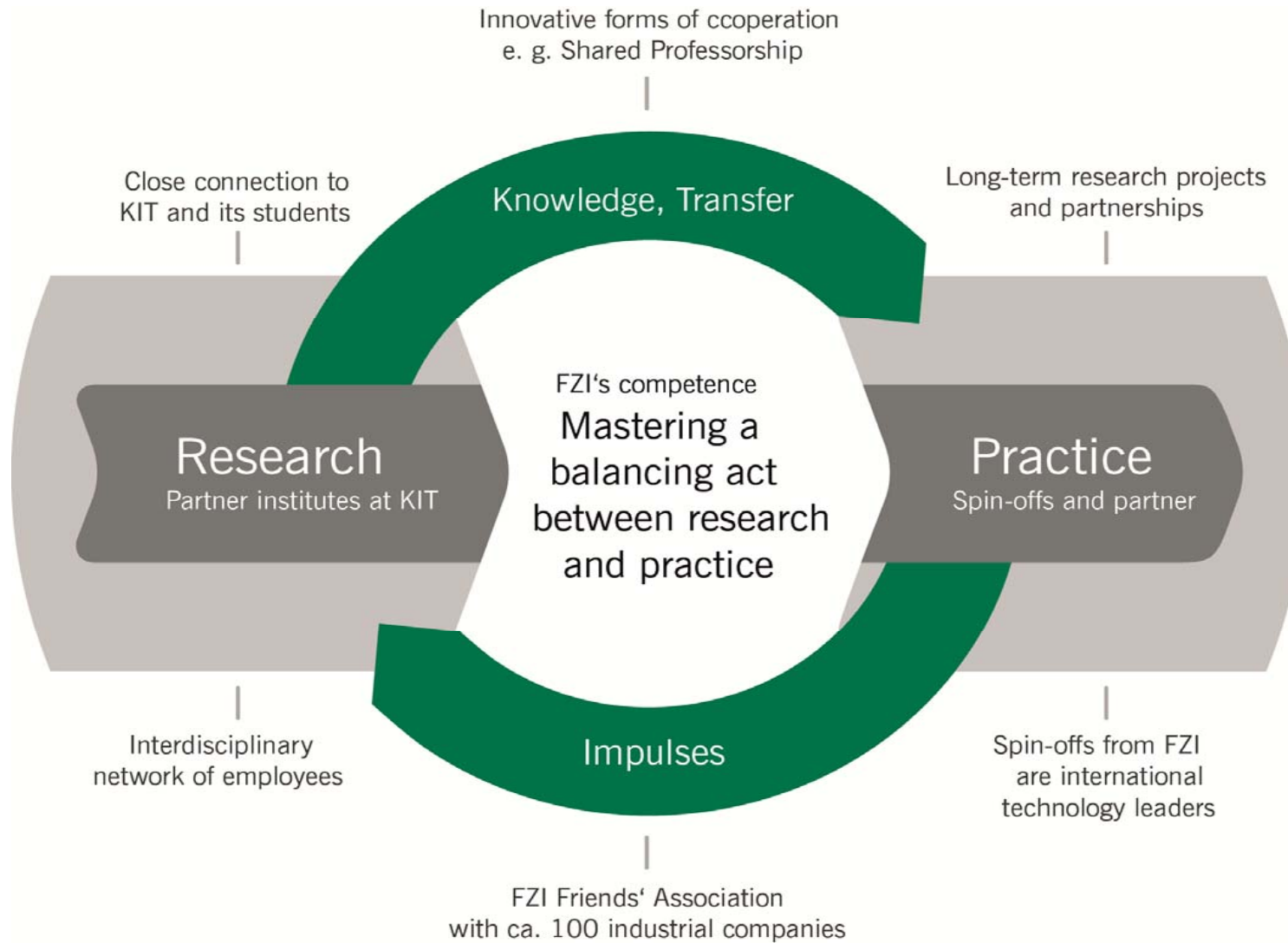Birger Becker, Fabian Kern, Manuel Lösch, Ingo Mauser, Hartmut Schmeck
FZI Research Center for Information Technology

