Data exchanges for the system integration of consumers: assessment of available standards and protocols

smartEn Position Paper

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Introduction

As the EU transitions from the traditional centralised energy system to a decentralised, digitalised and decarbonised system, Demand-Side Flexibility (DSF) is a crucial, reliable and cost-effective resource whose potential needs to be untapped. The accelerated electrification of end-use sectors and parallel increase of renewable generation will increase the system flexibility needs on average by 133% across Member States between 2021 and 2030. Comparing 2050 to 2030, a further increase on average by 250% is needed in the EU[1]. This increased volatility requires a rethink on how the energy system is managed, enabling and rewarding consumers for using their Behind-the-Meter (BTM) Distributed Energy Resources (DERs)[2] to (automatically) adapt their energy management strategies to different (implicit and/or explicit) signals[3].

This consumer-centric evolution is both a green and digital transition: data exchange is the foundation of a seamless interaction of consumers with the energy system they are part of. The activation of consumers' flexibility extensively relies on data flows and seamless communication between DERs, market players, system operators and traders.

But what are the crucial data flows required to activate consumers' flexibility?
Are the standards, protocols, ontologies already available to support them? Which are the best performing ones?
Is interoperability between standards a challenge for flexibility?

This Position Paper aims to reply to these questions and navigate through the multitude of standards, protocols and ontologies for data exchange to ensure that the flexibility of consumers and prosumers can be activated. The situation is made more complex by standards were developed at different times and with different purposes by various standards development organisations resulting in a fragmentation and segmented approach.

smartEn has selected and mapped a few of data exchange standards and protocols that support crucial data flows. This effort aims at supporting market players, system operators, power exchanges and regulators in the identification of the best data exchange standards and protocols as well as derive reference data structures and ontologies to be able to map data exchanges across business domains. While it seems rather obvious that a single standard cannot fit all domains, the objective of the paper is to provide an improved mapping of the relevant sets of standards to be considered in each business domain to foster interoperability and consent-based data sharing.

Identification of four data exchange flows

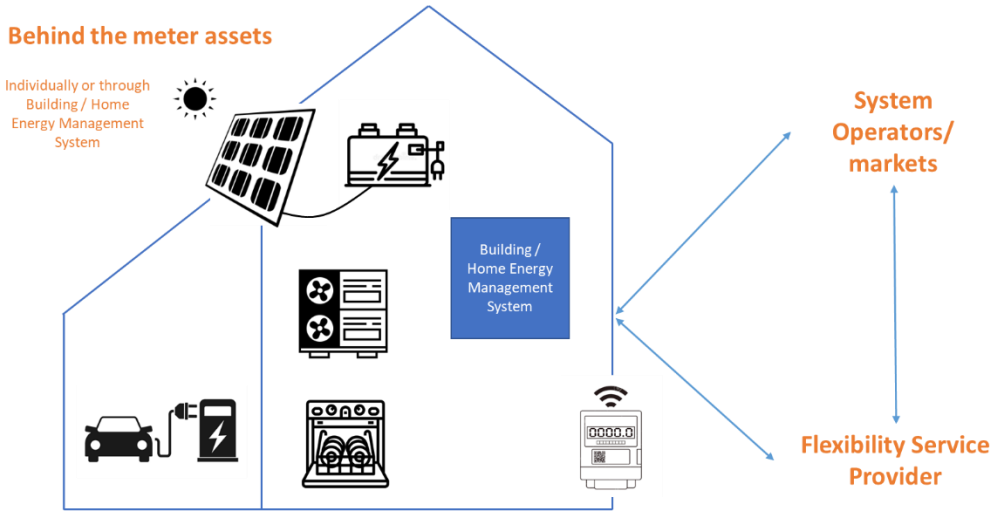
Data exchange implies the access and sharing of relevant, essential data to activate the flexibility of consumers and prosumers. Data sharing and access should not be limited to end-users, but should involve also system operators, market players and power exchange platforms.

