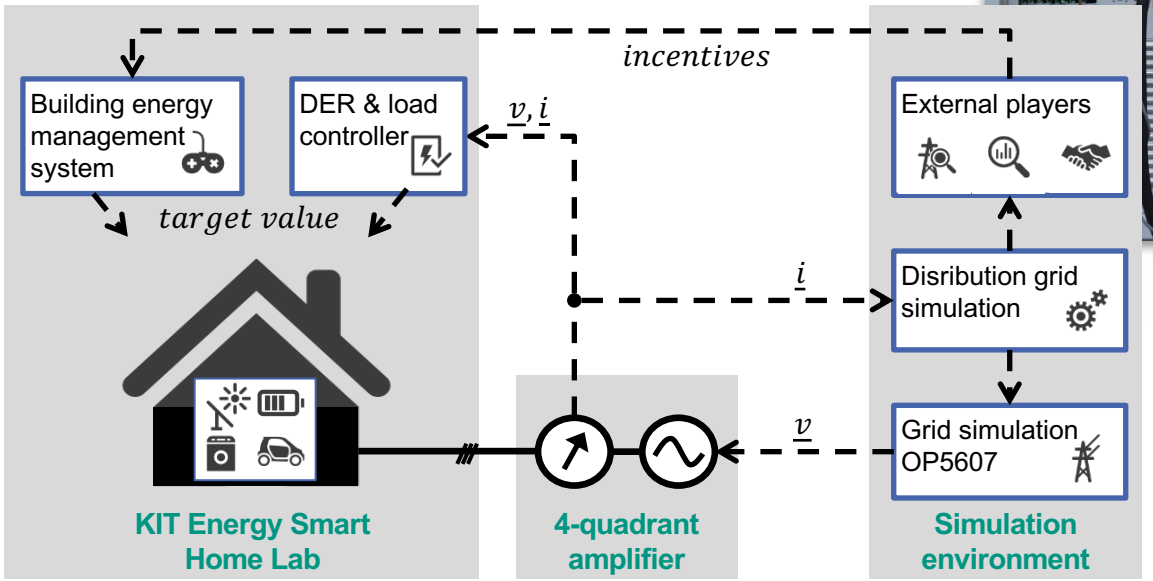
Power Hardware in the Loop Lab

- The real time simulation allows a faster development of new technology
- Focus on:
  - Digital Twins
  - Multi-modal and asynchronously-connected networks
  - Time-efficient real time modelling of grids and components