BUILDING ENERGY MANAGEMENT IN THE FZI HOUSE OF LIVING LABS
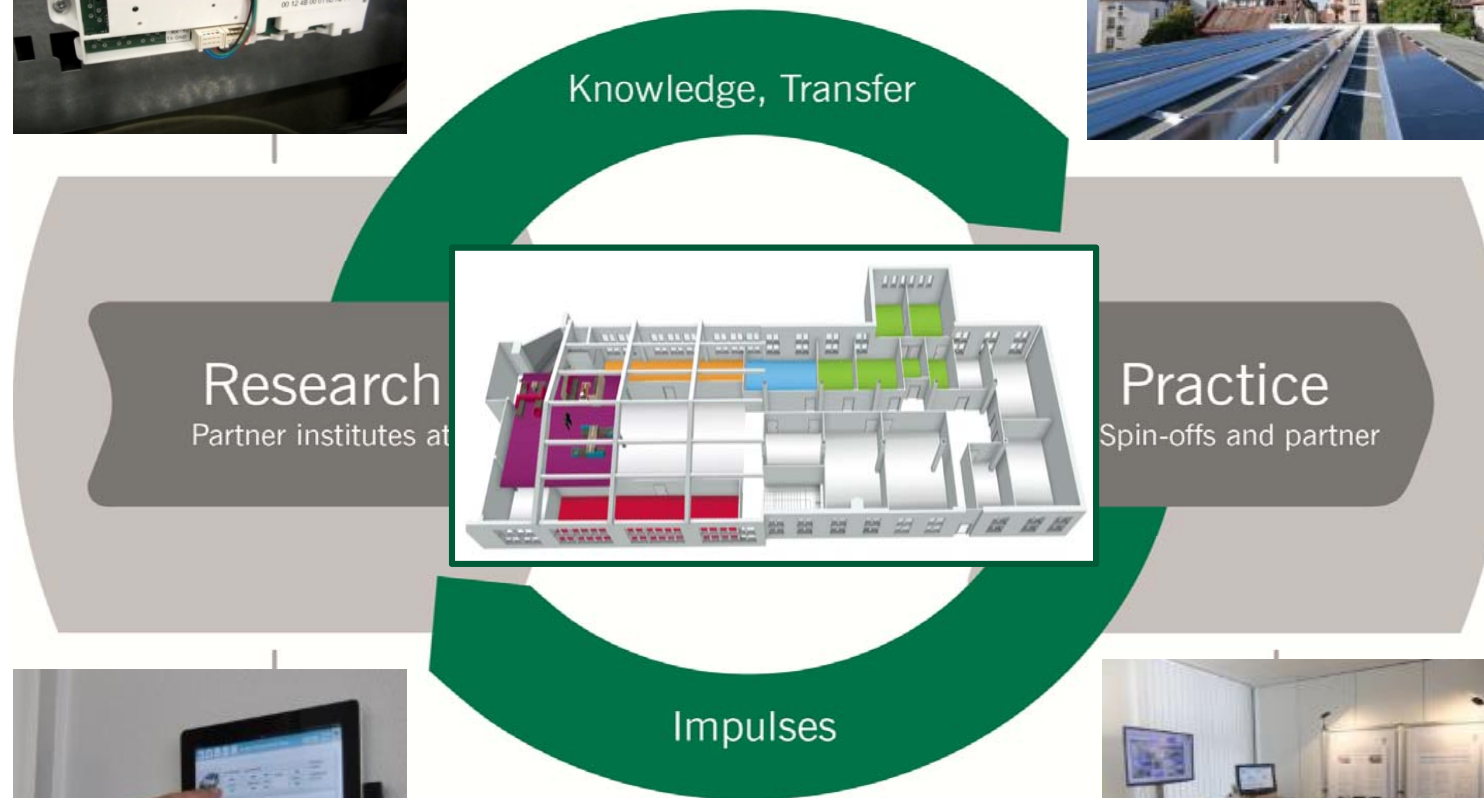