For the sake of simplicity, the following 4 data exchange flows have been identified as crucial ones to unleash the DSF potential, as outlined in the image below. For this effort we looked specifically at residential and non-residential buildings, not industrial consumers.

[1] Speech by Commissioner Kadri Simson at smartEn's Smart Energy Summit 2023 https://ec.europa.eu/commission/presscorner/detail/en/SPEECH_23_2367

[2] With BTM DERs we do not consider only individual devices such as white goods, heat pumps, EV chargers, etc, but also include Building Energy Management Systems (BEMS) which allow an optimal operation of a building by ensuring communication among individual BTM assets.

[3] Implicit reaction to dynamic retail prices and Explicit participation to TSO/DSO markets, wholesale electricity markets



- **Between Behind-the-Meter (BTM) DER assets**

DERs can consists of different types of flexible devices such as white goods, heat pumps, home batteries, V1G or V2G chargers, as well as Building Energy Management Systems (BEMS). BTM data exchange flows relates to the ability of DERs to communicate between themselves.

Each BTM DER assets can interact either individually and directly through dedicated Resource Operators, or they can be integrated through BEMS which allow an optimal operation of a (non-residential) building by ensuring communication among individual BTM assets. These data exchanges are key to automate DER response to implicit signals such as price, grid congestion alert, the 24-7 carbon footprint of the delivered electricity as well as explicitly to provide the data for the necessary submetering and baseline calculations for the flexibility service providers to bid the associated DER's flexibility into markets.

- **Between BTM DER assets (individually or via BEMS) and System Operators**

Some DERs offer fast response flexibility services which, in some exceptional grid stability emergency cases, require direct connection with grid operators for observability purposes, as already defined through the ACER Grid Connection codes for larger front the meter DER assets.

- **Between BTM DER assets (individually or via BEMS) and Flexibility Service Providers**

End-users may decide to contract the procurement of a flexibility service from one or several flexibility service providers (FSP) for one or more of their DERs, including via a BEMS. This data flow is looking at standards and protocols available which allow smart management of BTM DERs by FSPs.

- **Between Flexibility Service Providers and System Operators/markets**

To be able to sell the flexibility pooled by FSPs, each FSP depends on external signals received from System Operators (SOs) and price information from wholesale markets. On the other hand, to ensure the management of the power system, SOs need information on the flexibility available from FSPs. Harmonization of the standards used for flexibility market interfaces is key to this data flow to enable the exchange of data in real-time to untap flexibility potential and accelerate deployment of FSPs at Pan European level.

Selection of standards, protocols and ontologies for each data flow

For each data exchange flow, smartEn assessed existing ontologies, standards and protocols. The following ones have been identified as the best performing ones:

- **Between BTM DER assets**

SAREF, the Smart Appliances REFerence, is an ontology to create a shared model of DER data structures to enable interoperability in the smart appliances domain enabling the communication between in-home devices while keeping the option to use different protocols and standards depending of the type of DER to be interfaced. SAREF provides a common language for communication among BTM DERs, by aligning the data definitions adopted by multiple industries involved in same home/building environment.

The latest published version of SAREF, SAREF 2.0, includes an extension for the energy domain, called SAREF4ENER. It is complementary to the CIM ontology which is used for front-of-the-meter communication flows (more about it in following chapters), but they are not yet fully aligned.

smartEn believes that standards addressing individual BTM assets should be aligned with SAREF4Ener ontology and DER object definition to enable interoperable communication among them. Among available standards, the following ones are the most commonly used today and should be particularly prioritised:

- **IEEE2030.5 and IEC 61850-7**

IEEE2030.5 and IEC 61850 originated out of the need for protocols to organise and control distributed energy resources by system operators. In the meantime, they have become important standards for the exchange of information between resource operators- and consumer-oriented IoT devices with a relevance for the energy system. This standard has high relevance to support a wide range of operational functions as mandated by connection codes particularly which make them a perfect fit for smart inverters integrating storage and PV applications.