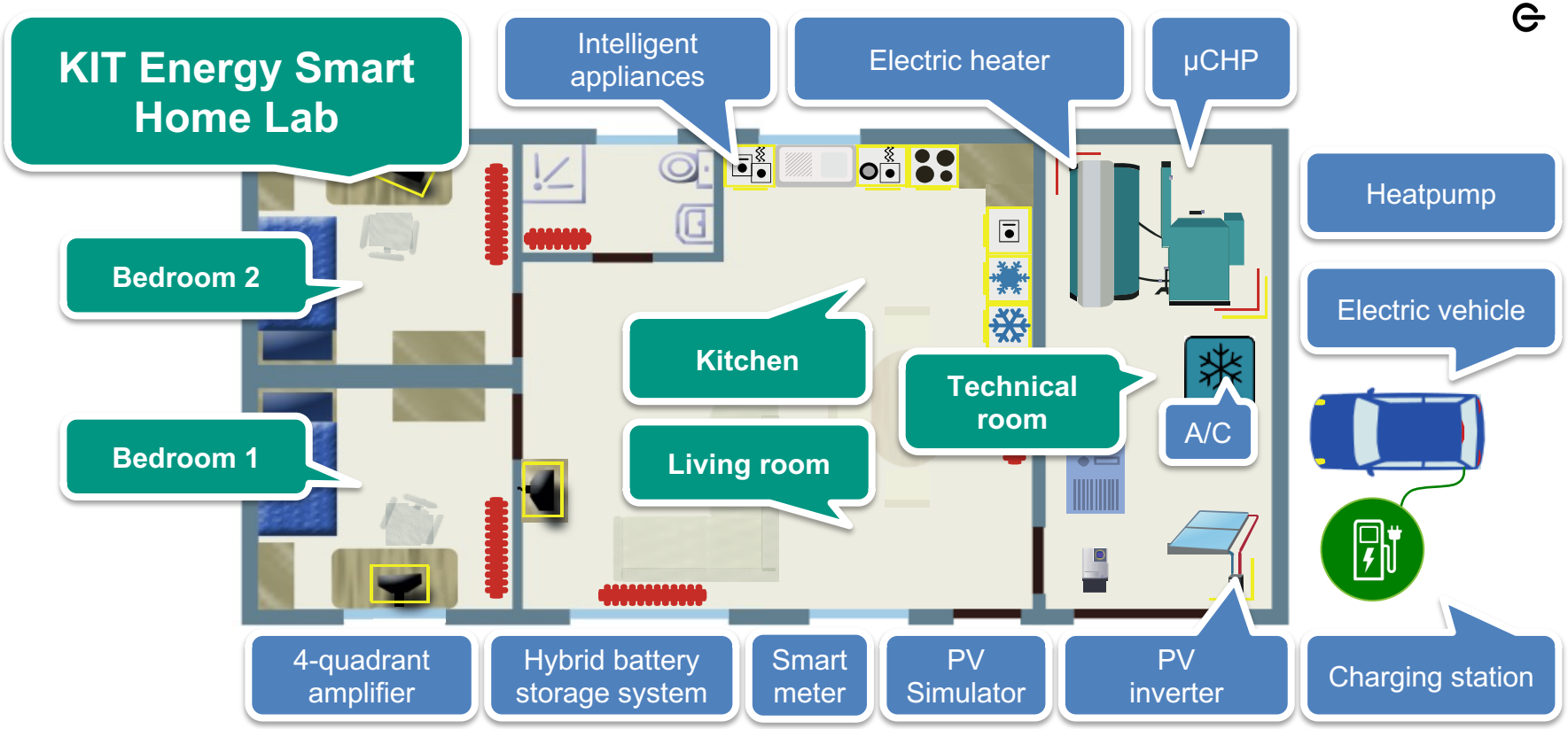


PHIL Setup at KIT IEH

- Software and computing set-up
  - **OPAL-RT HIL platform with HYPERSIM software**
    OP5030 real-time simulator, OP5607 I/O Expansion Unit
  - **Simulation setup**
    Dynamic model of 4-wire low voltage grid & electrical equipment
    Models of static and dynamic power quality events
- Hardware set-up
  - **2x linear power amplifier**
    Spitzenberger & Spies
    2 × 3 × 10 kVA, 400 V AC, 50 $^{V}/_{\mu s}$
  - **Current measurement**
    3x Pearson transducer (65 A, 20 MHz)

