STORAGE RESEARCH INFRASTRUCTURE ECO-SYSTEM

RI Information sheet 2022

Organisation, RI name

Technology(ies) of Energy Storage (that can be assign to the facility, e.g. electrochemical, chemical, thermal, cross-cutting, ….)

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Project Acronym	StoRIES
Call	H2020-LC-GD-2020
Grant Agreement No.	101036910
Project Start Date	01-11-2021
Project End Date	31-10-2025
Duration	48 months

This project has received funding from the European Union's Horizon 2020
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1. Photo

2. Geographical coordinates (˚, “, … N/S, E/W)

49°05'59.3"N 8°26'13.2"E

3. Description of the research infrastructure for the webpage

Description of the infrastructure: The Energy Lab 2.0 is a unique research infrastructure established by the Helmholtz Association. Here, Karlsruhe Institute of Technology (KIT), together with Forschungszentrum Jülich (FZJ) and the German Aerospace Center (DLR) 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 and 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, mechanical and magnetic 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 Energy Lab 2.0 of KIT opens two of its facilities for the trans-national access:

SEnSSiCC: The SEnSSiCC lab is the brain of the Energy Lab 2.0, where the field information is gathered, analyzed, and visualized; advanced controllers are studied and developed to optimize the energy use; and full-power testing in

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realistic conditions is enabled in order to assess the energy technologies performance. In particular, in the STORIES project, the SEnSSiCC will provide access to the Smart Energy System Control Laboratory (SESCL - https://www.iai.kit.edu/english/RPE-SESCL.php), Power Hardware In the Loop Laboratory (PHIL - https://www.elab2.kit.edu/phil.php) and Living Lab Energy Campus infrastructure (LLEC - https://www.iai.kit.edu/english/RPE-LLEC.php). These first two labs allow the power hardware in the loop testing of energy resources up to 1MVA and to reproduce large electrical grids in real time simulation. Thanks to a power interface, the real technology hardware is then connected with the real time simulation. The Living Lab real laboratory consists of three identical single-family homes and two office buildings. This configuration enables the analysis of energy data from differently equipped households under identical conditions. Furthermore, all these houses have an electric car charging station. The electric filling station charges the electric cars on demand and can also store excess electricity in the car battery. These three buildings can also be integrated into the SESLC laboratory's micro grid. Currently, in Europe, there are only few similar research infrastructures, and no one with the large know-how that the SEnSSiCC lab can provide. Furthermore, the connection of the SEnSSiCC with the other resources of the Energy Lab 2.0 permits the full-power testing of any storage technologies, such as batteries (1.5MWh Li-Ion, 800 kWh Redox-flow), supercaps (500kW), and flywheels (high-speed, 60kW, 3.6kWh).

The 1.5 MWh lithium-ion storage system is a near-series prototype. The thermal component activation of the concrete building as well as the use of the groundwater for temperature control of the batteries allow minimization of the operating and maintenance costs of the system and ensure a long lifespan. Compared to conventional systems, this system significantly reduces the required energy for cooling the battery storage. The redox-flow storage system consists of an energy part (electrolyte tank), a power part (electrochemical cells and DC/DC conversion) and a grid connection part (DC/AC conversion) in separate containers and has a nominal output of 200 kW and a nominal energy content of 800 kWh. To integrate the storage facility into the KIT test infrastructure, a higher-level control and data acquisition system was developed. This allows various operating strategies to be implemented.

A test facility for home storage systems (small scale storage systems up to 10 kW) is available. Hardware in the Loop test facility in which the storage systems can

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be tested under real conditions. Long-term as well as short-term tests can be carried out to characterize the systems. All-important parameters can be measured and recorded every 200 ms. Both the measurements themselves and the evaluations can be performed completely automatically.

