Ph.D. position offer:
Modeling and multi-criteria evaluation of the integration of centralized and distributed long-term energy storage in islands

2024-04-22

Keywords

long term energy storage, energy systems, electric power systems, hydrogen energy, sizing, energy management, multicriteria optimization

Context

Non-interconnected areas, including the French islands, suffer from an energy mix that is both more carbon-intensive and more expensive than mainland France. These areas are also highly dependent on imports of fossil fuels, especially oil, for electricity production and transport. La Réunion is an example of this, with, in 2022, an average electricity production cost of more than 280 €/MWh, an 85% energy dependency rate, 65% of the final energy consumption used for transport, and only 14% of renewable energy in primary energy consumption.

La Réunion has moved closer to 100% renewable electricity production by 2024, through the conversion of thermal power plants to biomass and bioliquids. However, the environmental impacts of these solutions are questionable, as is the choice to resort to importing wood from other continents. By 2030, the island is also aiming for complete energy self-sufficiency, which seems very ambitious.

The HyLES project is funded by the French national research agency ANR, ends in 2024 and is coordinated by FEMTO-ST. It is conducting a study of the energy mix and the role of hydrogen for the 2030 and 2050 horizons, according to different scenarios based on a modelling of production (particularly renewable), consumption, means of transport and the electricity transmission network. This work has shown the need for long-term storage (in addition to short-term storage on the scale of a few hours) on the scale of the island, but the question cannot be studied within the project due to lack of time. The work also pointed out the great difficulty in covering the needs necessary for the decarbonization of the aviation sector while that of the maritime sector would be conceivable.

Challenges to address

- The need for storage is still poorly understood, as it depends on changes in demand and the energy mix, and therefore on meteorological data. An evaluation of a minimum of 10 to 20 years of historical data would be necessary to identify the probabilities and durations of dunkelflaute phenomena (a period with low wind and sunshine), for example. On the other hand, demand response capacity – for example via the management of vehicle charging – could provide more flexibility on the demand side.
- Different technologies allow long-term storage (from several hours to seasonal) on a large scale. Pumped hydro plants are a classic solution, but their potential is limited, or the technologies need to be adapted, as with marine pumped hydro plants. Hydrogen – or its derivatives – is a potential solution, but it cannot be based on geological storage (salt caverns, etc.) due to its absence in La Reunion Island. Other technologies such as iron-air batteries, with low density but very low cost, may emerge in the future. Apart from the questions of technical feasibility, costs and performance, the question of the environmental impacts (emissions, biodiversity, resources, etc.) of these technologies must also be considered.
- Another approach would be to use distributed storage, for example in the form of residential batteries or even vehicle-to-grid (V2G). However, the coordination of these resources is much more complex because it relies on a large number of equipment, can impact users and raises the question of the underlying business model. The feasibility of this approach is therefore uncertain.

- In terms of management, the simultaneous consideration of short-term (minute to hour) and long-term (several years) dynamics poses problems of computation time, especially when the ageing of components is considered.

Scientific objectives

The focus of the Ph.D. thesis is on the modeling and multi-criteria evaluation of the integration of centralized and distributed long-term energy storage in La Réunion. Criteria will be of technical, economic, environmental, and societal nature. The main steps of the thesis will be as follows:

- Review of the related state-of-the-art, including data, models and results of the HyLES project,
- Collection of the necessary data and modeling of island energy systems,
- Design and implementation of demand and demand response scenarios, including vehicles,
- Modeling, integration, control, and evaluation of centralized long term energy storage,
- Modeling, integration, control, and evaluation of distributed energy storage,
- Comparison and analysis of both approaches, including in terms of complementarity,
- Writing of the thesis document and defense.

The selected applicant will also be expected to:

- Publish in international journals and conferences,
- Participate in project meetings and in communication and dissemination events,
- Participate in the scientific activities of the respective laboratories and universities.

Expected qualifications

- Master's or *ingénieur* degree in electrical engineering, energy, applied mathematics or a related field,
- Interest for energy issues, research, and interdisciplinary work,
- Knowledge in power systems, renewable energy, hydrogen energy, optimization,
- Experience with Python or Julia programming,
- Good level of written and oral English and, preferably, French.

Supervision

The selected Ph.D. student will be supervised by:

- Prof. Dr. Robin Roche, Full Professor at Université de Franche-Comté (part of UBFC) and FEMTO-ST,
- Dr. Dominique Grondin, Associate Professor at Université de La Réunion and ENERGY-lab.

Contract

The selected candidate will have a 36-month contract with Université de Franche-Comté. He or she will be part of the SPIM doctoral school and of the FEMTO-ST laboratory in Belfort. The contract is expected to start on October 1, 2024.

The estimated gross monthly salary (including social security) is of 1975 €.

Application

Applications must include the following documents:

- A detailed CV
- A transcript of results from the latest degree
- A cover letter
- At least one letter of recommendation

All documents must be sent to the following email addresses **before May 31, 2024**:

- robin.roche@univ-fcomte.fr
- dominique.grondin@univ-reunion.fr

Additional information

About UBFC, Université de Franche-Comté and FEMTO-ST

Université Bourgogne Franche-Comté (UBFC) is a community of universities and institutions which gathers seven higher-education and research institutions. UBFC currently hosts more than 60,000 students and 8,800 staff. It spreads across 13 sites in the Bourgogne Franche-Comté region in France. For more information, see https://www.ubfc.fr/.

Université de Franche-Comté (uFC) is a 600-year-old institution located in 5 cities, including Belfort, where the position will be located. It includes 27,000 students and 2500 staff and faculty members in multiple disciplines. In addition to UBFC, uFC is part of the STARS EU European alliance, along with 8 other European universities. For more information, see https://www.univ-fcomte.fr/.

FEMTO-ST is a joint research unit of several UBFC institutions (Université de Franche-Comté, ENSMM, UTBM) and CNRS, the French national research center. With over 750 researchers and staff, it is a leading institute in the field of engineering sciences. Its Energy department is located in Belfort, France, and hosts the largest French research group in hydrogen energy, together with a strong emphasis on electrical engineering. FEMTO-ST is a partner of FCLAB, a CNRS unit dedicated to applied hydrogen energy research and transfer. For more information, https://www.femto-st.fr/.

About Université de La Réunion and ENERGY-lab

Université de La Réunion is a French public higher education and research institution, located in the heart of the Indian Ocean, one of Europe's outermost regions. By virtue of its unique geostrategic position it is the only European university in the region. 15,000 students are admitted every year at six sites on the island. ENERGY-lab is a research unit associated with the Science and Technology Department of the Université de La Réunion, created in 2006. Composed of nearly 40 researchers and staff, the unit is structured in three scientific operations (SO) articulated around the central axis of optimisation of solar or intermittent intelligent energy systems:

- SO 1 – Solar field: variability in La Réunion and in the tropics, metrology and modelling,
- SO 2 – Energy storage and conversion: Fuel Cell (FC) systems and hybridisation,
- SO 3 – Energy optimisation of sensor networks.

For more information, see https://www.univ-reunion.fr/.