Karlsruhe Institute of Technology

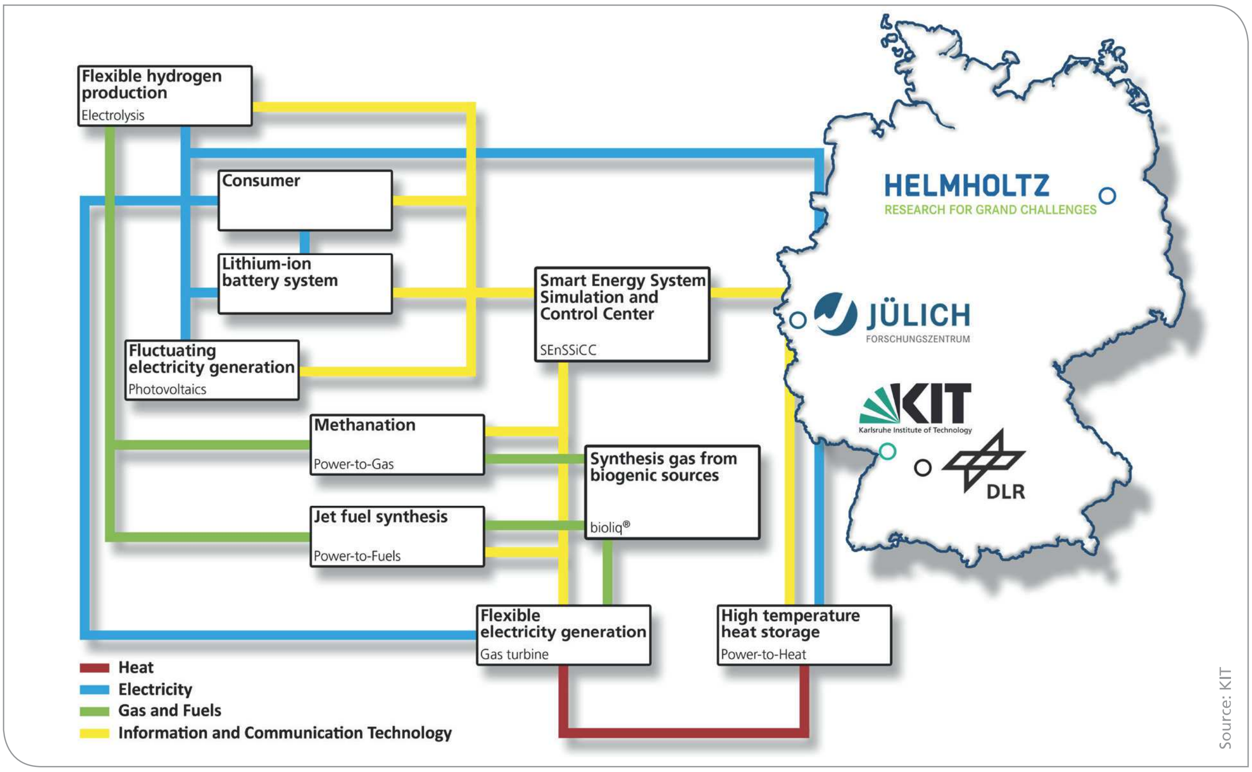
The Energy Lab 2.0:

The Future Energy System in the Focus

Until 2050, renewable energies are to reach a share of at least 80% of Germany's gross electricity production. To achieve this ambitious goal, the energy system of the future requires a shift of paradigm. Electricity generated from renewable sources, in particular from the sun and wind, will gain importance. However, wind and sun do not provide for a constant level of electricity at any place or time of day and over all seasons. Electricity consumption also fluctuates considerably over time and space. To compensate this imbalance between electricity generation and consumption, innovative approaches to the transport, distribution, storage, and utilization of energy are needed. Besides efficiency and costs, supply security and acceptance by society will decide on the success of such approaches.