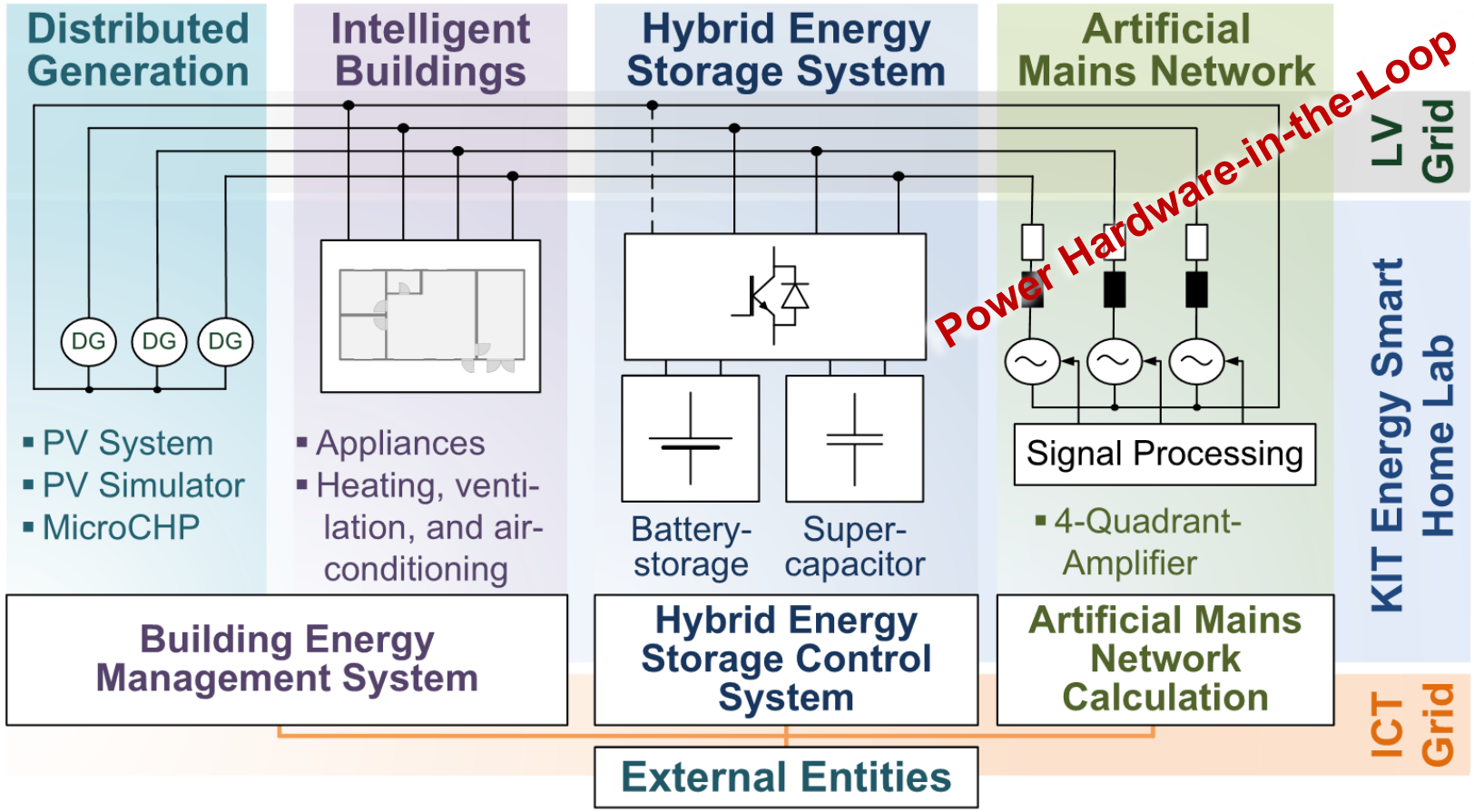


KIT Energy Smart Home Lab



- Devices under test
  - **Household appliances, DER, electrical equipment**
    µCHP, PV, heat pump, EV, battery storage
  - **KIT Energy Smart Home Lab (ESHL)**
    Smart, automated residential building
    Provision of ancillary grid services

KIT Energy Smart Home Lab



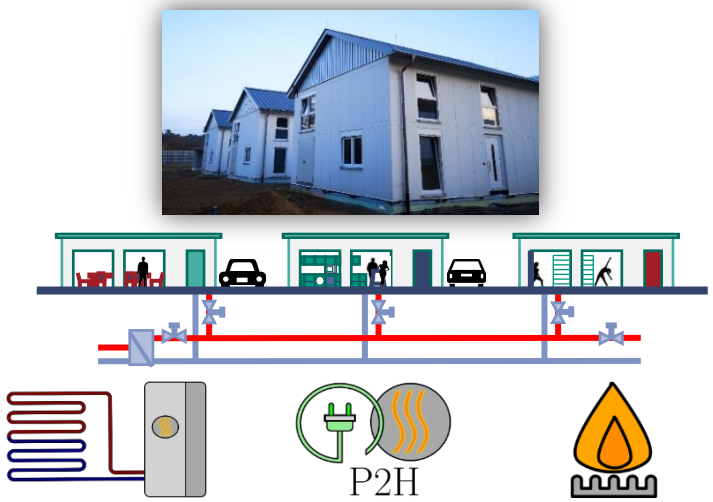
- Devices under test
  - **Household appliances, DER, electrical equipment**
    µCHP, PV, heat pump, EV, battery storage
  - **KIT Energy Smart Home Lab (ESHL)**
    Smart, automated residential building
    Provision of ancillary grid services

