A SERVICE CATALYST PROVIDING A NEUTRAL FRAMEWORK FOR SUPPORTING GRID OPERATION, WHILE PROMOTING MARKET-BASED SERVICES: GRID AND MARKET HUB

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Abstract

The grid and market hub is a core development of InteGrid, an H2020 project, which has recently entered its demonstration phase. This central and neutral hub aims to demonstrate the key role of the DSO in the energy transition, namely in a scenario foreseen to have a large-scale dissemination of DERs, being them small generation (PV, wind), electric vehicles, facing big growths or storage devices, with continuously decreasing prices. The Hub directly addresses several roles of the DSO, particularly as a market enabler, data manager and stakeholder manager, bridging the gap between distribution technical needs and new energy services for other distribution grid stakeholders. We overview the grid and market hub concept and how it is deployed under the InteGrid project to unlock data-driven services as neutral stakeholder.

1 Introduction

Under a DSO enabled ecosystem, the grid and market hub [1] provides services that support business needs from both regulated and market parties, where the grid users play a central role. In this framework, any participant can potentially perform any given role, as follows: (a) The DSO acts as data provider, making all data collection and pre-processing while also performing flexibility management, demanding for DER to act upon grid constraints at a local level (e.g., voltage violations); (b) The end-customers act as a service provider to the DSO or potentially third-party aggregators, by providing flexibility from their DERs (batteries, PVs, smart appliances), while also acting as a service consumer, for the services deployed in the GM-Hub by market players (third-parties); (c) Third parties can use the hub as a facilitator to access consumer data under their strict and explicit consent.

One very important aspect to mention before digging further on the activities taking place in the demonstrator is to stress that all the work carried out took into consideration the latest directives in what concerns data privacy and compliance, namely with the GDPR and sector specific legislation.

Focusing on InteGrid’s demonstrator and the accomplishments, this concept is being materialized in two geographical locations, Portugal and Slovenia. The set of services developed encompass backbone services: registration/authentication, as well as the functionality of “download & share my data”, being these a pre-requisite for accessing the advanced services: flexibility exchange to support grid operation, alarms about high consumption patterns, residential energy resources sizing, among others.

The solution integrates data from more than 3000 assets (from both geographical locations) on the field, distributed across 5 different source systems, always following the highest cybersecurity and data privacy standards, fulfilling all the requirements imposed by GDPR regulation. In Portugal, the implementation is complemented with the development of third-party services, such as the residential energy resources sizing (targeting residential users) or the consumption profiling for service enhancement (targeting industries). In terms of figures, the project accounts with more than 150 residential customers, and around 20 industrial & commercial (medium size) grid users. In Slovenia, the solution being developed addresses mainly flexibility provision by the VPPs through the Traffic Light Concept and the Flexibility Exchange to Support Grid Operation services. Furthermore, the solution also simplifies the usage of two VPPs, which is detailed in next chapter.

This paper overviews the Grid-market Hub, a platform that acts as a neutral data facilitator between stakeholders in the energy grid.

This paper is organized as follows: Section 2 overviews the concept of the Grid-market Hub; Section 3 characterises the demonstration scenarios for H2020 InteGrid Project; Section
4 highlights the roles of the Grid-market Hub as a data enabler and neutral stakeholder in the considered demo sites and, Section 5 concludes this paper.

2. Grid and Market Hub

The grid and market hub (Gm-Hub) builds a neutral market data manager, one of the newest roles in the smart grid context. The Gm-Hub enables the reliable and trustworthy data exchange between several stakeholders within the distribution grid, such as the DSO, TSO, third-parties, ESCos, aggregators or consumers; always behaves as a neutral stakeholder. As a centralised data facilitator with decentralised data storage, the Gm-Hub embodies the concept of neutral market platform developed within the UPGRID H2020 project [2], regulating data exchange between parties, such as consumption profiles or flexibility profiles from consumers; and considering the role modelling from projects evolvDSO [3] and adopted in EGI-SGTGF [3].

The Gm-Hub, developed and deployed as a cloud-based application, exposes a set of innovative services focused on data sharing for grid operations, unlocking new data-driven services that can be fed into third-party entities or ESCos. Central to the design is data privacy and cyber-security, exposing distinct profiles for grid services such as (a) Flexibility exchange for grid operation, (b) Traffic Light System, (c) Consumption profile for service enhancement; or consumer services such as (d) Information Feedback About Contracted Power, (e) Alarms About High Consumption Patterns, (f) Residential Energy Resources Sizing, (g) Share-my-data and (h) Download-my-data.