In addition to renewable electricity, heat and chemical energy carriers, such as gas and fuels, will have to be included and coupled smartly in the energy system of the future. So-called power-to-X technologies enable the production of heat and chemical energy carriers from renewable electricity and carrier molecules, such as water, carbon dioxide, or nitrogen, as well as their storage and distribution.

The Energy Lab 2.0 is a unique research infrastructure that is currently being established by the Helmholtz Association. Here, Karlsruhe Institute of Technology (KIT), together with Forschungszentrum Jülich (FZJ) and the German Aerospace Center (DLR), will investigate the interaction of important components of future smart energy systems. The Energy Lab 2.0 is a real-life laboratory combined with a simulation platform.



Sector coupling and information network of the Energy Lab 2.0

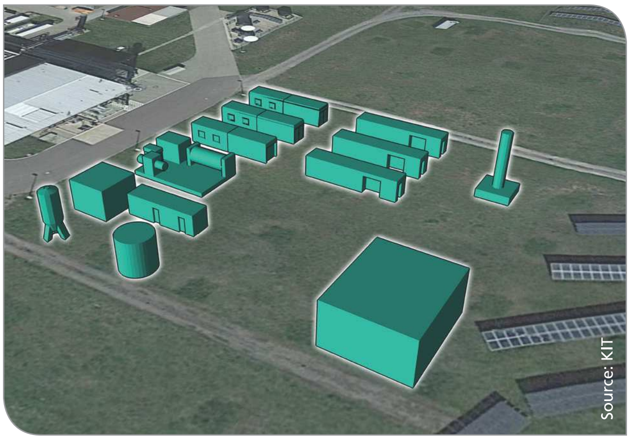
Research focuses on the smart interconnection of fluctuating electricity production by wind turbines and photovoltaic facilities with technologies for energy storage and sector coupling, power generation from stored chemical energy carriers with a high flexibility in terms of load and fuel, and consumers within the grid. To this end, scientists work on new grid topologies and grid stabilization methods and on the secure information and data networks required for this purpose.

The Plant Network of the Energy Lab 2.0

The plant network that is currently being established on the Campus North of KIT will be the first of its kind to investigate the interplay of renewable electricity generation from a fluctuating source (1 MW_{peak} photovoltaics) with electrochemical storage (1.3 MWh Li-ion battery) of this electricity and conversion into chemical energy carriers on a larger scale within a technical system environment. Conversion of electricity is achieved by producing hydrogen (100 kW PEM electrolysis). Together with CO_2, this hydrogen is used to produce synthetic natural gas (power-to-gas) and jet fuel (power-to-fuel). Jet fuel synthesis takes place in a compact, container-based plant by KIT's spinoff INERATEC GmbH, Karlsruhe. KIT collaborates closely with this spinoff in the field of Fischer-Tropsch synthesis. Additionally, the bioliq® plant is integrated in the plant network to study the synthesis of chemical energy carriers from residual biomass as an alternative carbon source together with additional hydrogen from water electrolysis. For load-flexible and fuel-flexible power generation from the stored gaseous and liquid energy carriers, three micro gas turbines will be installed (100 kW_{el} each). The DLR, Stuttgart, will study the storage of electricity in the form of high-temperature heat. This infrastructure as well as the new test center for electrolysis stacks to be built at Forschungszentrum Jülich will be integrated virtually in the Energy Lab 2.0.

Information Technology in the Energy Lab 2.0

To understand, monitor, and control the interactions of the different technologies in the energy system of the future, new methods for simulation and analysis are needed. For this purpose, the so-called Smart Energy System Simulation and Control Center (SEnSSiCC) is currently being built next to the plant network. The simulation and control center that covers an area of roughly 800 m^2 represents the "brain" of the Energy Lab 2.0. Here, all data are pooled, stored, displayed in various ways, and analyzed in detail. Apart from the information and communication technologies needed for simulation and analysis, SEnSSiCC will include a Power Hardware in the Loop (PHIL) laboratory to test new hardware components also under critical operation conditions.



Container-based plant network of the Energy Lab 2.0 at KIT

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