- **Zigbee**

Zigbee has historically been developed for home automation enabling all devices to securely connect and interact with approximately 5,000 certified products. Especially newer Zigbee devices already support the Zigbee data structure, known as Smart Energy Profile 2, which is partially aligned[4] with SAREF4Ener: it is currently only enabling the modelling of simple power and flexibility profiles, thus limiting its use for more complex flexibility activations (such as for storage and grid ancillary services).

- **EEBUS**

The EEBUS initiative was originally intended for home appliances, but it is now expanding into new DER domains such as EV smart charging equipment potentially allowing more complex control profiles (implicit price based controls, fast frequency controls as well as advanced voltage and reactive power controls). The EEBUS data structure aligns with SAREF4Ener.

- **KNX**

The KNX standard has been dedicated to the home and building automation domain for operations such as building control access, lighting as well as heating, ventilation, air conditioning, and household appliances. KNX has a very strong and well established commercial ecosystem based on many certified product and partnership agreements with installers. KNX is developing its own data ontology and it is currently not fully aligned with the SAREF4ENER ontology. Therefore, we recommend this gap to be filled to facilitate integration into future European energy data spaces and make KNX a practical and easier to use alternative for the DER communication protocols.

Another way to enable communication between BTM devices is to deploy Building Energy Management Systems (BEMS), notably in non-residential buildings. Two available standards, EN 50491-12-1 and EN 50491-12-2, are

[4] Zigbee Alliance was rebranded to Connectivity Standards Alliance (CSA). Connectivity Standard Alliance Data Model - known as Zigbee Cluster Library is a common Data Model used by several CSA standards like Zigbee 3.0, Zigbee Smart Energy Profile 1.x, Smart Energy Profile 2 and also Matter.

relevant to define five different types of characteristics for energy management relevant systems in buildings. These standards also define an interface between the building Customer Energy Management System (CEM) and the individual, asset-specific systems called Resource Manager (RM). When a BEMS is present, the reaction to external signals is handled by the CEM as the central point of interaction with the energy management related systems in a building.

- **Between BTM DER assets (individually or via BEMS) and System Operators**

In order to be able to deliver emergency flexibility directly to the SOs[5], DER BTMs (individually or aggregated via a BEMS) which have significant impact on the grid have obligations to offer direct real-time interactions with grid operators. This is particularly true for aggregated DERs equipped with smart inverters, hence the importance of considering standards designed for advanced inverter controls in this data flow.

- **IEEE 2030.5/IEC 61850-7/IEC 61850-90-8**

The IEEE 2030.5 (Smart Energy Profile 2.0) and IEC61850-7 sets of standards were created to enable the most comprehensive data exchange profiles for such emergency control interactions.

The IEC 61850 standard originally designed to manage data exchanges within substations – has recently expanded to include data exchanges outside substation boundaries. It aims to manage data exchanges with larger scale DERs including generation systems, energy storage systems, and controllable loads directly connected to distribution substations. The associated DER data exchange profiles are complementary to other FSP data exchanges to manage explicit or implicit signal exchange received from energy market participants operating into flexibility markets.

These standards are key to the development of new advanced grid optimization schemes that might evolve in response to future non-firm connections requiring grid automation and controls to interact in real time with smart inverters for fast frequency response, grid emergency controls, real-time grid constraints management or Volt/VAR optimisation through distribution feeders. The associated data models have been primarily developed out of the CIM and IEC61850 grid ontologies, since associated data structures need to be mapped according to grid structures and topologies. These ontologies remain to be mapped with BTM SAREF4Ener data structures to facilitate data integration throughout the energy value chain.

