STORAGE RESEARCH INFRASTRUCTURE ECO-SYSTEM

RI Information sheet 2022

Empa, NEST

Technologies of Energy Storage: electrochemical, thermal and 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

1. Photo

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

Location: Dübendorf, Switzerland.

Coordinates: 47.40281477846064 ˚ N, 8.61254893193125 ˚ E

3. Description of the research infrastructure for the webpage

As an interdisciplinary research institute of the ETH Domain, Empa, the Swiss Federal Laboratories for Materials Science and Technology, conducts cutting-edge materials and technology research. Through efficient technology transfer, Empa is turning research results into marketable innovations – true to its mission statement: *The Place where Innovation Starts*.

As part of its research focus areas on energy and the built environment, Empa operates several research and technology transfer platforms, including NEST, a modular demonstrator building to accelerate innovation in construction and building-related sectors (www.empa.ch/web/nest/). NEST is located at the Empa campus in Dübendorf, Switzerland and offers long-term monitoring of residential buildings (3 modules as shared flats with 2-3 tenants each, data available back to 2017), office spaces (2 modules with 4-8 desks each, 4 meeting rooms in total) and a gym module, to assess real-life use patterns of people, district systems and energy consumption. NEST has over 1'000 visitors per month (Average 2017-2019) and regularly offers workshops for professionals from the construction and energy industries. As an open-innovation platform, NEST is open to partners from industry and academia to demonstrate and evaluate their concepts and technologies. Since its construction in 2016, NEST has created a strong ecosystem of more than 140 partners.

NEST offers a versatile neighbourhood-scale multi-energy platform to optimize energy management at district level (https://www.empa.ch/web/energy-hub). A dense network of

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sensors and actuators with over 8'000 data points, remotely accessible to research and industry partners, offers performance monitoring. Together with experts from Empa's Urban Energy Systems Laboratory and external research and implementation partners, a strong expertise in energy-related data-driven research activities has been developed. This includes the evaluation of machine learning algorithms in a real-life environment to optimize control of domestic heating/cooling systems, grid stabilization at neighbourhood scale and anomaly detection for sensor data.

These neighbourhood-scale multi-energy distribution and hybrid storage facilities will be made available to project partners and are therefore of particular interest for the STORIES project. These facilities will allow the partners to obtain energy data from real-life use patterns and to implement, demonstrate and validate novel algorithms at reduced risk.

The setup comprises a wide variety of components, three thermal networks, three electrical networks and two gas networks. All components can be controlled individually and – depending on the research question at hand – operated separately or in concert. The results on the practical capability and systematic combination of individual technologies will help our partners from the energy sector and from industry to make decisions on future investments and can provide useful recommendations for planners, architects, energy suppliers and regulators.

The core infrastructure comprises of a thermally integrated edge data center (20 kW_{th} out of the H2020 ECO-Qube project), batteries (total 169 kWh), super-capacitors (1 kWh), heat pumps (total 142 kW_{th}), fuel cells (2 kW_{th}), ground heat exchangers (2 x 260 m, 1 x 12 m), an ice storage (69 m^3), photovoltaic installations (total 122 kW_p), solar thermal installations (7 kW_p), an electrolyser (180 kW_{el}; 2.7 kg/h H_2), H_2 storage (approx. 100 kg), a methanisation plant (3.6 kg/h), domestic hot water production and storages, HVAC systems in NEST Units at Empa.[1] These components are interconnected via three electricity grids (400 V), three heat grids (water and/or glycol), two gas grids (H_2, methane) and equipment for coupling the building sector (office and residential units at NEST) and the mobility sector (local fuelling stations). An overview of the setup is depicted in Figure 2 and 3.

[1] Richner, P., Heer, P., Largo, R., Marchesi, E., Zimmermann, M. (2018). NEST – a platform for the acceleration of innovation in buildings. Informes de la Construcción, 69/548, e222, 8 pp. https://doi.org/10.3989/id.55380

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Figure 2: Overview of energy-related systems and components in each of the NEST modules and at the Empa mobility demonstrator move, all interconnected via several networks (3 electrical, 3 thermal, 2 gas [not shown]). The NEST module names are abbreviated in bold letters.

