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HOLISDER Project: Introducing Residential and Tertiary Energy Consumers as Active Players in Energy Markets †

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Abstract: Although it has been demonstrated that demand-side flexibility is possible, business application of residential and small tertiary demand response programs has been slow to develop. This paper presents a holistic demand response optimization framework that enables significant energy costs reduction for consumers. Moreover, buildings are introduced as main contributors to balance energy networks. The solution basis consists of a modular interoperability and data management framework that enables open standards-based communication along the demand response value chain. The solution is being validated in four large-scale pilot sites, which have diverse building types, energy systems and energy carriers. Furthermore, they offer diverse climatic conditions, and demographic and cultural characteristics to establish representative results.

Keywords: energy efficiency; demand response; interoperability; energy management system

1. Introduction

The European Union (EU) aims to move towards a low-carbon economy and contribute to the mitigation of climate change following its commitments with the Paris Agreement. Under this context, one of the key targets is the increase uptake of renewable energy sources to reduce greenhouse gas emissions [1]. As a consequence of this large-scale integration of renewable and distributed energy sources, the European energy market is evolving towards a less predictable, more decentralized and flexible-to-operate market. Therefore, Demand Response (DR) schemes are becoming more popular, with commercial and industrial DR already being technically and economically viable. However, residential and small tertiary resources are still excluded from the market, even though European energy policies aim for consumer empowerment in the energy market [2].

Moreover, buildings can provide different sources of energy flexibility and storage for the distribution and transmission system operators to balance the available supply and manage the quality of the electric power [3]. Therefore, the challenge needs to be the integration of DR enabling technologies into building energy management systems (BEMS). That way, building-energy system interaction is viable for optimising energy consumption, production and storage at building level, considering availability and price of the energy at each time. Additionally, it is also necessary to ensure interoperability between BEMS and different Smart Home devices, beyond brands, technologies and/or standards.

There still remain several key enablers that need to be satisfied to benefit from the huge potential and enhance the commercial viability of Demand Side Flexibility offered by the building sector, while maximizing its value for both prosumers and energy market stakeholders.

2. Conceptual Solution

In response to the aforementioned challenges and needs, this paper presents the HOLISDER project. HOLISDER introduces a holistic demand response optimization framework that enables significant energy cost reduction on the building/consumer side. Additionally, small and medium-sized buildings (residential and nonresidential ones) are introduced as major contributors to maintain the energy networks' stability through optimized energy management. HOLISDER enables:

- Energy costs savings for energy consumers;
- Creation of new revenue streams for energy consumers;
- Promotion of self-consumption for prosumers;
- Utilization of the energy storage capacity of buildings;
- Encourage consumers to participate in DR programs;
- Promote consumers' participation in energy markets;
- Enhance operational stability and security of energy networks;
- Replicability across different building types and energy systems;
- Adjustment to demand response regulations around EU Member States.

The basis of the solution consists of an open and modular end-to-end interoperability and data management framework that enables open standards-based communication along the demand response value chain. In more detail, the interoperability and secure data management framework couples two major technologies/products to ensure the integration, communication and operation on top of any building and district energy management system, as well as Smart Home systems and devices.

Implicit demand response stands at the forefront of the demand response optimization framework. Dynamic and real-time energy tariff schemes are available to consumers to modify their energy consumption patterns and shift them away from peak periods. These represent the first step to empower and engage consumers in the participation in energy markets.

However, it is necessary to ensure enhanced and long-lasting engagement facilitating consumers' participation in the market. To this end, a series of innovative solutions and applications are introduced in HOLISDER to enable: personalized informative billing, human-centric energy management and control decision support, scheduling and automation, self-consumption promotion, cost-effective storage, and predictive maintenance advising.

3. System Architecture

The architecture of the framework is presented in this section. The HOLISDER solution requires the definition and implementation of a novel software and hardware system. This system will enable real-time communication and data acquisition from the premises of the consumers, quick and accurate processing and analysis of the data, and finally, the consistent and on-time propagation of price and/or control signals from the retailer or aggregator to their customers.

To this extent, the system architecture comprises three main component layers, each containing different modules to provide the required functionalities. Figure 1 introduces the detailed architecture of the HOLISDER system showing the communication details among the three layers, as well as the different modules that compose them. In the following subsections, the function of each layer is presented.