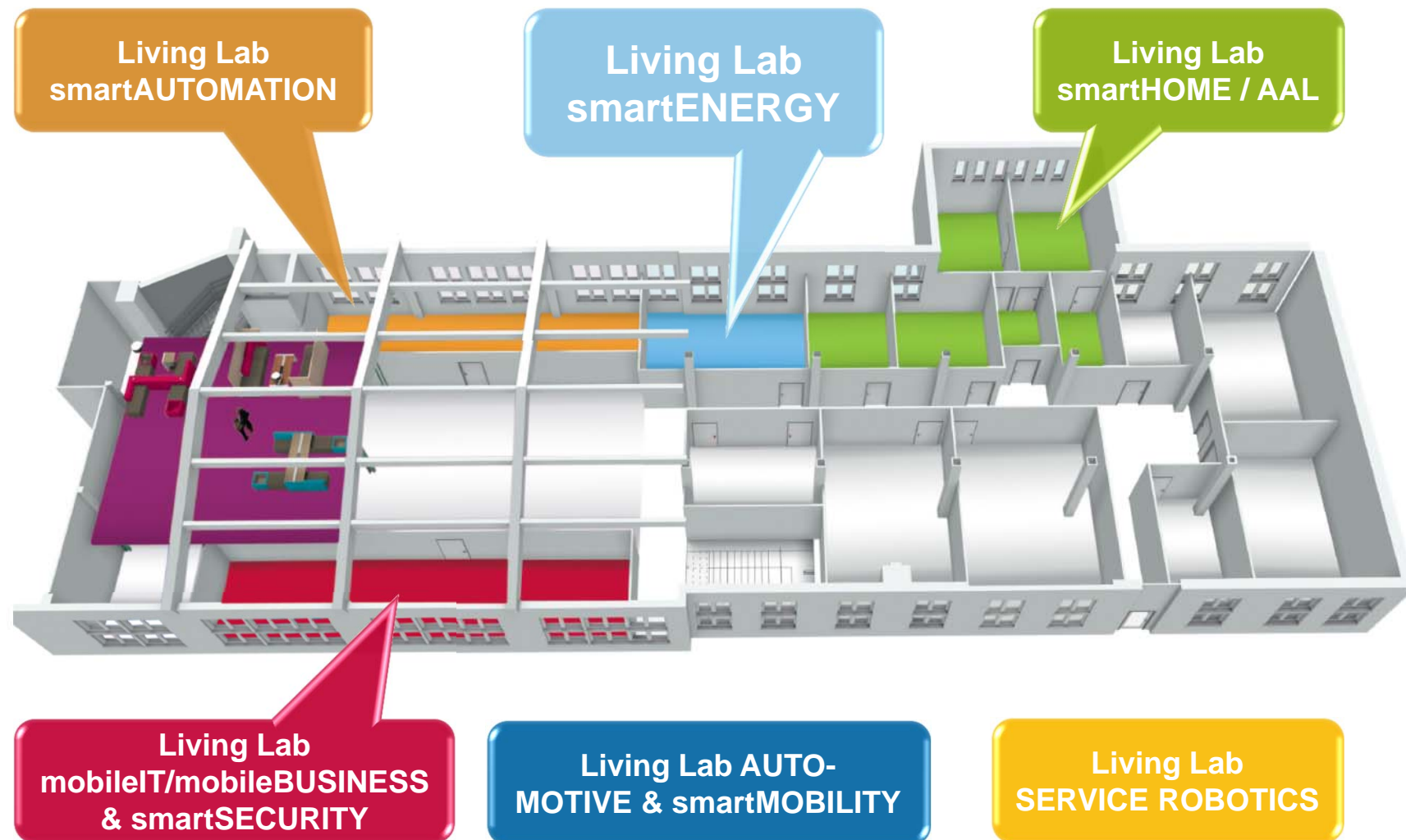4th D-A-CH Energieinformatik Conference 2015, Karlsruhe

