Proceeding Paper

Energy Communities: How Tools Can Facilitate Their Enhancement [†]

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Abstract: This workshop brought together a selection of H2020 EU-funded projects to offer an overview of different tools used for the optimization of local energy networks and demonstrate how to facilitate grid interaction from the perspective of technology leaders representing four H2020 projects. This session offered a unique opportunity to discuss different approaches and compare the frameworks, practices, and tools used by different energy communities.

Keywords: energy communities; tools; sector coupling; local energy networks

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1. Introduction

In recent years, the energy paradigm in Europe has started to change, moving from a centralized to a distributed approach. Thanks to important European regulations such as the Clean Energy for All Europeans Package (2019) and demonstration projects funded by the European Commission, the integration of smart energy systems in energy communities and local energy networks has started to become more widespread around the continent. This paper aims to present the results achieved during a workshop at Sustainable Place [1]. Four projects funded by the European Commission—MUSE GRIDS, COMPILE, MERLON, and IELECTRIX—are working on strategies to maximize the impact of energy communities in different contexts and energy system setups. Their tangible experience in physical and/or virtual demo sites will provide valuable suggestions and ideas on technical and non-technical tools that can support local energy networks and energy communities in Europe. These different projects are able to provide a panorama of various technical and non-technical tools that can be utilized, advice on how to design and implement them, as well as an assessment of which tools are missing or should be developed further.

2. Projects

2.1. MUSE GRIDS

The main objective of MUSE GRIDS [2] is to offer a key contribution to the roll out of multi-energy management systems in the context of local energy communities. To do so, MUSE GRIDS maximally exploits the potential of the demonstrations, user interactions, partnerships, and communication means. As real-life results are key in learning and development processes as well as essential in convincing decision makers and other relevant actors, the project level's decisive objective is to demonstrate in two real test

cases (i) how to interconnect local energy grids; (ii) how to utilize synergies in the energy system to maximize efficiency and reduce costs, CO₂ emissions, and energy losses; and (iii) how to reach an affordable energy independency by maximizing local self-consumption based on RES. The project is based on analyzing two different but complementary energy communities: (i) a municipal microgrid in a historical town on a top of a hill (OSIMO, Italy) with a DHN (a smart water pumping system with a large PV presence that aims to optimize supply management to make it more reliable thanks to the use of EVs) and (ii) a rural area (OUD-HEVERLEE, Belgium) with houses equipped with RES generators and flexible assets and where the engagement of local energy communities can be further promoted, leading to the effective integration of an enlarged local energy community. In both demo sites, the interconnection of the different energy networks is achieved by integrating different flexible technologies (i.e., EVs, electro-thermal storage, large thermal storage, batteries, etc.) 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 optimize and aggregate energy grid management systems in a multi-energy context. The MUSE GRIDS architecture Smart Control was developed in order to: (i) provide a framework for monitoring, controlling, and collecting data from different sources and tools; (ii) develop a smart controller to optimize synergies among energy networks; (iii) develop data visualization tools to raise awareness and encourage the engagement of final users. Energy management and technological flexibility assets are demonstrated in two complementary and advanced demo sites to demonstrate the integration of existing and innovative technologies as well as possible barriers to their application throughout the whole energy value chain (from generation to final users).

2.2. COMPILE

COMPILE [3], an EU-funded project that began in November 2018 and that is led by the University of Ljubljana, includes 13 EU partners and 2 international partners from India and China. The main aim of the project is to demonstrate the opportunities offered by remote areas or areas weakly connected to the grid—the so-called energy islands—for the decarbonization of energy supply, community building, and creating environmental and socioeconomic benefits. These opportunities have been demonstrated at five pilot sites with the help of six COMPILE tools. The findings from the pilot sites taking part in the project have led to the creation of toolsets that have the potential to empower other communities to take on their local energy systems with large or even entire shares of renewable energy. Six COMPILE tools that cover both the creation and running of energy communities, as well as technical solutions for the operation and management of local energy systems, were developed. Newly established tools were used in one of COMPILE's main pilot sites, Luče in Slovenia. The outcomes of the project have shown that there is a low-cost way to unlock the “hidden power” of existing networks. Namely, technical tools have enabled the installation of an additional 102 kW PV instead of a 10 kW one, which was an initial foresight and suggestion by the DSO. All of the nine new PVs were equipped with a smart controller—HomeRule, built by the COMPILE project partner—as well as with its curtailment algorithms. With the installation of a community battery, the COMPILE partners were the first in Slovenia to set up and test the island mode operation on a low voltage level that can provide power for 2–3 days depending on the weather. The use of the battery in island-mode operation can also power communication towers and fire stations, as well as permitting the operation of critical infrastructure in the case of extreme weather events, thus improving the safety of the whole town of Luče.