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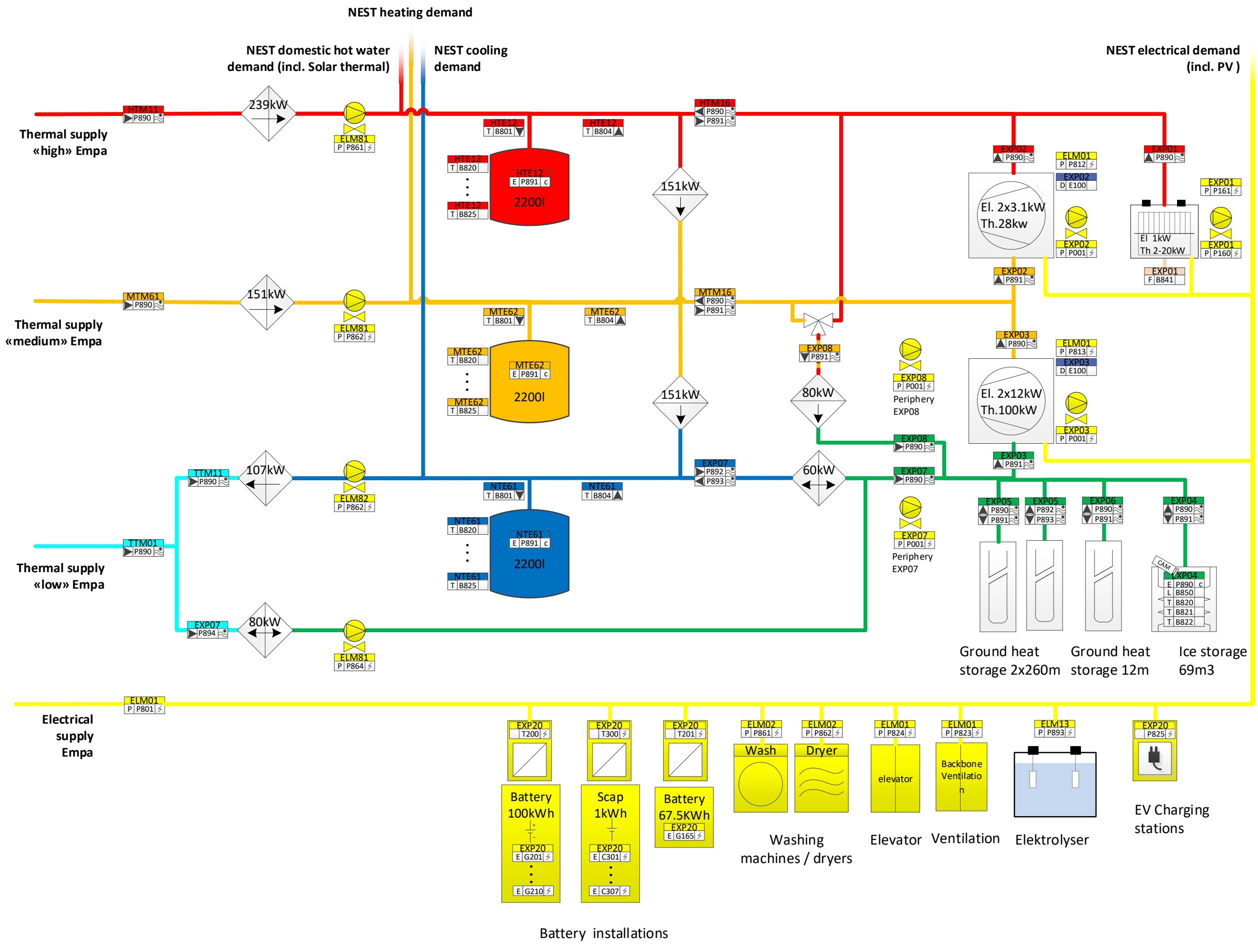

Figure 3: Schematic representation of the hybrid storage and conversion facilities at NEST and the Empa mobility demonstrator move. Gas networks not shown.

Empa follows an open data approach. As a part of this initiative, a documentation on the existing infrastructure can be found here: https://info.nestcollaboration.ch/wikipediapublic/

<u>Services currently offered by the infrastructure:</u>

Services provided to our partners includes sharing data, enabling the installation of components and systems for prototype evaluation in the domain of buildings and building technology, as well as the implementation of control algorithms, e.g. to maximize comfort while minimizing energy consumption, or to optimize the collaboration between individual buildings or systems. These services are enabled by a versatile and readily expandable platform for data acquisition at building and neighbourhood scale.

Currently, several activities are ongoing to evaluate and demonstrate data-driven control algorithms in real-live environment. In addition, surveys can be conducted to gather user/resident feedback and assess their acceptance/willingness to pay/motivation to use for novel technologies and control schemes.

Apart from the baseline controller (state of industry controllers that operate the systems 24/7 and collect data for modelling and benchmarking), an underlying safety mechanism is

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implemented, such that no harm for the equipment or personnel exists during novel research activities on energy management schemes. This safety mechanism stays in operation during research experiments, when the baseline controller is switched off and control-scripts from researchers act on the systems.

Several interfaces are provided to researchers to access live or historical data and to control the infrastructure. The most commonly used interface is a python client. Other possibilities include a MATLAB client or a REST API (https://info.nestcollaboration.ch/wikipediapublic/data/livedata/clients/).

Past projects include:

- Thermal load forecasting for auxiliary reserve provision with a heat pump[2] as part of a PhD thesis,
- a data-driven identification of thermal building dynamics for predictive control[3] as a Master Thesis,
- an adaptive save Bayesian controller tuning of a heat pump[4] as a Master Thesis.

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 applicable.

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

A short data usage agreement is required before giving access to database and control. More details can be found in the link below.
https://info.nestcollaboration.ch/wikipediapublic/data/process/access/

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

[2] Bünning, F.; Warrington, J.; Heer, P.; Smith, R.; Lygeros Machine learning and robust MPC for frequency regulation with heat pumps. 2020. https://arxiv.org/abs/2009.06920

[3] Bünning, F.; Huber, B.; Heer, P.; Aboudonia, A.; Lygeros, J. Experimental demonstration of data predictive control for energy optimization and thermal comfort in buildings. Energy Build. 2020, 211, 109792 (8 pp.). https://doi.org/10.1016/j.enbuild.2020.109792

[4] Khosravi, M.; Eichler, A.; Schmid, N.; Heer, P.; Smith, R. S. Controller tuning by Bayesian optimization. An application to a heat pump. In 2019 18th European control conference (ECC), presented at the 18th European control conference (ECC 2019), Napoli, Italy, June 25-28, 2019; IEEE: sine loco, 2019; pp 1467-1472. https://doi.org/10.23919/ECC.2019.8795801

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- Electrochemical ☒
- Chemical ☐
- Thermal ☒
- Mechanical ☐
- Superconducting Magnetic ☐
- Cross-cutting ☒ (Specifically: energy management at district level)

7. Key words for the webpage

hybrid storage facilities, multi-energy platform

8. TRL level (if applicable):

- 1-3 ☐
- 4-6 ☒
- Above ☐

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