FZI Research Center for Information Technology

Innovative forms of ccoperation
e. g. Shared Professorship

Close connection to
KIT and its students

Knowledge, Transfer

Long-term research projects
and partnerships

FZI's competence
Mastering a
balancing act
between research
and practice

Research
Partner institutes at KIT

Practice
Spin-offs and partner

Interdisciplinary
network of employees

Impulses

Spin-offs from FZI
are international
technology leaders

FZI Friends' Association
with ca. 100 industrial companies

FZI House of Living Labs (HoLL)

FZI House of Living Labs is not only about energy…

Living Lab smartAUTOMATION

Living Lab smartENERGY

Living Lab smartHOME / AAL

Living Lab mobileIT/mobileBUSINESS & smartSECURITY

Living Lab AUTO-MOTIVE & smartMOBILITY

Living Lab SERVICE ROBOTICS

FZI House of Living Labs: Building Services

© FZI Research Center for Information Technology
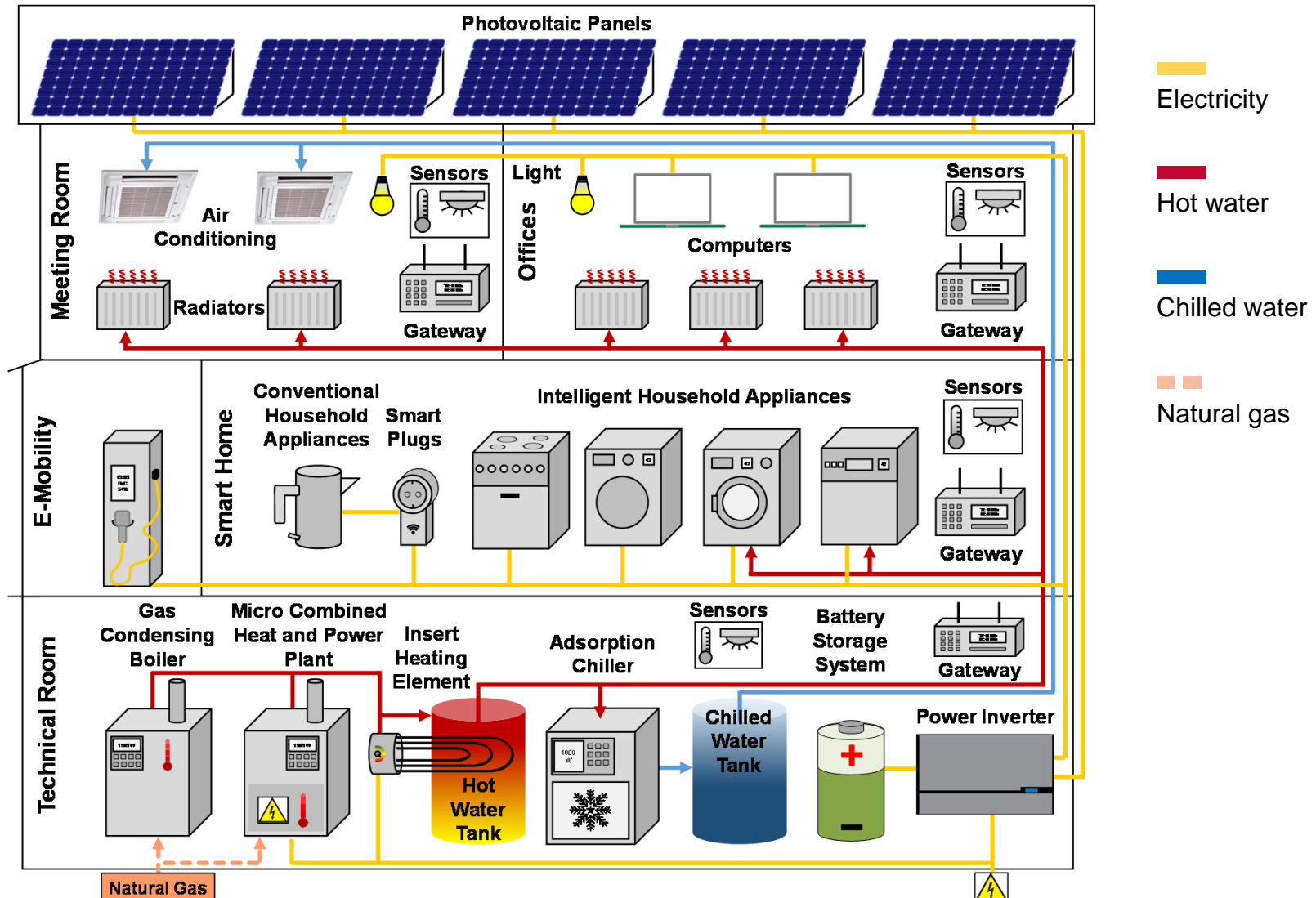
FZI House of Living Labs: Technical Details Electrical and Thermal

- Electrical equipment
    - PV panels $15\ kW_{peak}$
    - Battery storage systems $3 \times 10\ kWh$
    - Inverters $3 \times 5\ kW$
    - MicroCHP unit $5.5\ kW_{el}$, $12.5\ kW_{th}$, $20.5\ kW_{gas}$
    - Electric vehicles   Smart fortwo ED, Peugeot 3008
    - Smart meters and sub-meters   various
- Thermal equipment
    - Adsorption chiller $9\ kW_{cooling}$, $15\ kW_{hot}$
    - MicroCHP unit $12.5\ kW_{th}$, $5.5\ kW_{el}$, $20.5\ kW_{gas}$
    - Gas-fired condensing boiler $95\ kW_{gas}$
    - Electric insert heating element   0, 0.5, …, 3.5 kW
    - Hot and chilled water storage tanks   3250 liters and 3000 liters
    - System controller   SolarNext chillii
    - Heat flow metering system   Aquametro AMBUS Net

