Combined AI and Data solutions for creation of INSIGHTS

Challenge 2.3

Energy system Digital Twin decision support tool

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Challenge and context

Grid operators increasingly face grid balancing challenges due to rising energy demand and the growing share of decentralized renewable energy production. To balance power generation and demand, a portfolio of energy storage technologies can be deployed, including electrochemical storage (e.g., batteries, hydrogen technologies) and thermal energy storage. Thermal storage can play a significant role by shifting heating or cooling loads, improving sector coupling, and reducing peak electricity demand. Moreover, with the advances in thermophotovoltaic (TPV) technology that provides conversion from heat to electricity, thermal storage enables output of both electricity and heat.

However, energy conversion and storage equipment, including both electrical and thermal systems, incur capital and operational expenditures that ultimately affect the final price of delivered energy. Optimal sizing and integration of local renewable generation, electrical storage, and thermal energy storage are therefore essential to achieving an economically efficient and flexible energy system.

Due to numerous variables, such as time-dependent profiles of energy consumption (electric and thermal), renewable generation, storage state dynamics, and dynamic pricing signals, and their nonlinear interdependencies, optimal system configurations cannot be derived analytically. This challenge calls for AI and data-driven solutions to optimally size, coordinate, and control distributed energy resources, including microgrids with integrated thermal and electrical storage.

Use case and expected solution

The expected solution should enable the microgrid operator to determine the optimal sizing of local energy assets to reliably meet both electrical and thermal heating energy demands. In addition, it should incorporate advanced energy management capabilities that control grid assets operation in a way to stabilize the grid, reduce the overall costs, and enable the microgrid to offer ancillary services.
The proposed sizing and real-time operational strategy should minimize total energy costs, reduce capital expenditures for both electrical and thermal energy storage systems, and limit curtailment or wastage of renewable energy, while maximizing the value of distributed resources through intelligent grid control.

Specification for use case

A Digital Twin (simulation model) of local energy systems and real-life measurements of energy consumption will represent a core of the playground. The provided Digital Twin enables simulation of thermal and electrical energy balance over a desired time and observing economic results as a function of equipment sizes and prices. The digital twin will be used to experiment and test microgrid control algorithms for different pricing scenarios. The main focus of the scenarios will be on inclusion of novel thermal energy storage solutions and provision of ancillary grid services.

The selected third party is expected to have experience with provision of ancillary (grid) services and is expected to contribute with the following:

- Develop an optimization algorithm for optimal sizing of a microgrid components using a microgrid Digital Twin
- Develop a microgrid grid energy control algorithms using predictions of heat and electricity needs
- Implement and test the developed solutions in a digital environment with real world data and for different scenarios

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- Demonstrate operational scenario of ancillary grid services together with the use of thermal storage solution

Key Performance Indicators

Key Performance Indicators (KPIs) should clearly demonstrate the relevance and impact of the proposed solution. They must address at least two of the following dimensions: resource optimisation, Green Deal objectives, and social impact. All KPIs must be SMART (Specific, Measurable, Achievable, Relevant and Time-bound), ensuring they remain quantifiable throughout the project.

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