GRID AND MARKET HUB: EMPOWERING LOCAL ENERGY COMMUNITIES IN INTEGRID

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ABSTRACT

This paper describes the grid and market hub (gm-hub) platform that is being developed as part of the H2020 InteGrid project and its capabilities to empower local energy communities by democratizing access to smart meter data and foster data-driven energy services. The gm-hub will bring together the interests of the electricity sector's stakeholders, which will make their decisions with better information, based on data provided by the DSO such as electricity consumption. InteGrid is working in the implementation of a local social network for contextual feedback about energy consumption in order to foster behavioural demand response in a local community.

INTRODUCTION

Distribution System Operator (DSO) needs to provide transparent access to information, which motivated the development of data exchange platform operated by the DSO or by an independent regulated entity to support new market players and business models.
The InteGrid project started in January 2017, and is due to end in June 2020. It has a consortium of 14 participants from 8 EU Member-States with EDP Distribuição (EDPD) coordination. As the Portuguese main DSO, the role of EDPD is becoming more central, given that most of the renewable energy sources are connected to the distribution grid. This includes wind and solar generation, but also grid-level storage and e-mobility charging infrastructure.
In this context, InteGrid project aims at developing and testing a grid and market hub (gm-hub) cloud-based solution to support the provision of services in a neutral standardized way between DSO and stakeholders like electricity retailers, transmission system operator (TSO), aggregators, group of consumers and energy services companies (ESCo). The main goal is to facilitate market access allowing new business models and services while ensuring efficient and secure network operation as well as highest standards of data security.
The gm-hub operates in a regulated domain, thus all the embedded services should respect the regulatory framework for data management and exchange. Furthermore, this central platform should be perceived as an enabler of third-party services that can emerge in the gm-hub ecosystem. In fact, the word "market" is much broader than the wholesale electricity market scope since it encompasses also the electricity retail market, as well as energy services trading (e.g., energy efficiency, consumer engagement, forecasting).
The innovations are produced by InteGrid: (a) hub between technical grid management functions at the advanced distribution management system (ADMS) level and grid users flexibility; (b) manage "regulated" flexibility products (e.g. home energy management system – HEMS – flexibility for grid support) in a neutral and transparent way; (c) hosts a set of services for grid-users like contracted power feedback mechanism and creates data sharing conditions for third-party services.
The remaining of the paper is organized as follows: section 2 presents a state-of-the-art review of data management models; section 3 presents the overall concept of the gm-hub and section 4 its data-driven energy services; section 5 explains the local social network concept. Section 6 presents the conclusions.

REVIEW OF DATA MANAGEMENT MODELS AND SERVICES

The Council of European Energy Regulator (CEER) in the "Review of Current and Future Data Management Models" report analysed eight European countries (NO, IT, DK, DE, NL, ES, GB, BE) in terms of data management model [1]. It highlighted the difficulties in establishing a clear separation between centralised, partially centralised or decentralised data management models. The majority of the eight countries except DK with a centralized data hub and BE with partially centralised, have a decentralised data management model. However, the future models are expected to be centralized, in some cases with decentralised storage at the DSO level (case of GB, ES and NL).
Atrias is a joint initiative of the five most important DSO in Belgium that consists in a mechanism called central market system that operates as a hub between the databases of the DSOs and the data systems of the energy suppliers [1]. The EDA initiative in Austria established a secure, reliable and standardized exchange of electronic documents over the internet related to the supplier change process and meter data from smart meters. The communication protocol is ebXML (electronic business XML).
The H2020 FLEXICIENCY project developed and demonstrated pan-European marketplace that aims at delivering services and exchange of data, tools, methodologies, in a standardized way across Europe. It operates as the hub for business deals between stakeholders (DSOs and services providers), which might implement any peer-to-peer communication flow [2]. The platform receives/submits data/service request and readdresses requests to the platforms (e.g., DSO

platforms, service platforms) where the data, services, software and tools are located. Physical data transfer is performed by point to point connected, i.e. from DSO to/from service platform and from service platform to service platform). The services are based on electricity data accessibility and can be either Business to Customer (B2C) - offered to the end users of electricity by regulated or unregulated players in the energy sector - or Business to Business (B2B) - exchanged between the aforementioned players.

Green Button is an industry-led work that provides a common format for electrical energy metering data so that electricity consumers can access their data in an easily readable and secure format. A common technical standard was developed for the meter readings and consists in an eXtensible Markup Language (XML) text file. Once customers access their data, they can share it as they choose, by independent choice and action, with those they trust. In some cases, Green Button data can be linked directly with third party software data analysis platforms and several web and mobile applications have been developed to analyse customer usage.

The neutral market access platform was developed and tested in the H2020 UPGRID project. The platform is hosted by a DSO and regulates all the interactions between the DSO and the various market agents [3]. The solution encompasses the exchange of information through this data hub, including consumption profiles from the DSO and flexibility profiles (and availability) from the HEMS. To increase scalability and to avoid collusion, UPGRID solution considers an additional system called Retailer Platform (RP) for each retailer. The RP is responsible for receiving information or requests from the UPGRID platform, process and send this information to its HEMS.