The smart charging domain is a specific DERs domain with its own standards and protocols. Recently, a new data exchange profile (IEC 61850-90-8) has been created to specifically cover data exchanges between EV Charging Point Operators from the electromobility business domain with SOs. However, charging point operators and vendors are still largely using OCPP as reference data exchange through deployment.

- **OCPP**

The Open Charge Point Protocol (OCPP) has developed an open standard that connects EV charging equipment to EV Charging Point Operators, preventing any vendor lock-in from charge point vendors. OCPP 1.6 is widely deployed and provides smart charging capabilities and extensions for specific use cases. The latest version, OCPP 2.0.1, introduced new data exchange profiles in order to enhance the remote management of the charging station and prepare for future energy management and flexibility transactions. The industry is slowly making the transition towards OCPP 2.0.1. OCPP 2.1 should be published in 2023, it will enable native V2G capabilities while staying backward compatible with OCPP 2.0.1 for previous functionalities.

- **Between BTM DER asset (individually or via BEMS) and FSPs**

In the domain of demand-side flexibility management, the majority of smartEn's members are still using proprietary data exchanges to access DER data from their operators, typically based on bespoke and DER specific

[5] They are defined as significant grid users by the ACER Grid Connection Code.

REST APIs for explicit and implicit demand-side flexibility interactions. This currently prevents any seamless plug and play integration of DER into flexibility aggregator and easy flexibility aggregator switching as considered through the new flexibility code.

Although incomplete, smartEn considers the Open Automated Demand Response (OpenADR) to currently represent the best option to further standardise such data exchanges and seamlessly integrate DERs that are directly installed by consumers on their sites into the most relevant and rewarding flexibility revenue schemes from FSPs. These data exchanges correspond to critical flexibility messages such as flexibility baselining, implicit price schedule exchanges, nomination and real-time activation.

Moving forward associated data exchanges should be improved taking advantage of on-going developments from the Technical Committee of IEC[6] for DERs enabling advanced grid interactions, particularly for DERs equipped with smart bidirectional inverters such hybrid inverters for PV and storage as well as EV bidirectional chargers. In particular progressive evolutions of the IEC62746 series – which includes OpenADR – should be considered to improve implicit price based interactions with aggregators participating into flexibility markets[7].

- **Between FSPs and SOs/markets**

FSPs and SOs need to exchange near real-time data for the submission of flexibility bids and at time of dispatch, for instance. As smartEn's primary objective is to enable pan European participation of flexibility players and lower barrier to market entry[8], smartEn advocates for the harmonization of data exchanges. smartEn proposes to do so by utilising the updated IEC 62325 model (CIM Market model) to develop pan-European pivot energy data spaces favouring data exchanges between flexibility service providers and System Operators. The information included should cover market participant registration and prequalification, grid capacity allocation, forecasting, bidding and contracting, activation, clearing and settlement.

In addition, the same IEC standard has been considered by the Expert Group 1 of the European Commission's Smart Grid Task Force. The Expert Group 1 is responsible for drafting the Implementing Act on data interoperability for demand response, which is essential to ensure data exchange consistency between market interfaces, and also flexibility service providers. To achieve this, it is fundamental to harmonise TSO balancing market interfaces through the use of IEC 62325 and expand the associated data exchanges to DSOs. This will avoid market fragmentation and ensure optimal "coordination between TSO – DSO" at both pan-European and member state levels through the use of coordinated flexibility registers. Some TSOs (such as Fingrid and Elering) and DSOs (such as Enedis) have started exploring this through the prototyping of flexibility markets.

Conclusions

With the development of new flexibility markets and the increasing number of DERs, new flexibility services are emerging, which leads to an increase in the complexity of data exchange across sectors. Interoperability of best performing standards, protocols and ontologies, as those identified and described in this paper, play a crucial role to ensure synergies between domains to fully unleash the flexibility potential from all consumers.