Chemical ES: Energy Lab 2.0 contains a modular container-based Power-to-X plant complex for investigation of integrated process chains for chemical energy storage at a scale of 100-200 kW_{el}. The site concept is based on fixed storing positions of 40 ft ISO containers making the infrastructure more flexible and enabling the evaluation of different technologies for electrolysis and synthetic fuels in a technical environment. A Siemens Silyzer 100 PEM electrolyzer with 100/300 kW power rating is available for producing up to 33 Nm3 /h of hydrogen at 35 bars. The hydrogen is deoxygenated and dried before being sent to a 2000 Nm3 5 pressurized storage tank. In addition, a 150 kW SOC electrolyzer (Sunfire RSOC 150/30, 2019) capable of producing 40 Nm3 /h of hydrogen at ambient pressure is already available and awaiting the installment of a compressor to pressurize the produced hydrogen to 35 bars for storage in the tank. Full commissioning of this line is expected in October 2021. Moreover, a second storage tank is available for CO2. The storage capacity is 11 tons of liquid CO2. CO2 and hydrogen from the tanks are converted into Fischer-Tropsch fuels in a two-stage modular plant consisting of a RWGS unit to first convert CO2 and hydrogen into synthesis gas and a Fischer-Tropsch unit to produce long-chain hydrocarbons from the synthesis gas. Unconverted synthesis gas and gaseous side products of the Fischer-Tropsch unit can be recycled back into the RWGS unit. The plant has been developed by INERATEC GmbH, Karlsruhe and is the first of its kind. It has a design capacity of 200 L/d and is currently being extended by a third stage for upgrading the Fischer-Tropsch products to liquid fuels, i.e., kerosene, diesel, and naphtha. Up to 24 tons of Fischer-Tropsch products can be stored in the product storage facility. Moreover, a catalytic combustion unit is available to treat any harmful offgas for disposal.

Services currently offered by the infrastructure: The **SEnSSiCC** allows the realistic testing of energy storage technologies in realistic grid conditions. This permits to validate any developed hardware or software-based solutions in real field conditions, enabling a more accurate and realistic assessment of the energy storage technology performance. This concept overcomes the classical lab tests, where the setup hardware restrictions (costs, space, installation time) are relaxed

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by the real time simulation, and thus allows the scientists to repeat experiments faster and in a safer way (e.g., no impact on customers like in the field experiments). In the PHIL lab has been recently tested the performance of a 60kW-3.6kWh highspeed Flywheel energy storage, by means of power hardware in the loop testing in a south German network, showing promising results in contributing to the primary frequency response. The SESCL lab facility is used to provide a flexible microgrid topology to test modern energy technology systems and novel control algorithms. Since the experimental field is galvanic isolated from the public power grid, control strategies can also be approved and investigated there in borderline areas. The busbar matrix is the central component of the experimental area. It consists of a total of over 400 contactors of different types and power classes, which are monitored and controlled by a central, remote-controlled automation system. This allows a fully automated rapid sequence of experiments with different microgrid topologies as well as various producers, consumers and prosumers with defined parameters. The busbar matrix provides both AC and DC busbars. Currently, the laboratory infrastructure is being validated and optimized in overall functionality using an adapted IEEE 5-bus system example. The SEnSSiCC has been recently brought in operations (beginning of 2020), and thus we are starting our international cooperation activities. However, we have received strong interest from industrial partners in validating energy technologies in the lab. As an example, the PHIL lab will perform external testing for the Kopernikus Projekt "ENSURE", to verify experimentally the performance of the in-project developed charging stations for electrical vehicles by Maschinenfabrik Reinhausen.

The large-scale storage systems are currently used to test different operating strategies.

The Hardware- in-the-Loop test facility for small (up to 10 kW) storage systems is currently used for several coordinated projects on national level as well as for industry cooperation's. Most of the time it is used for long- and short-time performance tests of storage systems with an output of less than 10 kW.

The **Chemical ES** infrastructure is currently used for several collaborative projects on national level to investigate the steady-state and dynamic performance of Power-to-X plants focusing on Fischer-Tropsch fuels and synthetic methane as products. The existing synthesis plants can produce about 100 kW_{th} of chemical energy output. The upgrading of Fischer-Tropsch fuels to drop in fuel quality will

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be added by the end of 2022. Moreover, additional container plants for methanol synthesis, ammonia synthesis and liquefaction of synthetic methane will be added to the site in the next 2-3 years to implement power-to-methanol and power-to-ammonia process chains as well as to complete the process chain from CO_2 and H_2 to liquified synthetic methane. The experimental data are used to develop digital twins of different Power-to-X process chains. In the future, the site could accommodate other container-based plants for electrolysis, fuel synthesis, or electrosynthesis for performance evaluation when integrated in the entire PtX-process chain. This is intended with a view to future collaborative projects on EU level.

4. Availability of the research infrastructure

(Please indicate time periods in which infrastructure will not be available for StoRIES in the next 2 years – if already known)

Not known yet when the infrastructure will not be available.

5. Special considerations (confidentiality / NDA agreements, insurance requirement, special training, HSE training)
HSE training
Possibly confidentiality / NDA agreements

6. Energy storage technology that can be analysed/studied by using the research infrastructure

- Electrochemical ☒
- Chemical ☒
- Thermal ☐
- Mechanical ☒
- Superconducting Magnetic ☐
- Cross-cutting ☐ (Specifically: ...)

7. Key words for the webpage
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8. TRL level (if applicable):

- 1-3 ☐
- 4-6 ☒
- Above ☒

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