2.3. MERLON

MERLON [4] has developed an integrated local energy management system (ILESEM) to support distribution grid operation in a high-renewable scenario. The solution puts prosumers at the center, preserving their comfort and individual preferences while creating a win–win situation among the members of a local energy community and other involved

stakeholders. ILESEM performs multi-level optimization while enabling the realization of novel business cases. The MERLON tool suite combines: (i) An IoT solution at the prosumer level that enables gathering the real-time data of indoor environmental conditions and appliance operations; (ii) A number of back-end systems incorporating the algorithmic framework responsible for the optimal coordination of the various DERs within the local energy system (LES); (iii) A number of user-friendly UIs that target different actors of the LES value chain—i.e., prosumer, aggregator, and DSO.

The integrated MERLON solution can be exploited in various business scenarios. It enables the LES to provide balancing and ancillary services as well as allowing it to participate in wholesale energy markets, which may reduce energy costs of LES consumers through time-varying energy prices, for instance. It can be exploited in the area of distribution network management with the objective of supporting the economic operation and development of a local distribution network by limiting power flows and thus mitigating thermal and voltage constraints. The MERLON solution may also be utilized to increase the security of the supply by enabling emergency islanding operation, thus minimizing the load shedding required and the inconvenience costs that frequently occur during emergency conditions. The MERLON solution and underlying community-based business models are currently being demonstrated in two pilot sites in Europe (Austrian/Strem and Spain/Crevillent), while its replicability potential is being evaluated at the European and international levels, with a focus on the Indian energy context.

2.4. IElectrix

The IElectrix project [5] is a response to the Horizon 2020 Call of the European Commission “Integrated local energy systems (Energy Islands)”. The main objective of the IElectrix project is to develop innovative technical solutions and tools in order to: (i) Accelerate the integration of renewable energy sources into distribution networks in regions where networks need to be reinforced—so-called energy islands; (ii) Prepare and facilitate the implementation of local energy communities.

In this context, 15 European partners and 1 Indian partner have designed and implemented 5 real-scale demonstrators coordinated by distribution system operators implementing embedded electric island systems in Austria, Germany, and Hungary as well as an urban microgrid in Delhi, India. Enedis is the IElectrix project coordinator, while E.ON is the project director. The project started in May 2019 and will be completed in October 2022 (42 months). Among the innovative solutions developed for IElectrix, Odit-e designed a low-voltage network digital twin model built from smart meter measurements for the Indian demonstration. This empirical model reproduces the exact behavior of the LV grid without any network component information such as cables type/length, network topology, or GIS. The use of this digital twin enables the development of three different business cases in this project: (i) network identification and analysis (through a webapp, the local DSO will be able to visualize the correct topology of the LV grid); (ii) network PV capacity (in the same webapp, the local DSO will have the ability to visualize the installed PV production for each meter, as well as the available capacity for each meter, each feeder, or the whole substation); (iii) real-time state estimation (with more data, such as forecasted weather data and HV/MV substation data, it is possible to gain a precise estimation of the state of the grid 24 h ahead. This will be used by the DSO to build a demand response program where flexibilities are sent to the consumers 24 h ahead and where their engagement is continuously monitored in order to optimize the program).

3. Key Findings and Conclusions

While presenting their solutions and tools for facilitating the enhancement of energy communities, these four projects highlight a common vision of the potentialities and barriers existing for the future role of LECs in the energy transition in Europe. The common ground on which these projects are based is that the decarbonization of districts and cities will require a high share of decentralized non-programmable renewable energies. The ever-

increasing share of non-dispatchable renewable energy is creating challenges for the (local) electric grid in terms of congestion management and power quality. LEC can strongly contribute to the decarbonization of districts and cities and the tools presented should help the advances in this direction by proposing solutions that address different technical and societal aspects. Four main findings can be identified after the workshops. First of all, future smart energy systems require a high flexibility in terms of final energy use in order to deal with the uncertain production of RES. The second outcome is that this flexibility can be achieved in two main ways: by maximizing sector integration and by involving citizens in flexibility programs. This can also be achieved through aggregators. The third finding is that citizens need to be empowered to participate in flexibility programs: even if technical solutions are available, there needs to be a strong focus on social aspects (citizen involvement, technology acceptance, etc.). Finally, future smart energy systems need to be designed, which means that local energy planners and local policy makers need planning tools that are useful for envisaging how the present energy system can be decarbonized in the future by means of emerging technologies such as storages and EVs. This will probably also require the definition of new architectures and new means for the control of energy systems.

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