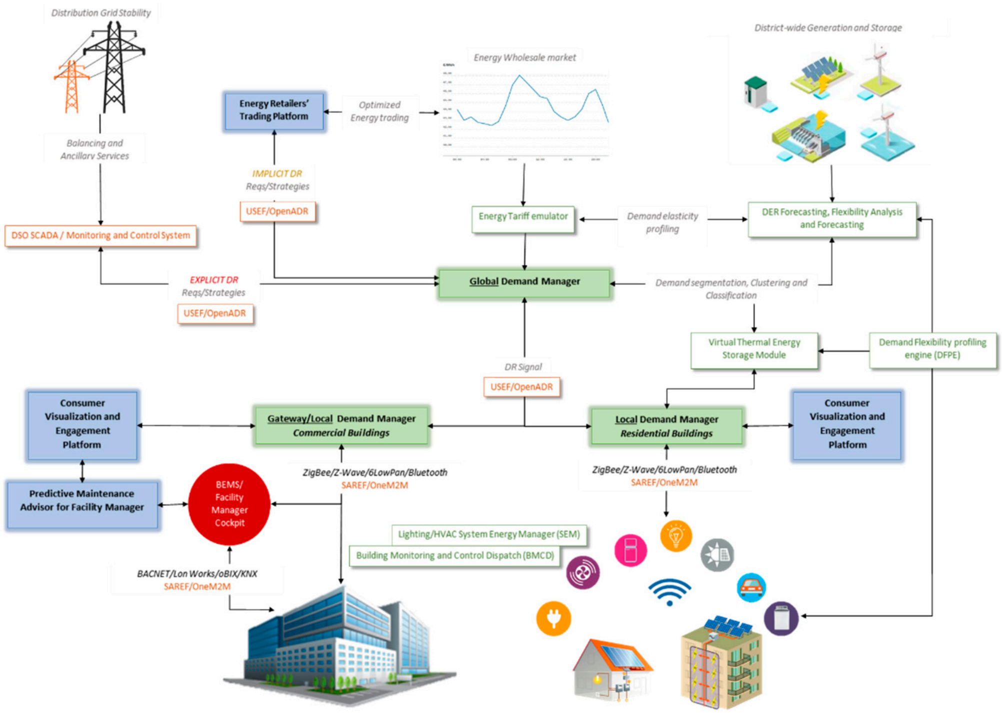

Figure 1. Detailed representation of the architecture of the solution.

3.1. The Interoperability and Secure Data Management Layer

The objective of this layer is to ensure technical and semantic interoperability across the DR value chain using and developing well-established open standards and protocols. The layer is the central piece of the presented solution, responsible for the communication and storage of the historical sensor data. The main component of the layer is a modular Enterprise Service Bus (ESB). The ESB contains a Message Oriented Middleware (MOM) and two gateways to ensure the integration, communication and operation between BEMS and Smart Home devices. The two gateways are: JACE gateway that enables the interoperability between most of the commercial BEMS and building control protocols, and EF-Pi gateway that ensures interoperability with Smart Home protocols and devices while enabling optimized energy management at building level with the integration of the required intelligence functions [4].

3.2. The Holistic Demand Response Optimization and Control Dispatch DSS Layer

This layer comprises two types of managers, the Local Demand Manager (LDM) and the Global Demand Manager (GDM).

3.2.1. Global Demand Manager (GDM)

In the GDM the high-level optimization of aggregated volume of flexibility is made. It also provides tools to assist in deciding the processes for transferring the required flexibility for consumers' benefit. It offers processing and analytics engines, user interfaces, and displays the necessary functionalities to the retailers and the aggregators.

3.2.2. Local Demand Manager (LDM)

The LDM performs three primary functions: Computing demand flexibility and/or elasticity, sending flexibility requests to the HVAC and lighting devices, and finally, monitoring the progress of a DR event to identify if it is satisfied or not.

3.3. The Visualization Platform and End-User Toolkit Layer

The last layer is the user interface of the framework. It is based on previously developed and validated tools configured to fit in the presented interoperable framework. Interfaces are available both on web and mobile using intuitive human machine interface (HMI) techniques. Each interface is presented as a multipurpose dashboard adapted to fit the needs of the different actors involved in the demand response value chain.

4. Validation Framework

The solution is being evaluated over a period of 12 months and validated in real-life conditions by a large and diverse population of residential and commercial consumers in four dispersed geographical areas: Greece, U.K., Finland and Serbia. Building occupants, energy retailers, aggregators and facility managers continuously remain at the heart of design, development and validation activities. The selected validation sites exhibit diverse characteristics (climatic, cultural and demographic) to ensure a representative validation process, while ensuring a high replication potential around the EU [5]. Finally, the scale of the prominent pilots, the diversity of involved stakeholders and the population size actively involved establish the necessary critical mass upon which the large-scale promotion and uptake of the solution is pursued.

5. Conclusions

This paper presents a novel solution that introduces residential and tertiary energy consumers as active players in energy markets, ensuring significant benefits through their engagement in implicit human-centric demand response programmes. The solution enhances the intelligence of BEMS and Smart Home systems with the integration of information and communication technologies. With these technologies DR is optimised, and predictive maintenance functions are incorporated. Furthermore, the solution delivers an open standards-based modular solution that ensures end-to-end interoperability between smart grids, BEMS and Smart Home devices. Finally, the adoption of the solution as a next-generation DR optimization framework is promoted by validating the solutions in real-life environments and ensuring enhanced consumer engagement in demand response.

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References

1. United Nations Paris Agreement, UN, France, 2015. Available online: https://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf (accessed on 10 January 2021)
2. Smart Energy Demand Coalition. *White Paper: Empowering Residential and SME Consumers*; SEDC: Brussels, Belgium, 2016. Available online: https://smarten.eu/wp-content/uploads/2016/10/SEDC-White-Paper-Empowering-Residential-and-SME-Consumers.pdf (accessed on 10 January 2021).
3. Internation Energy Agency (IEA). *Examples of Energy Flexibility in Buildings: Annex 67 Energy Flexible Buildings*; IEA-EBC: Paris, France, 2019. Available online: https://www.annex67.org/media/1894/examples-of-energy-flexibility-in-buildings.pdf (accessed on 10 January 2021).
4. Konsman, M.J.; Wijbrandi, W.E.; Huitema, G.B. Unlocking residential Energy Flexibility on a large scale through a newly standardized interface. In Proceedings of the 2020 IEEE Power & Energy Society Innovative Smart Grid Technologies Conference (ISGT), Washington, DC, USA, 17–20 February 2020; pp. 1–5.

5. Eguiarte, O.; Garrido-Marijuán, A.; de Agustín-Camacho, P.; del Portillo, L.; Romero-Amorrortu, A. Energy, Environmental and Economic Analysis of Air-to-Air Heat Pumps as an Alternative to Heating Electrification in Europe. *Energies* **2020**, *13*, 3939.