FZI House of Living Labs:
Technical Details Building Automation

- Wireless technologies
  - Bluetooth Smart / LowEnergy   Appliances, beacons
  - EnOcean   Building automation (sensors/actors)
  - Wi-Fi   Appliance (dryer)
  - ZigBee   Appliances, smart plugs
- Wired technologies
  - General Electric HabiTeq Qbus   Building automation (sensors/actors)
  - KNX   Building automation (sensors/actors)
- Gateways
  - Bluetooth Smart   Raspberry PI with Bluetooth USB module
  - EnOcean   Raspberry PI with EnOcean GPIO module
  - KNX   Hager tebis KNX
  - Qbus   GE HabiTeq CTD Controller
  - ZigBee   E.G.O. EEBus Smart Gateway

Integration of many different technologies!
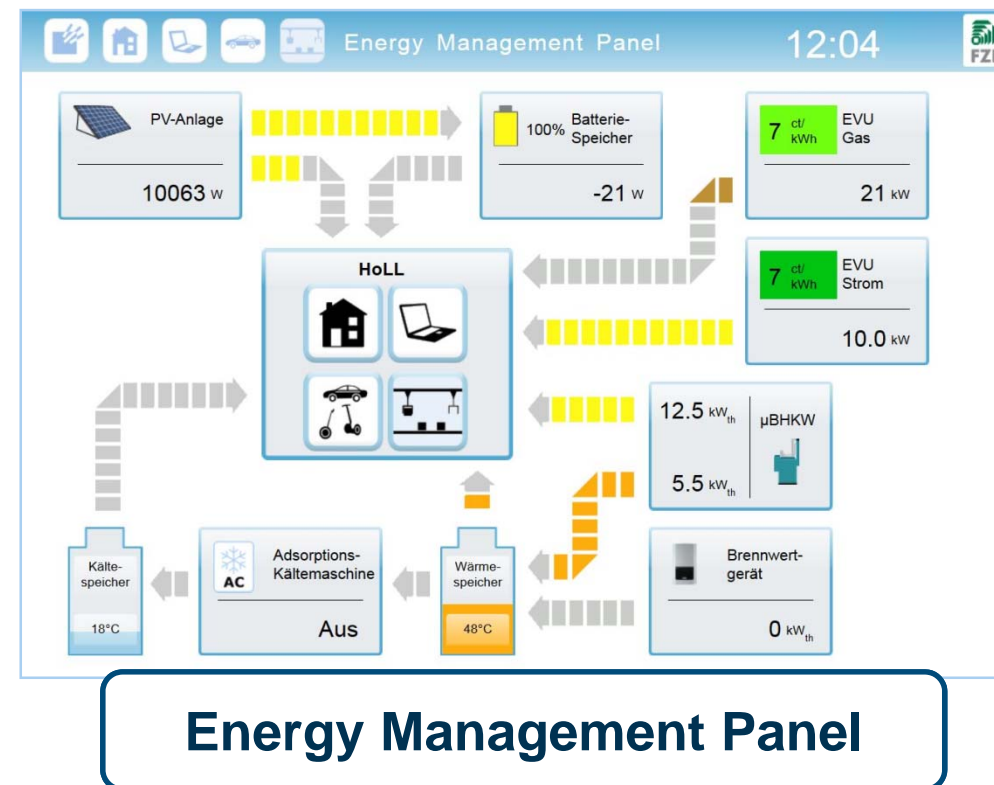
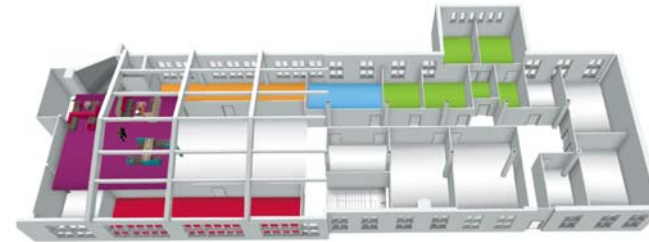# FZI House of Living Labs: Energy Management