The interactions from stakeholders to each one of these services is guarded by advanced certificate-based authentication mechanisms, enabling cyphered data tunnels for data exchange, and, most importantly, consumer centred services in which consumer data is exchanged to foreign parties under direct and explicit consent from the consumers themselves. This goes directly in line with GDPR regulations, putting data privacy as one of the central conceptual pillars of the Gm-Hub.

The cornerstone of the Gm-Hub lies in its role modelling and data storage architecture. As a pivotal entity, all parties can provide trust to the Gm-Hub, while it establishes and keeps track of service endorsement and usage clearance. This implies that stakeholders can only interact with services to which they have been registered and pre-authorized. Figure 2 highlights the data architecture, depicting a clear frontier to where data is stored and handled. The Gm-Hub will only hold the minimal required data for its own operation. This includes client or service registration data, service usage data or transient data provided by the grid operation services. The last case implies that data will live within the Gm-Hub data structures for the required transit time before being forwarded and discarded, never being persisted. Consumer data follows the same guidelines, being never persistently stored or buffered, being requested from the DSO whenever a stakeholder requests it via the Gm-Hub. This data abstraction is also put into place to consumer mapping. Upon registration in the Gm-Hub, consumers are validated against the DSO’s systems by providing a point of delivery code and an engagement code provided to them by the DSO. The latter data is the only one persistently kept in the Gm-Hub, being it unable to directly identify a given consumer and track its real identity. This ensures that data is never persisted outside its original realm.

3 InteGrid demonstration Scenarios

Figure 2: InteGrid (Gm-Hub related) Demo tools

On the scope of the Portuguese demonstrator two demo clusters have been defined to perform the field tests. In total, under these two clusters, more than 3000 assets have been included in the demonstration.

3.1 Medium Voltage Demo characterisation

This voltage level has been tested in the region of Mafra and included 7 primary substations, Mafra and other 6 in the
surrounding area, whose voltage transformation is from 60 to 15 kV. There is a total of 20 customers that were actively involved and participated in the execution of the MV use case. There are several use cases (UC) tested under this scenario. The most representative one is UC 1, which is as follows: Predict and solve MV Grid constrains using embedded flexibility resources (generators and industrial Clients). In short, the UC consists on 8 different steps: (1) Operator run an 24h predictive OPF to detect future grid constrains; (2) If constrains are detected, run predictive MPOPF to determine the solution using grid flexibility; (3) Transfer the result to the ADMS; (4) Validate and analyse MPOPF results on the ADMS; (5) Use the VPP-T Tool to pre-book the flexibility resources in the appropriate timeslot; (6) Activation request are sent to the resources; (7) 15 min prior to action run real time OPF to confirm flexibility activation; (8) Observe in DSP Tool the Flexibility resources RT measurement to validate activation. A similar scenario was replicated in Slovenia, where the MV connected industrial customers with identified flexibility were involved (comprising two HV/MV substations).

3.2 Low Voltage Demo characterisation

This voltage level has been tested in the region of Alcochete, Caldas da Rainha and Valverde. It includes more than 1000 LV connection points spread over 12 secondary substations. A total of nearly 150 consumers have been installed with a flexibility pack, composed by a combination of PVs, storage, thermal electric water heaters, smart washing machine and HEMS.

There are also several UCs tested in the LV demonstrator. For pragmatism, UC 2 - Address the operation control of the LV flexibilities (i.e., small-scale storage, consumer/prosumer flexibility, DSO LV assets) based on a predictive management and real-time monitoring of voltage profiles is explained in the next set of steps:

1. LV flexibility from households is available and the flexibility profiles defined in the UI of the HEMS;
2. Grid technical constraints are assessed based on near real time and historical data;
3. Flexibility is pre-booked using the Low Voltage Control (LVC);
4. Flexibility is allocated at the LV level (e.g., customer premises, grid assets) by resource and activated.

4 Market Hub Role in Project Demo Sites

The Gm-Hub plays a central role across demonstration scenarios for both MV and LV installations, making available a set of services and enabling data exchange. Each service exposes a set of APIs that enable several systems to connect and exchange both grid operation and LV consumer-based services.