[6] Technical Committee 57 of IEC develops standards for power systems control equipment and systems. It includes energy management systems, supervisory control and data acquisition, distribution automation and associated information exchange for real-time and non-real-time information, used in the planning, operation and maintenance of power systems.

[7] The associated ontology is already aligned with the IEC62325 CIM data models which have started to be considered for new TSO pan European flexibility markets such the new European balancing platforms.

[8] smartEn Position Paper - Setting a digital strategy for a cost-effective decarbonisation of the energy system

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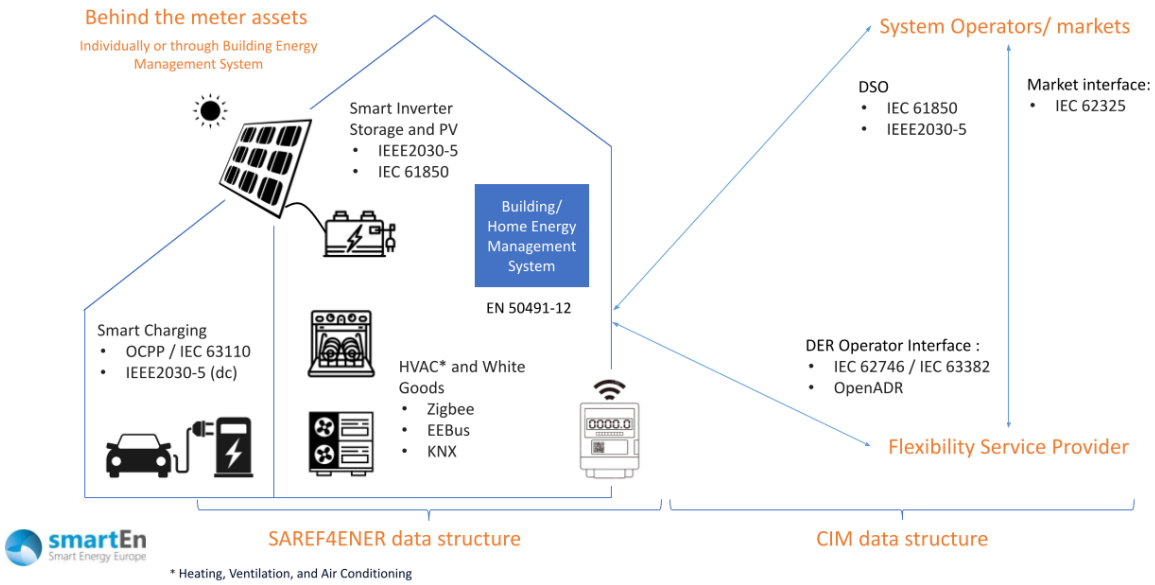

smartEn does not recommend a one-size-fits-all approach, but rather favour the use of selected domain specific data exchange standards and protocols depending on the flexibility use case and product taxonomy considered. This will ensure the maximisation of benefits from data exchange interoperability across these domains using reference data structures and ontologies to map standard interactions.

The interoperability of standard is key to unlocking the full DSF potential of consumers by allowing DERs and their associated operators to openly communicate with FSPs or SOs for the different kinds of flexibility products. We recognise that standards are still evolving in this space, and we are confident that a move towards open-source standards will be widely embraced. We also caution against picking any single open-source standard at this time, while nevertheless encouraging a set of minimum interoperability requirements. This approach will ensure that competition, innovation and improvement to standards continues to happen in this space.

We urge the European Commission to encourage interoperability of standards and protocols in view of the forthcoming new Data for Energy stakeholder working group, while ensuring coherence between different pieces of legislation regulating open data access.

About smartEn - Smart Energy Europe

smartEn is the European business association integrating the consumer-driven solutions of the clean energy transition. We create opportunities for every company, building and car to support an increasingly renewable energy system. Our membership consists of the following companies:

The positions expressed in this document represent the views of smartEn as an association, but not necessarily the opinion of each specific smartEn member.
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