GRID AND MARKET HUB CONCEPT

Role Model

The role model of the gm-hub concept is depicted in Figure 1, where the basic interactions between the roles are illustrated. Inside the gm-hub domain, are the four DSO roles proposed in the evolvDSO project [4] and adopted by EG1-SGTF [5].

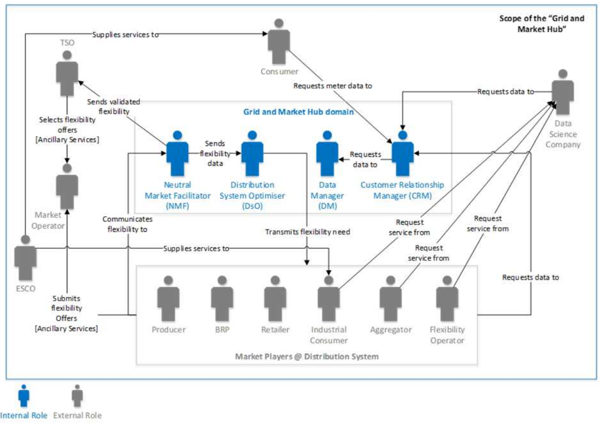

Figure 1 – Role model of the gm-hub.

The InteGrid project adopts a centralized gm-hub platform with decentralized data storage. In countries with several DSOs, it is assumed that a regulated and independent third party will assume the data manager (DM) and customer relationship manager (CRM) roles. However, the neutral market facilitator (NMF) and distribution system optimiser (DsO) roles are exclusive of each DSO since require a direct link with the ADMS system. In this scenario, this means that the NMF and DsO roles would be inside the DSO domain and the DM and CRM inside this independent operator domain and a direct bi-directional link between the two domains is needed. Furthermore, network analysis functions for flexibility pre-qualification and management might require exchange of information between multiple DSOs, which is performed via gm-hub.

Outside the gm-hub domain, the ecosystem of the gm-hub comprises multiple external roles from market players connected to the distribution system, TSO, market operator, consumer and services providers like ESCo and data science companies.

A third-party can extract business value from the services offered by the gm-hub and also offer a range of B2B and B2C services external to the gm-hub central platform. The main driver of these third-party services is the exchange of multiple types of data related to electrical energy usage and generation, considering different update rates, spatial and temporal granularity.

The gm-hub also establishes a direct cooperation between DSO and TSO for the ancillary services market, in terms of flexibility pre-qualification, activation and management, following the EG1-SGTF conceptual model [6].

Finally, another objective of the gm-hub is to enable the use of local flexibility for technical constraints management, particularly at the LV grid level (using the HEMS as gateway) where aggregation capacity is very limited and the technical problems very localized.

Main Principles

The main principles of the gm-hub follow the recommendations in "CEER Advice on Customer Data Management for Better Retail Market Functioning" [7].

Privacy and Security

Consumers have full control over the access to their customer meter data, i.e. choose the way in which their metering data shall be used and by whom. The exception is technical data for grid management, which is controlled by the DSO to fulfil regulated duties, and consumption data for the consumer's retailer that is essential for electricity billing. The principle is that the gm-hub user shall state what information can be collected, with what frequency and for how long.

Transparency

The gm-hub will make available information about: a) the customer's rights with regard to customer data management; b) what type of customer meter data exists and what it is used for; c) how customer meter data is stored in gm-hub and for how long; d) data access conditions for market players and third parties. This information will be presented in a customer-friendly way. A core element of transparency is the format in which data is provided to gm-hub end-users. The gm-hub will use the following models defined according to the EG1-SGTG report [5]. B2B services: XML data exchange format inspired by CIM IEC 61968 for meter data. Flexibility exchange data inspired by the ENTSO-E "Reserve Resources Processes"; B2C services: comma separated values (CSV).

Accuracy
Validation, estimation and edition functions are applied, according to measures established in legislation/regulation, to improve data quality.

Accessibility
In terms of stakeholders' data accessibility, the following cases are considered in the gm-hub:

- *gm-hub to customer*. Customer can access its consumption data directly from the gm-hub. The customer may later transfer this data to a third party, which established a contractual relationship with the customer.
- *gm-hub to retailers, Balancing Responsible Party (BRP) and TSO*. BRP and retailers can only access consumption data from their customers, which can be used to implement billing services or flexibility settlement processes. The TSO can access this data to support grid technical management/planning and regulators to study new tariff structures and other internal activities. The customer consent is not necessary and there is a contractual relationship between the gm-hub operator and these end-users.
- *gm-hub to third parties (e.g., ESCo, Data Science Company)*. Third-parties can only access data of a specific consumer after explicit customer consent. In general, the data access authorization is directly associated to a third party service provision and can only be used within the scope of the service. These authorizations are valid for an agreed upon time and can be revoked at any time by the consumer.

