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Enabling Technologies for Wide-Scale Implementation of Energy Communities' Projects †

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Abstract: The cluster on Enabling Technologies in the framework of the Fast Track on Energy Communities workshop held in Rome during the Sustainable Places 2021 conference presented a series of H2020 projects and their innovative technological solutions to facilitate the uptake of energy communities, demand-response and energy efficiency projects in Europe.

Keywords: enabling technologies; energy communities; toolbox; demand-response; DR platform; ECTP; energy efficiency

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1. Introduction

Energy communities are rapidly becoming a trend movement towards a more participative and democratic energy transition. The technologies currently available in terms of energy assets (solar panels, home batteries, heat pumps), measuring components (smart meters and sensors), and management systems (energy management systems (EMS), peer-to-peer (P2P) platforms, demand-response (DR) toolboxes) are mainly ready for marketization, to allow energy trading between neighbors. Eight H2020 projects are developing innovative technological solutions to reach the above goals, and they joined forces on a common workshop organized within the framework of the Sustainable Places conference to expose their approach and discuss potential synergies.

2. E-LAND

The main concept is the E-LAND toolbox, a modular set of methodologies and information and communication technologies (ICT) tools to optimally manage local multi-vector energy systems (MVES) and isolated communities. The modular toolbox can be customized to meet local requirements and is expandable to incorporate new tools.

In order to ensure an effective replication of the E-LAND modular toolbox in MVES and isolated communities, E-LAND project is developing a replication toolkit. The goal of the toolkit is to provide valuable insights for communities to build a low-carbon, economically sustainable energy island. It will contain the following actionable guidelines

to develop and carry out new projects, concrete examples from real-life experience, and easy-to-use documentation for those who want to utilize the E-LAND toolbox.

E-LAND also provides long-term planning for local sector-coupled energy systems that includes planning of the multiple energy vectors: electricity, heat and gas. The short-term optimization tool first detects/corrects missing, corrupt or inaccurate (due to outliers) data, re-samples them, if needed, and gets energy load profiles (daily, weekly). Short-term optimization is planned for generating an optimization schedule 24 h ahead of the local MVES by considering the multiple assets available. One of the on-site planning optimization tools is the Multi-Vector Simulator (MVS), which allows the evaluation of local sector-coupled energy systems that include the energy carriers electricity/heat/gas, and the energy planning application (EPA), developed to support the open-source optimization tool multi-vector simulator.

3. iFLEX

The project aims to achieve this goal by providing innovative solutions, called iFLEX Assistants, that act between consumers, their energy systems, and external stakeholders helping consumers to engage in DR (demonstrated in Slovenia, Greece and Finland).

The iFLEX Assistant is an intelligent software agent that aims to make participation in DR as easy as possible for users by automating all daily operation tasks. In general, the iFLEX Assistants are designed to provide a common approach to enhance user experience, including a high level of automation and personalization in a wide variety of DR and energy services.

An iFLEX Assistant consists of an end-user interface and several back-end components implemented as microservices. The end-user interface is designed to provide natural and seamless way for consumers to interact with the assistant. The back-end components consist of an automated flexibility manager, consumer digital twin, and a variety of components designed to interact with external systems such as building automation systems, aggregation platforms, markets, and weather forecast services. The automated flexibility manager and consumer digital twin components work together to provide flexibility management that adapts to the consumer. The key idea is to use deep learning together to form accurate digital twins of users and their buildings in order to accurately forecast load profiles, flexibility and response of the system at the consumer level.

4. LocalRES

The main objective of LocalRES is to demonstrate, at TRL8, innovative local energy systems following a sector coupling approach, which will be able to interconnect and optimise the joint operation of different energy vectors (electricity, heating, mobility, etc.) by maximising the renewable energy system (RES) contribution and enhancing the energy system flexibility and supply security. In particular, two main tools will be delivered that will boost the expected structural change in the current energy system at generation, market, distribution and users levels: the planning tool and the multi-energy virtual power plant (MEVPP). The first tool aims at supporting users to perform strategic pre-feasibility studies for the development of a renewable energy community (REC) and support their optimal design; the second one provides RECs with the technology and methodology enabling the provision of different services in energy and flexibility markets.

The ICT solutions will have a set of benefits for both users and the EC manager. For the users, specific attention is given to support their strategic decisions based on monitoring and prosumer behavior models, and to the enabling of citizens' participation in both internal (peer-to-peer trading) and external markets (flexibility and ancillary services). Concerning the EC manager, the benefits include the optimization of the electricity system operation in synergy with local RES, sector coupling, mobility and energy storages, and the development and deployment of control algorithms to optimize the energy flows.

5. MUSE GRIDS

The main objective of MUSE GRIDS is to deliver a key contribution to the roll out of multi-energy management systems in the context of local energy communities (LECs). The project is analysing two complementary energy communities: a municipal microgrid in a historic town in Italy (Osimo) and a rural area in Belgium (Oud Heverlee).

