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Demand-Response Optimization in Buildings and Energy Communities, a Case in Value Stacking †

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Abstract: In this paper, the application of demand-side flexibility to residential users and energy communities is discussed. From the H2020 project HOLISDER, it appears that selected Key Exploitable Results are not commercially interesting on their own as flexibility services but certainly are an add-on by cross-value stacking to regular energy services. For groups of prosumers, such as energy communities, cross-stacking can enlarge the awareness and commitment within the communities and, therefore, play an important role in the uptake of citizen communities as promoted by the EU Green Energy Package.

Keywords: demand-response flexibility; energy communities; cross value-stacking

1. Introduction

The energy system plays an essential role in our society while forming the backbone of the economy. Nowadays, the energy industry has to deal with growing electrification of applications and of the integration of an accelerating uptake of renewable energy resources. The implication of both these trends creates big challenges for energy network parties. The system operators have to deal with network congestion caused by the decentralized power generation. Further, the network operators face system instabilities with power balance due to the irregularity of the power production. Besides the need to tackle the impact of these trends on the performance and quality of the energy grid, one also sees the opportunity for creating value for a broad set of stakeholders. Here, one has to think of value not only for network operators but also for building owners, residential prosumers, and local energy communities [1].

Naturally, congestion problems can be relieved by enlarging the capacity of the power grid. However, this comes with significant investment costs, and moreover, does not solve the balancing problems. Fortunately, by active demand response programs, prosumers may change their demand. Their available demand-side flexibility, offered to system and network operators, can support in dealing with imbalance or congestion problems. Offering demand-side flexibility has an economic value for prosumers.

In the last few years, demand response has been proved technically and economically viable for large commercial and industrial prosumers but for residentials and tertiary users (for example,

building owners), it is still under development. Many residential pilots have been set up to demonstrate that, together with adequate technology, flexibility on the demand side works but the introduction of business applications is besides an uptake for EV charging rather slow.

The H2020 project HOLISDER [2,3] has been working on a business accelerator for these residential user groups by developing an interoperability and data management framework. Based on this solution, a number of products and services (Key Exploitable Results) have been selected for market segments like aggregators, retailers, ESCos (Energy Service Company), and facility managers. Related Business Innovation Plans with financial projections show that while the key HOLISDER products are very useful in flexibility value chains for residentials, these products are not commercially interesting on their own as flex products but moreover are interesting as cross value stacking, add-on services like energy efficiency advice and smart maintenance.

In this paper, the concept of flexibility services and its value stacking is described. Furthermore, some key exploitable HOLISDER products for flexibility value chains are presented where residential prosumers and hence energy communities are involved. The induced cross-stacking enlarges the awareness and commitment within the energy communities and so plays an important role in establishing citizen communities, as expressed in the EU Green Energy Package [4].

2. Demand Response

2.1. Flexibility Services and Its Actors

Demand Response (DR) relates to programs that stimulate prosumers to make short-term changes in their energy demand. Necessary for DR is the availability of flexibility at prosumer level: The ability of devices and applications to adjust the power it may take out of the grid, the power it may feed into the grid over time or both [5]. These flexibility services can be categorized along two types of stimuli. The short-term responses triggered by price signals from the energy market belong to the domain of Implicit demand-side flexibility. The other domain, Explicit demand-side flexibility, covers flexibility services initiated by an energy party, e.g., by the Balance Responsible Party (BRP) or the system operators: Transmission System Operator (TSO) or Distribution System Operator (DSO).

For a good understanding of who can profit from demand-side flexibility and how it can be delivered, the positioning papers of the USEF (Universal Smart Energy Framework) Foundation [6,7] prove to be very useful. In the USEF role model for the implicit case, the prosumer is served by ESCos. Here, prosumers optimize in-home (self) consumption or generation towards grid connection limits. In the explicit case, the aggregator party plays a central role between the prosumers (providing flex) and the requesting energy parties mentioned above (BRP, DSO, and TSO). The aggregator accumulates the flexibility from several prosumers and offers it to different markets. For a general business perspective on the provision of flexibility services, see [8].

2.2. Value Stacking of Flexibility Services

To enhance the economics of investments in flexibility value chains regarding new technologies, one may bundle services. For example, in the explicit flexibility case, aggregators can maximize value by providing multiple flexibility services to one or more market parties based on one portfolio of accumulated flexibility from a set of prosumers. Such stacking of flexibility services is possible on different levels, such as in time, in pools, and by double serving. For more details, see [9]. In the implicit flexibility case, one has for prosumers the add-on value of stacking flexibility services. On top of regular energy generation or consumption, the offering of newly developed energy services, like insights, is a bonus for prosumers: They can get, for example, more comfort, obtain smart maintenance, or obtain less energy-related (operational) costs (energy efficiency). In this paper, this type of value stacking is addressed as cross-value stacking.