System Architecture

Figure 2 depicts the gm-hub data storage architecture that is used to provide all stakeholders with access to data services. The gm-hub architecture will be composed of an application server, which will handle requests, and produce the outputs for the other two actors. The application server will rely on local storage, in order to store data related to the other actors. With regard to privacy concerns, data will be transmitted via a secure communication channel, to avoid interception. In the same context, communication must be authenticated.
The gm-hub's local storage preserve all relevant information, except for customer meter data, which should only exist in the DSO domain. Examples of data to be stored are access tokens, the identities of the actors or session information. The gm-hub provides two entry points, one for DSO communications and another for stakeholders. Communication with the gm-hub is bidirectional, via a secure channel.
When stakeholders request either data or flexibility to the gm-hub, it communicates with the DSO to retrieve such data. The data is then transmitted to the original requester. The gm-hub will respect the privacy by design principles, and with this regard, no user data will be stored locally. Indeed, user data will only be streamed to the requester.
The gm-hub, upon a valid request, generates a temporary key that can be used by stakeholders to request data from the DSOs. The gm-hub operator is responsible for validating the key, handling the requests, processing them and return the data in an appropriate way.

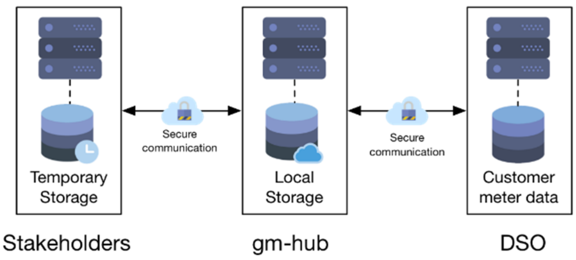

Figure 2 – gm-hub data storage architecture.

DATA-DRIVEN SERVICES

This section describes the different data-driven services of the gm-hub platform and ecosystem.

Basic Services
Consumer can perform two main actions: a) request meter data and b) authorize data sharing. The first use case corresponds to download its own data in a readable format (in CSV). The second one corresponds to authorize third parties to use their data (in XML).

Advanced B2C Services
Information feedback about contracted power (gm-hub service): provide information to the consumer about the usage of contracted power, considering operating grid conditions, season of the year and HEMS flexibility from intelligent load management functions.
Alarms about high consumption patterns (gm-hub service): generate alarms to LV consumers about high consumption patterns related to energy consumption.
Residential Energy Resources Sizing (third-party service): service for a LV consumer about optimal sizing of residential storage, PV and electric water heater.

Advanced B2B Services
Traffic light concept (gm-hub service): technical validation of flexibility for frequency control, activated by the TSO, from distributed energy resources connected to the distribution grid.
Flexibility exchange to support grid operation (gm-hub service): exchange information about available flexibility in the distribution grid per grid user and communicate the pre-book of the available flexibility to solve technical

constraints in the MV and LV grid.
Consumption profile for service enhancement (third-party service): predict the consumption profile of a client in order to offer value added services that will increase engagement between consumer and retailer.

CONTEXTUALIZED FEEDBACK

In order to unlock the full potential of the demand response programs, achieving a long-term household engagement is essential. To incentivize this engagement, one mechanism that is used is the benefit of monetary savings. However, in practice, the monetary savings are too small to promote a behavioural change compared to the comfort of not making any effort and the initial interest in pure energy feedback (i.e. from in-home monitoring or energy apps) diminishes over time [8].
Based on this, a need for a new type of engagement mechanism became apparent. The premise for any service that is used with regularity is that it creates a real and concrete benefit for the end-user. So what if energy feedback is not given in within an energy app, but instead as part of a more natural context that gives the end-users a clear benefit? After evaluating the needs of households, reversing the increasing trend of "globally connected yet locally isolated" [9] was selected as a suitable context. The proposed solution is a local social network called LocalLife, a sustainability-oriented social network for people that live close to each other, aimed at facilitating and enriching local life by helping neighbours connect. It is based on secure neighbour-to-neighbour interactions, that are geographically bound to the buildings and the neighbourhood. This is the context in which collective energy feedback and load shifting goals are provided.
The concept is based on recent work [10] that suggest that social influence combined with a sense of community responsibility could promote intrinsic motivation and increase engagement. As such, it is a low-cost, and highly scalable engagement mechanism that only relies on a forecasting signal and access to smart meter data.
For the current pilot testing in Stockholm, Sweden, a solution with one of the local DSO is used. However, this approach is not scalable in Europe, as separate agreements and integrations would be needed for almost every DSO. The existence of a centralized European gm-hub with an easy and standardized way to access the household consumption regardless of where the household is located, would enable scalability and replicability of third-party smart grid services like LocalLife across Europe, thus potentially increasing the household engagement and grid flexibility.

CONCLUSIONS

This paper described the overall concept for the gm-hub, which main objective is to facilitate market access allowing new business models and services while ensuring efficient and secure network operation as well as highest standards of data security. The gm-hub operates in a regulated domain, and it is an enabler of third-party services that can emerge in the gm-hub ecosystem. One of these third-party service is contextualized feedback to induce behavioural DR and promote energy efficiency actions at the individual and community level.

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