

3rd party identity card

Project acronym/name	6G-SANDBOX <i>Supporting Architectural and technological Network evolutions through an intelligent, secureD and twinning enaBled Open eXperimentation facility</i>
Logo (if any)	
Organisation name(s)	ENERGY COMMUNITY BESSARION LIMITED LIABILITY COOPERATIVE, (ECB)

Objective, goal, use case

Energy Communities (ECs) are collaborative initiatives that democratize access to renewable resources by deploying shared photovoltaic (PV) parks to meet their members' electricity needs. **A fair, transparent method for sharing PV output is essential.**

Traditionally, each EC member (consumer) receives a fixed percentage of the PV installation's capacity (kW). 6G-EARN instead enables dynamic allocation of actual energy produced (kWh) (for example, on a daily basis) by forecasting one day ahead i) each end-point's consumption and ii) the available green energy (PV generation) . We identified three critical requirements for broad adoption of our "PV-as-a-Service" model:

1. Privacy preservation : No raw user data may be exposed, as consumption profiles can reveal sensitive personal information (e.g. occupancy patterns).
2. Ease of deployment: Adding a new member must involve minimal on-site work and inexpensive hardware.
3. High forecasting accuracy: Accurate day-ahead predictions maximize the number of users served by a shared PV park, improving return on investment and individual savings.

Concept, approach

Our data collection solution heavily relies on the existence of a fixed line. However, PV parks are mainly installed in rural areas where there is no fixed line coverage or the cost and effort required for the installation of a fixed line are quite high. Besides, electricity consumption data are sensitive as they could reveal significant information for the user itself. For example, from the user electricity consumption profile, his presence in the house can be easily deduced. Currently, the community members have inherent trust to the system operation due to their strong interpersonal relationships and willingly share their consumption data. As the community expands, this cannot be assumed for the new members.

These challenges hinder the further adoption of our service offering and 6G-EARN addresses them by developing:

- i) a (Beyond)5G-based solution for remote monitoring of electricity consumption/generation; and
- ii) a privacy-preserving forecasting solution that will enable us to expand our target market and attract more users. Privacy is ensured by design through the use of local ML models and Federated Learning (FL).
- iii) improve the forecasting accuracy, by utilizing weather data from locally deployed weather stations.

Results (testing, validation) and Impact

The main findings from the development and testing of the 6G-EARN service over 6G-SANDBOX are:

1. **Improved accuracy through FL:** Aggregation of data from multiple sources as per Federated learning and with integration of external resources improves prediction accuracy by more than 100% (in cases of limited available data per client).
2. **Strong day-ahead forecasts:** Forecasting the daily consumption of a household can be sufficiently accurate, with Mean Absolute Percentage Error (MAPE) <20%.
3. **User grouping matters:** Aggregating consumption data from too diverse data sources may have the opposite effect, and hence careful grouping of the users is necessary.
4. **Lightweight training:** 6G-EARN training can be completed in less than 10 minutes even without GPU availability at end-clients.
5. **Broad vertical service support:** 6G-SANDBOX supports the deployment of any properly-designed cloud service and experiment with a diverse set of simulated Trial Networks scenarios.

6G-EARN enables accurate forecasting of energy consumption per household, which is necessary for optimized allocation of electricity generation according to each member's needs, and eventually translates to improved return on investment. Besides, by adopting dynamic, privacy-preserving day-ahead energy allocation, ECB can attract more members that follow the recently applied net-billing scheme and are not willing to share their sensitive electricity consumption data.

Overall, by improving forecasting accuracy and fairness, 6G-EARN increases renewable energy utilization and fosters trust in shared-economy models, advancing inclusiveness, sustainability, trustworthiness and cross-sector innovation.