3. Exploitable Products for Demand Response Optimization

3.1. Approach of the HOLISDER Project

The H2020 HOLISDER project [2] addresses the development of a holistic DR optimization framework that enables actors in the flexibility value chain to use and combine effective tools for unlocking flexibility of residential and small commercial buildings and thus realize viable business models. The developed products and services have been evaluated in real-life conditions at four different pilot sites with a mix of building owners and occupants, energy retailers, aggregators, and facility managers. The entire HOLISDER System is based on an "open" and modular end-to-end interoperability and data management framework, which enables open standards-based communication along the DR value chain.

The HOLISDER tools that have been developed provide solutions allowing the energy consumers to step into volatile real-time energy market tariffs, complementing them with Critical Peak Pricing (CPP) and Peak Time Rebate schemes (PTR) to address critical situations in energy networks and demand-supply balancing operations. The tools enable personalized and context-aware guidance to consumers, reducing energy bills, enhancing self-consumption without compromising their comfort or indoor environment quality. Moreover, integrating and interoperability technologies have been adapted and used to manage DR optimization functions in residential and non-residential buildings.

3.2. HOLISDER Business Innovation Models for the Flexibility Value Chain

In the HOLISDER project, a number of key exploitable results have been identified for a holistic DR optimization Framework and System. Below, three of these exploitable products are described as relevant for residential prosumers and for energy communities representing a group of these prosumers.

1. The *HOLISDER Facility Flexibility Management* is a tool for ESCOs and Facility Managers that breaks down the global flexibility requirements into the flexibility that can be offered by each distinct load at the consumer side. Moreover it automatically dispatches the appropriate control signals and actions over these specifics, either upon approval of the consumer (in implicit demand response) or through direct load control (in explicit demand response). This product consists of the Building Monitoring and Control Dispatch Module, Virtual Thermal Energy Storage, Demand Flexibility Profiling Engine, and the End-User visualization platform.
2. The *HOLISDER Energy Tariff Emulator* is an application for ESCOs, aggregators, retailers, and facility managers. It collects and analyzes wholesale energy price data, renewables output, along with information about energy network constraints, to produce real-time retail price estimations. In doing so, it promotes the use of implicit DR programs to energy consumers. The informative billing will be offered to consumers in order to promote the use of DR programs.
3. The *HOLISDER Visualization Toolkit* consists of a broad range of web-based interfaces and multi-purpose dashboards that use an intuitive Human-Machine Interface technique. These apps allow different parties in the Flexibility Value Chains, such as ESCOs, retailers, aggregators, and facility managers, as well as the consumers, to analyze, monitor and support decision-making with respect to the energy consumption assets contained at the residential places. Through the real-time monitoring of these assets, effective DR campaigns can be addressed by detecting where to use flexible energy consumption for prosumers or for local energy communities. This information about add-on profitable energy efficiency will be displayed as web-based and visual analytical information to the parties. The consumer-specific part of the kit is used for visualizing the explicit DR scenario, offering a user interface to the end-user for increasing awareness and providing insights on consumption patterns and flexibility potential. The kit may also be used for implicit DR, allowing consumers to set up individual rules for the control of specific devices and align them with variable tariff levels.

4. Leveraging Energy Communities

4.1. The Enhanced Role of Energy Communities in the Market

The Clean Energy Package (CEP) establishes a new type of energy market entity as a consumer empowerment and engagement mechanism, namely the so-called Citizen Energy Community (CEC), see [4]. Indeed by explicitly asserting that CECs are to be "allowed to operate on the market on a level playing field" [4], CEP provides the foundation of the regulatory and legal framework for consumer initiatives and communities to become a key stakeholder in the energy market. In particular, these communities may choose besides their retailer an independent aggregator. Therefore, the CEP gives the ongoing energy transition efforts a much-anticipated boost towards sustainable implementation and widespread adoption of its practices. In doing so, the role of energy communities goes beyond simply providing a way to organize citizens that wish to cooperate in energy activities based on open and democratic participation. It also provides citizens with tangible means to enact market incentives and actively shape related products and services. The reinforced importance of CEC can reinstate business opportunities that would otherwise fail or simply stagnate since their business case value from a purely financial perspective may not be viable. However, a CEC can also embody such additional driving forces as social cohesion, member acceptance, and community well-being. These driving forces can, therefore, guide decisions and promote business case continuous viability by bundling seemingly unrelated services to end up with a competitive and holistic value proposition incorporating social, economic, and environmental dimensions.

4.2. Stacking of Services in Energy Communities

Within the context of a CEC, its members can extract added value by stacking various services that match the community's local needs, both short- and long-term. A CEC may choose to act as its own aggregator and pursue a role within the different flexibility markets. Or it may simply actively manage and collectively optimize its self-consumption and generation towards, for example, realizing in practice a Positive Energy District (PED) in the case of a geographically bounded community. Going a step further, a CEC established within a PED can essentially use their leverage to negotiate better (tax) terms and tariffs since it can be perceived from typical grid operators as a virtual single point of delivery. Besides, investing in renewable energy and related infrastructure is becoming both more attractive and affordable for the community as a whole, promoting further its social cohesion and democratizing expenses in dealing with energy poverty in particular, thus, ensuring its members' continuous commitment. In case the value from flexibility services may not be enough to guarantee successful and continuous uptake, creating bundles with services related to, for example, mobility ("kWh for km") can provide the necessary counterbalance. In the EU H2020 project, POCITYF, peer-to-peer energy trading is considered as a community-based mechanism where earned energy quota may be exchanged as a voucher for use in (public) transportation [10].