- Standardized integration and interoperability
- Smart grid capabilities
- User interaction
- Optimization
  - Multi energy
  - Multi objective
- Other domains
  - Assistance ⎫
  - Comfort ⎪
  - Entertainment ⎬ **FZI**
  - Information ⎪
  - Safety ⎪
  - Security ⎭
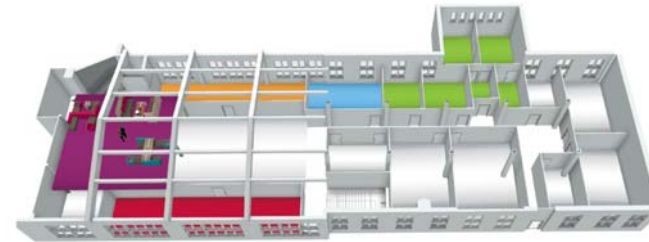
FZI House of Living Labs: Energy Management Panel

- Standardized integration and interoperability
- Smart grid capabilities
- User interaction
- Optimization
    - Multi energy
    - Multi objective
- Other domains
    - Assistance
    - Comfort
    - Entertainment
    - Information
    - Safety
    - Security

Energy Management Panel

FZI House of Living Labs:
# Energy Management with Devices

- Standardized integration and interoperability
- Smart grid capabilities
- User interaction
- Optimization
  - Multi energy
  - Multi objective
- Other domains
  - Assistance
  - Comfort
  - Entertainment
  - Information
  - Safety
  - Security

# FZI House of Living Labs: Building Energy Management System

- Standardized integration and interoperability
- Smart grid capabilities
- User interaction
- Optimization
  - Multi energy
  - Multi objective
- Other domains
  - Assistance
  - Comfort
  - Entertainment
  - Information
  - Safety
  - Security
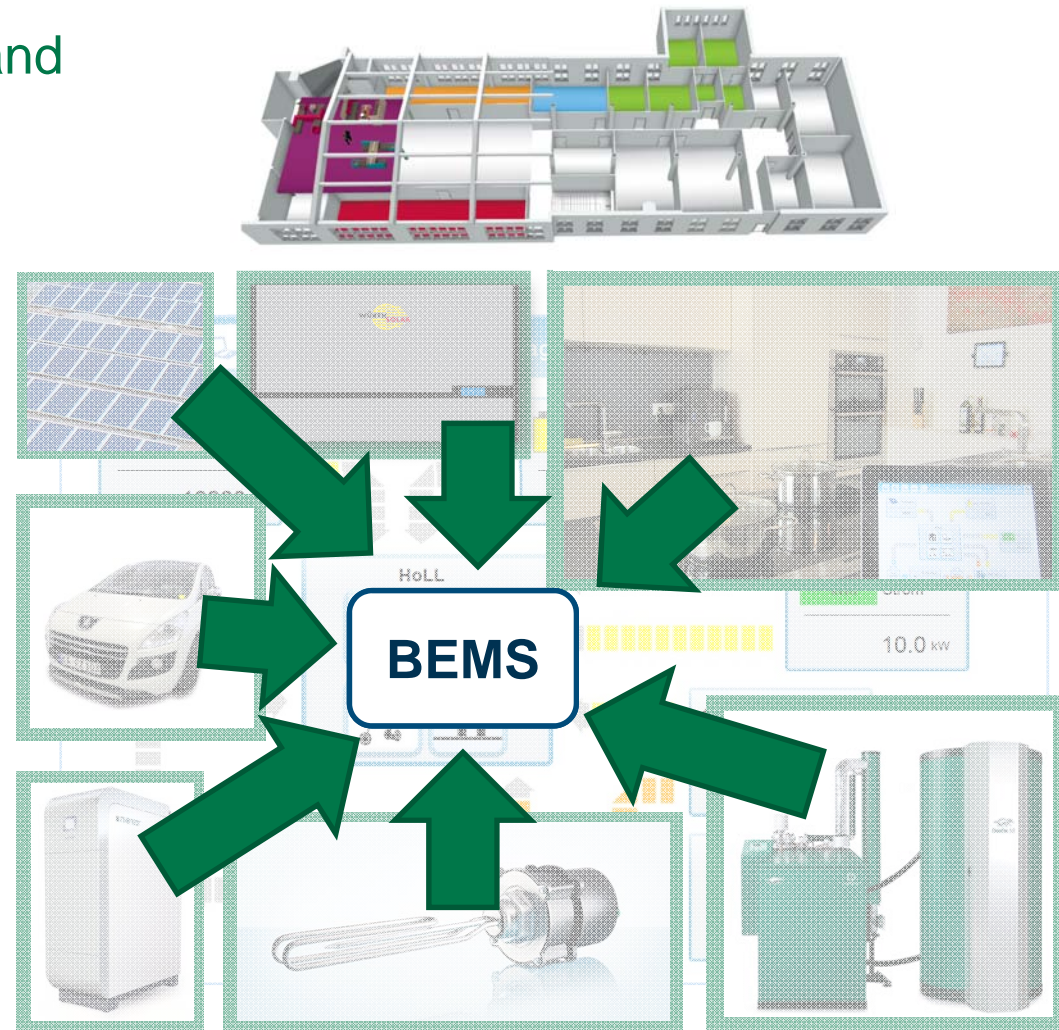
BEMS: Building Energy Management System

