The ESHL is a fully automated building utilized for PHIL system studies of future distribution grids.

The Energy Smart Home Lab (ESHL)

The Energy Smart Home Lab (ESHL) is a laboratory environment for future distribution grids and active grid participants. It comprises distributed generation, storage and building automation, and thus enables for system integration studies.

The intelligent building is run in a Power Hardware-in-the-Loop (PHIL) environment, which allows for the simulation of complex grid setups and scenarios. The ESHL itself combines measurements of thermal and electric energy flows, prognosis data and the momentary grid condition in order to optimize its behavior with respect to different optimization goals.

With this flexible test bed, challenges of distribution grids can be emulated and applied to the ESHL as future prosumer, capable of optimizing internal energy flows while providing ancillary grid services to future energy grids.

Ongoing Research since 2009

The Energy Smart Home Lab was established and further developed within several projects:

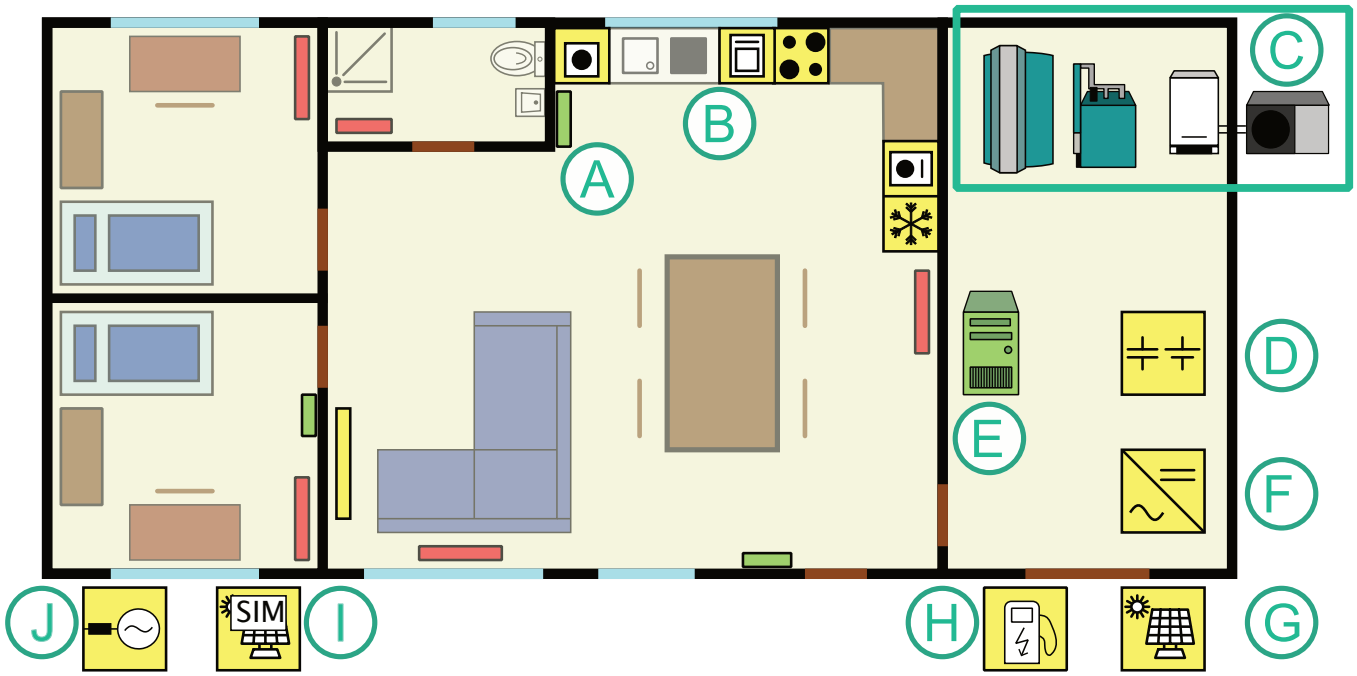
- MeRegioMobil (2009-2011): Integration of electric vehicles as mobile storage and flexible load.
- iZEUS (2012-2014): Grid friendly integration of electric mobility.
- grid-control (2015-2018): Investigation of a wholesome concept for future distribution grids.
- C/sells (2017-2020): Establishment and joint operation of energy cells for optimized operation of future energy systems.
- flexQgrid (2019-2022): Prevention of critical grid conditions and evaluation of future control concept.

The Energy Management Panel (EMP) provides a user interface between the intellient household and its habitants.

Karlsruhe Institute of Technology

ENERGY LAB

The Energy Smart Home Lab (ESHL)



Ground Plan of the 60m² flat with intelligent household appliances and controllable electrical equipment,
A: Energy Management Panel; **B:** Intelligent electrical devices;
C: Heating System: Warm water storage, el. heating rod, micro-CHP, heat pump;
D: Hybrid battery system; **E:** Energy Management System;
F: Solar power inverter; **G:** PV system; **H:** EV charging point;
I: PV simulator; **J:** Artificial mains network

Optmized Grid Integration of Future Intelligent Households

For future energy grids, new challenges arise. The demand for electrical energy rises, while the amount of decentralized energy producers and active loads increases. Especially in low voltage grids, new control algorithms and concepts for building optimization can help reducing necessary grid expansion and increase grid stability.
In order to investigate future grid scenarios and to enable for system integration studies, the KIT set up a Power Hardware-in-the-Loop test bed, which allows for fast and detailed grid simulation. The Energy Smart Home Lab, the real-world intelligent building, is connected to this grid environment. With help of this test bed, complex grid situations can be applied to the intelligent building. Feeding back the ESHLs behavior to the real time simulation environment enables for complex interactions between the container flat and the grid simulation. This way, control concepts including multimodal energy optimization and ancillary services enhancing the power quality can be developed and tested under realistic conditions.
The fully equipped household furthermore allows for user acceptance and behavior studies. With its integrated building automatization, incentive-based control strategies can be investigated in real-world applications.

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