4.3. An Illustrative Example

The HOLISDER Visualization Toolkit (see Section 3.2) may serve as an illustrative example of the discussed cross-value mechanism. Here, we consider the situation where energy parties contract energy communities as an entity (grouping a set of united prosumers). Communities are not energy specialists, so the visualization apps can help them to avoid a third party.

For setting up Demand Response campaigns, different parts of the visualization toolkit may support flexibility actors with their specific responsibilities and functionalities. The aggregator/ retailers' part oversees the assets' energetic monitoring and historical measures of the entire portfolio. In addition to this, Explicit and Implicit Demand Response ongoing and finished campaigns are depicted in terms of the different clusters formed in the community. This platform also allows the actor to have information regarding the historical and day-ahead wholesale prices. On the other hand, the ESCos and facility managers part gives insights to these parties regarding the energy consumption and production as well as maintenance actions and abnormal situations at the

location. In addition to this, the application will display the Energy Cost Calculator. Finally, the Consumers Application is focused on both final consumers and prosumers. This tool provides energy consumption and production information for the residential place, just as the user's flexibility in the Demand Response participating events. The Energy Cost Calculator is also available in this application, enabling the user to define their consumption routines. Thus, the Visualization Toolkit gives analytical insights as an add-on service to flex providers and to the community as an entity, e.g., showing profitable trends. Therefore, the community can make collective decisions to grow as a company.

5. Conclusions

By researching the details of the Business Innovation Models, based on the related value propositions and targeted segments, the identified HOLISDER key exploitable products for residential consumers appear to be interesting as add-ons, see [11]. That is, for residential consumers, the HOLISDER products are not fully commercially interesting (e.g., regular households obtain an extra or savings of the order of 100 euros/year) on their own as flexibility products or services but certainly are useful by (cross-value) stacking to regular energy services, e.g., providing insight in energy usage. Thus, flexibility services can be seen as a bonus for small prosumers.

For energy communities, where energy parties can contract them as an entity relevant HOLISDER products may add cross value by creating social cohesion and awareness while ensuring the commitment of their community members.

Note that the policies mentioned in the CEP give CECs ample space for shopping around for flexibility products and their providers. Furthermore, if a community is large enough, it can act as its own retailer or aggregator (see Figure 1). To conclude, the cross-value stacking of flexibility products as promoted within HOLISDER, can be an important driver for the uptake of CEC as envisioned within the EU.

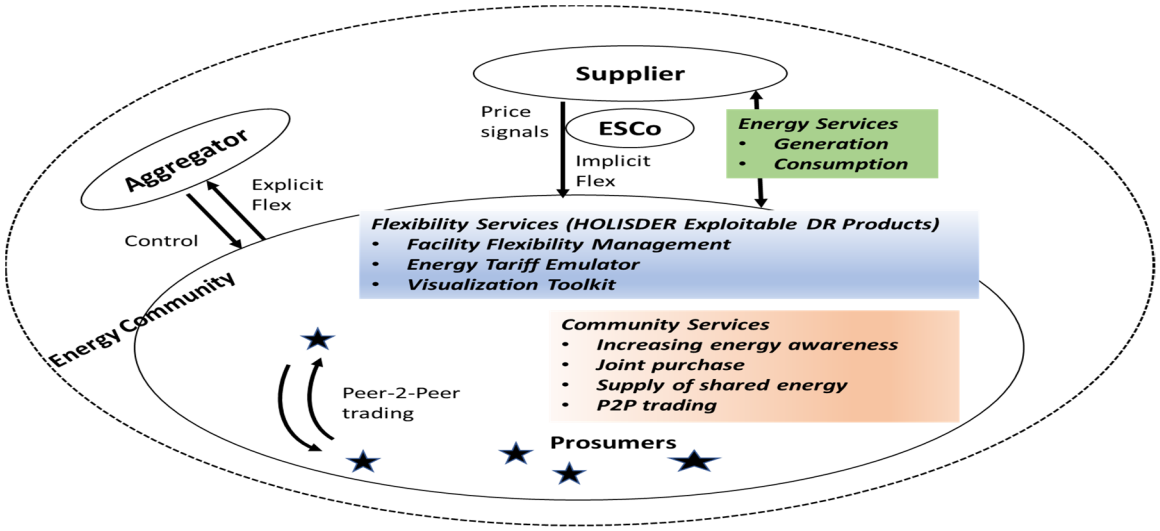

Figure 1. Overview of services related to Energy Communities: *Community Services* offered to its own members (prosumers), *Energy services* and stacking *Flexibility services* that Energy parties can offer to the community as a whole. The dashed contour illustrates the situation where the energy community takes on the roles of the energy parties itself (Figure is adapted from [12]).

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