Organic Smart Home: Simplified Architecture
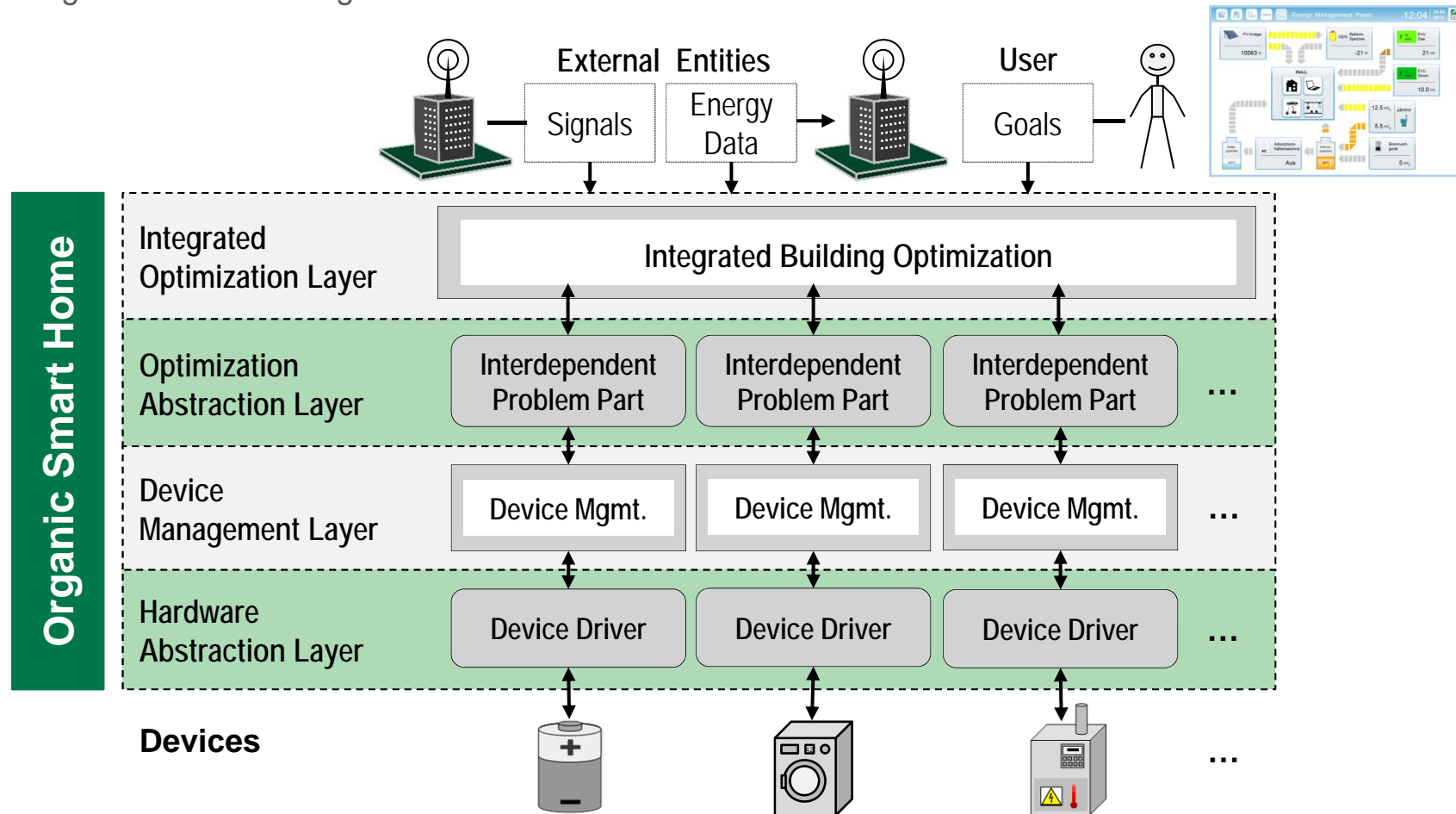
Organic Smart Home

www.organicsmarthome.org

More about Organic Smart Home architecture and optimization:
Mauser, I.; Müller, J.; Allerding, F. & Schmeck, H.: "Adaptive Building Energy Management with Multiple Commodities and Flexible Evolutionary Optimization", Renewable Energy, Elsevier, 2015