From the ICT point-of-view, the Gm-Hub is a replicable and scalable cloud-based application that leverages on the elastic capabilities of cloud providers to scale the system according to demand. In the case of InteGrid H2020 Project, the Gm-Hub leverages on SAP’s Cloud Platform. The cloud-based deployment allows a Gm-Hub instance to serve both demos for the InteGrid H2020 Project in their multiple locations.

A description of the available services and their interactions follows:

4.1 Flexibility exchange to support grid operation

This service enables data exchange to acquire and control flexibilities from LV consumers available in the distribution grid to assist the DSO in solving technical constraints on the network. This service is built around two sub-services: The Forecast and the Flexibility sub-services, where several external software components connect. In a nutshell, the home energy management system (HEMS) installed in LV consumers’ homes provides their flexibility (and manages the activation of smart devices inside home). The Low Voltage Control (LVC) system provide real time and preventive data that HEMS devices require to operate. The Forecast service provides load and RES regarding several network points but also pricing forecasts according to the Iberian pricing (MIBEL). The Commercial Virtual Power Plant collects forecasts to provision needs for future periods.

4.2 Traffic Light System

The Traffic Light System (TLS) enables data exchange for the traffic light concept mechanisms, in which the DSO validates the bids offered in the reserve market by entities operating in the distribution grid. The service facilitates data exchange between the DSO’s and a TSO’s realms. During the demos, the DSO Tool provides the data visualization and control panel for the DSO and the Technical Virtual Power Plant (VPP-T) for the TSO’s control tools. The Multi-Period Optimal Power Flow identifies and solves flow constraints while the TLS acquires bids and introduces autonomous control functionalities (e.g., Autonomous Frequency Control Reserve). The virtual power plant tools introduce intricate operation with a set of ancillary tools available and provide benefit to the operation of the MV grid available in the Portuguese and Slovenian demo sites.
### 4.3 Consumer Services

The Gm-Hub enables users to provide explicit consent on the usage of their own data. This unlocks a set of new data-driven services, both for the direct benefit of the consumer, but also, to third party entities whose business is built around the use of anonymised consumer data. To sponsor such features, four services surrounding the use of consumer data are available which we highlight in Figure 4, which displays the user interface of the platform.

![Figure 4 - Consumer services available in the Gm-Hub](image)

These services are provided via data exchange between the Gm-Hub and the DSO interface, which can retrieve metering data respecting the consumers. The data acquisition is made through a cryptographic channel established between the DSO infrastructure and the Gm-Hub. Moreover, consumers are required to register themselves in the Gm-Hub, a process during which the Gm-Hub validates that consumers are legitimate by trading an engagement code provided by the DSO directly to them.

The **Download my data** service enables consumers to collect their metering data. Via a dashboard, the user can fill-in the time period intended, and the request is forwarded to the DSO. The consumer afterwards downloads the data from the Gm-Hub dashboard.

The **Share my data** service builds one of the core new data-driven services available. With this service, third-party entities can register and request the use of consumer data. Via an authorization management system and dashboard built-in the Gm-Hub, consumers provide their explicit consent on data usage. In compliance with the GDPR and the terms and conditions, the consumers review the goal for which their data is going to be used and for how long. On this basis, users approve the usage and can revoke this authorization at any given time. This service then enables third-parties to ingest consumer’s data through a standardized API, expediting the integration with their systems.

The **Feedback About Contracted Power** service enables consumers/prosumers to get a feedback on their contracted power usage by displaying their metering data and providing a feedback on whether they could reduce their contracted power and, consequently, reduce their monthly bill. The data analysis is provided via the data requested to the DSO.

Finally, the **Alarms About High Consumption Patterns** service establishes a data-driven service, that triggers an alarm to warn consumers that their current consumption fell within a safety threshold (configured by the consumer). The analysis is conducted from the historical metering data requested to the DSO.

### 5 Conclusion

The Grid and Market Hub (Gm-Hub) and its role as a new neutral market facilitator, allows new data-driven services with high impact on their business models. Deployed as a cloud-based application, the Gm-Hub offers an efficient and secure platform to exchange operation and maintenance data for both the MV and LV networks. This paper highlighted the developments made and characterized how this new stakeholder was implemented in two demo sites in Europe, in the scope of the InteGrid H2020 project. The Gm-Hub operates in a regulated domain, expediting data exchange and unlocking new data-driven services to third-parties, inducing behavioural DR and promoting energy efficiency actions, both at the individual and community levels.

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