Applications and services for industry

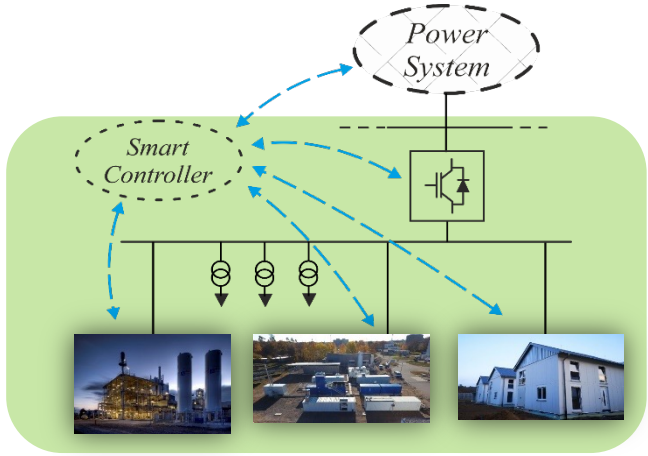
- Distribution system operators
  - Support in the integration of new technologies in realistic grid conditions
  - Evaluation of the impact of new control strategies
  - Consultance in the development of multi-modal networks
- Manufacturers
  - Final validation and performance evaluation of market-ready products in real grid conditions
  - Support in improving products
  - Certification of the products performance

Storage and EVs Integration

Sector coupling



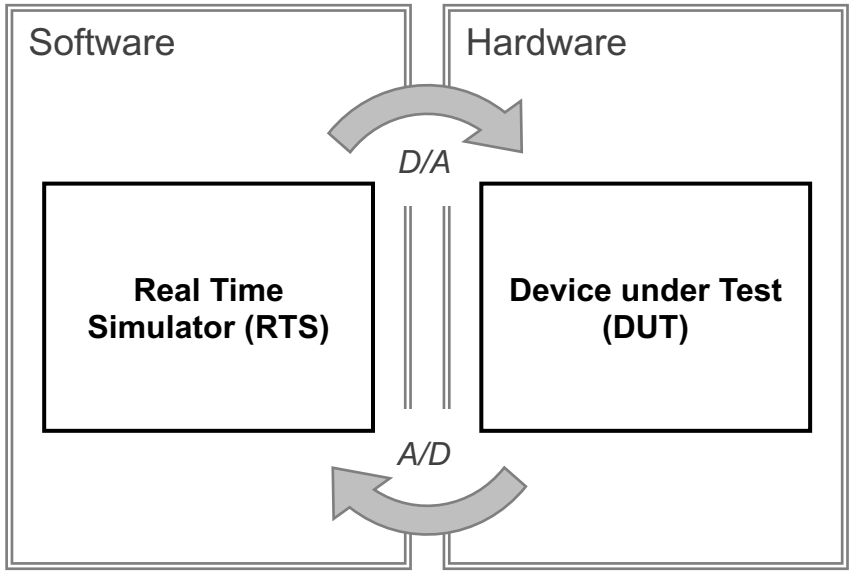
New control concepts



Real Time Simulation and Digital Twin

Real-time Workshop at KIT

- Focus on **Power Hardware-in-the-Loop**
- Addresses **research associates** and **operational levels** of research institutes & manufacturers (presentation language: English)



- Promote platform-independent **scientific exchange**
- **Place and Date**
  Autumn 2020
  Karlsruhe Institute of Technology
  Karlsruhe, Germany
- **Contact**
  sebastian.hubschneider@kit.edu

Source: https://www.google.com/maps

Thank you

Dr.-Ing. Simon Waczowicz
Head of Research Platform Energy

Karlsruhe Institute of Technology
Institute of Institute for Automation and Applied Informatics (IAI)

Phone: +49 721 608-24918
Email: simon.waczowicz@kit.edu

www.iai.kit.edu