Organic Smart Home

www.organicsmarthome.org

- Java 8, free & open source (GPLv3)
- *Organic Computing* architecture
- Smart building (residential and commercial)
- Real-world application as well as simulation
- Energy optimization
  - *Optimization Abstraction Layer*
  - Multi energy and multi objective
- Demand side management
  - Variable tariffs
  - Control and priority signals
- Data storage, visualization, and configuration
  - *Energy Management Panel*
  - Multiple databases: SQL, RRD, HDF5, InfluxDB

More about Organic Smart Home architecture and optimization:
Mauser, I.; Müller, J.; Allerding, F. & Schmeck, H.: "Adaptive Building Energy Management with Multiple Commodities and Flexible Evolutionary Optimization", Renewable Energy, Elsevier, 2015

Exemplary Research:
Optimization of a Trigeneration System

- Combined Cooling, Heat, and Power (CCHP)
  - CCHP = Combined Heat and Power (CHP) + Adsorption Chiller
  - Meeting room Hollywood in the FZI House of Living Labs
- Optimization
  - Prediction of cooling demand (room reservations in Outlook)
  - Optimize the efficiency
    - Outdoor temperatures in the morning
    - Flow and tank temperatures
- Reduction of energy costs by
  - 9% when optimizing microCHP
  - 12% when optimizing adsorption chiller
  - 14% when optimizing whole system

Higher efficiency
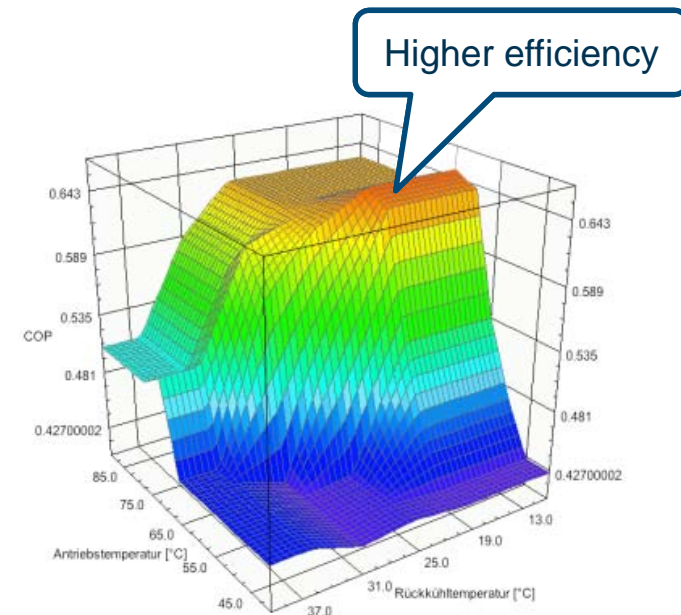
Source:
Mauser, I.; Feder, J.; Müller, J. & Schmeck, H.:
"Evolutionary Optimization of Smart Buildings with Interdependent Devices",
EvoStar 2015: 18th European Conference on Applications of Evolutionary Computation, LNCS, Springer, 2015

From Research to Practice

- Publicly funded research projects
- Cooperation and integration with KIT
  - Energy Smart Home Lab (ESHL)
  - Energy Lab 2.0
  - Storage and Cross-linked Infrastructures of the Helmholtz Association

- Direct, bilateral cooperation with industry partners and contract research
  - Energy
  - Building automation
  - Electrical equipment
  - Household appliance
  - Automotive

Lessons Learned and Conclusion

- Energy management
    - Automation of energy management is crucial
    - Hardware integration is a challenging task

- User has to remain in the loop
    - Information and feedback
    - Acceptance
    - Individual objectives
    - Override functionality

- Our approach: hardware and simulations
    - Automated energy management
    - User-centric energy management
    - Integrated optimization of all energy carriers
    - Multi-objective optimization
    - Standardization