In both demo sites, the interconnection of the different energy networks is being achieved integrating different flexible technologies (e.g., EVs, electro-thermal storage, large thermal storage, batteries) and optimally managing them via proper multi-energy demand side management (DSM) driven by end-user habits. The MUSE GRIDS concept includes the development of a multi-objective smart controller to properly optimize and aggregate energy grid management systems in a multi-energy context. MUSE GRIDS Smart Control has been developed in order to provide a framework for monitoring, controlling, and collecting data from different sources and tools, develop a smart controller to optimize synergies among energy networks and data visualization tools to raise awareness and engagement of final users. Energy management and technological flexibility assets are demonstrated in the two advanced demos demonstrating the integration of existing and innovative technologies and possible barriers for their applications in the whole energy value chain (from generation to end users).

6. SmartBuilt4EU

Buildings are on the way to transform from passive isolated elements to smart buildings, able to adapt to occupants' needs and behave as active nodes fully integrated to the energy grids and other infrastructures. Still, the market uptake and wide-scale roll-out of ICT and smart technology is slow due to challenges like engaging building occupants, connecting and managing various devices and systems, achieving optimal building operation, as well as the high fragmentation of the ecosystem. Therefore, the main objective of SmartBuilt4EU is to consolidate and support the innovation ecosystem in the smart building value chain through concrete networking actions, so as to establish the grounding of a future full-fledged smart building market in Europe.

The project is mapping and nurturing a European smart buildings community, with EU projects at its centre, while promoting key innovators and innovative solutions for smart buildings through its web platform. Collaborative open task forces are also involving key stakeholders to identify barriers, opportunities, and best practices for the take-up of smart buildings. These findings will be translated into recommendations to policy makers and a Strategic R&I Agenda that will feed the design of future Horizon Europe calls. In addition, the project will coordinate contributions of the community to the Smart Readiness Indicator (SRI) promotion, experimentation and implementation.

7. eNeuron

The main goal of eNeuron is to develop innovative tools for the optimal design and operation of LECs, integrating distributed energy resources and multiple energy carriers at different scales. This goal will be achieved by promoting the energy hub concept, as a conceptual model for controlling and managing multi-carrier energy systems and optimizing their architecture and operation. In the context of multi-carrier energy systems, connecting technologies are those that connect at least two energy networks ("sector coupling") so that one energy carrier in input is converted by that technology into at least two different energy carriers operating as many energy networks.

eNeuron optimisation tools will be developed with a general mathematical formulation, by creating a holistic framework for multi-carrier LEC planning and operation, and this type of approach will ensure a high potential of replication across Europe, with a valid tool providing support to decision-makers in understanding the benefits derived by the optimal management of local energy resources.

Digitalization and artificial intelligence are key aspects in the eNeuron LEC, where prosumers are provided with energy management systems (software and hardware) that,

locally, coordinate the operation of multiple carriers, accelerating the development of multi-energy technologies and improving energy efficiency.

8. Accept

ACCEPT aims to deliver a digital toolbox that energy communities can use to offer innovative and desired digital services, complementing their existing non-digital services to their members and customers, and gain access to revenue streams that can financially support their operations and ensure longevity and good functioning of the community itself. To achieve this aim, the ACCEPT consortium is framing the citizen engagement and business modelling activities in the same priority as the technical development ones. Their intertwined implementation will be the critical success factor for the delivery of the ACCEPT solution as a minimum viable product that has already passed preliminary market testing and financial viability checks.

The main components of the ACCEPT solution include, among others, the consumer digital twin model, a community-level P2P energy/flexibility exchange platform, a tool for managing district-level assets and community tools for energy and flexibility management.

Replicability of the ACCEPT solution will be achieved through standardization (all ACCEPT solutions should ideally be compatible with well-established industry standards), interoperability (e.g., use of agnostic communication protocols for the building-level IoT gateway used within the project), and dynamic and varying network configuration (four different pilot sites in which data-driven models will be used for maximum adaptability of the solution to the varying contexts of the trials).

9. Parity

The PARITY project addresses the "structural inertia" of distribution grids by providing a local flexibility market platform through integration of IoT and Blockchain technologies, and tools for automated control of distributed energy resources (DER) flexibility, DER profiling and smart grid active network management.

Several innovative technologies are being developed within the project like the automated user profiling, a human-centric power-to-het model, and flexibility forecasting per asset and prosumer (including electric vehicles). The smart contracts-enabled market platform includes the local electricity market, which facilitates P2P trading among prosumers, and the implicit local flexibility market, which is integrated in the local electricity market. Other important components are the aggregator toolset and the DSO Toolset. The former clusters prosumers' assets to create virtual power plants and facilitates automated flexibility trading to wholesale and ancillary markets, and flexibility to DSO through the local flexibility market. The latter performs smart grid network monitoring and active network management operations in intraday or near real-time.

ICT and artificial intelligence (AI) can support energy communities in various ways. In PARITY, models for comfort profiles and for load and flexibility forecasting are created, targeting improved energy management and efficiency. Moreover, prosumers can access the different tools via web-based user interfaces that follow design guidelines for a common look and feel.

10. Conclusions

The SP2021 workshop demonstrated that there are several technological solutions under development for the uptake of energy communities around Europe. They mainly consist of DR platforms and toolboxes for easy and transparent energy trading at a local level, with a user-centric approach, and are easily replicable and scalable. Their validation in the related pilot sites is of vital importance for their market exploitation.

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