FLEXIBILITY AND OPTIMIZATION SERVICES VALIDATION IN A MICROGRID

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ABSTRACT

This paper describes how, within FLEXICIENCY project, Flexibility and validation services are being implemented and verified, with a special focus on two large scale demos, out of the five running in the project. It also describes how energy systems from different countries across Europe are integrated using a B2B communication standard specified and implemented in the project.

INTRODUCTION

The electricity supply-demand balance is been progressively challenged by a growing proliferation of distributed energy resources together with new consumption habits. In this scenario, microgrids can provide a viable and localized solution for increasing flexibility and supporting network operators in the management of the electricity system.
Flexibility-oriented solutions have been developed within **FLEXICIENCY** [1], a four-year project launched in 2015, funded from the European Union's Horizon 2020 research and innovation programme under grant agreement n° 646482. Flexibility solutions are particularly tested in two different demonstrators in **Spain** and **Austria**.
The Spanish demo focuses on a set of services for microgrids, implemented in the City of Malaga, while in the Austrian demo a pan-European aggregator is emulated with a Virtual-Power-Plant.
A **European Market Place** (MP) has been developed within the project to facilitate B2B interactions among energy players in an open and standardised way, being tested in the demos. With the EU Market Place acting as contact point, relevant data for the provision of new services, including flexibility, can be exchanged at cross-border level, opening up the energy market and fostering the entry of new and existing players.
The possible advantages from the introduction of a European Market place are tested in further three large-scale demonstrators, which are now running in **Italy**, **France** and **Sweden**.

SPANISH DEMO

In the Spanish demo, a microgrid-scheduling model is deployed to optimally manage local resources while providing flexibility services to the utility grid. In case of failure of the power grid, microgrid's generation and loads can be isolated from the grid and operate independently for prolonged periods. The model can also support stable operations by feeding power back to DSO grid and help in restoration after major blackouts.

Advanced services such as peak-shavings, power factor or voltage regulation are also tested: an integrated energy system consisting of renewable distributed generation, storage and loads (including electrical vehicle charging-stations) is operated as a single, autonomous grid either completely separate from, or connected to, the DSO grid.

One of the key factors that distinguish the adopted solution is the novelty of the algorithms used to ensure a reliable and accurate operation of the system.

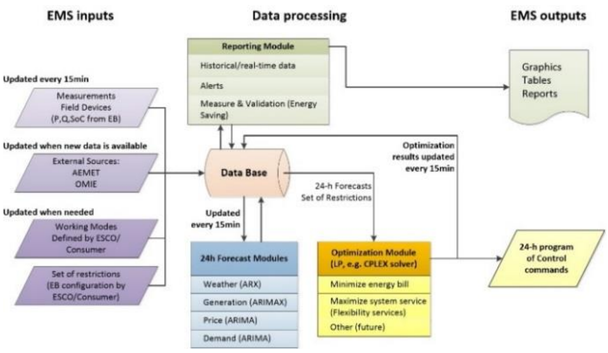

Figure 1. Algorithm data flow in the Spanish demo

As in **Error! Reference source not found.**, the algorithms are fed by the data stored in a database, which includes information not only gathered from on-site devices (inverters, power analyzers, BMCs, etc.), but others like meteorological data (wind speed, solar radiation, temperature, humidity, etc.) from AEMET (Agencia Estatal de Meteorología) or energy prices from OMIE (Operador del Mercado Ibérico de Energía). This helps to model a more realistic system.
Furthermore, user preferences, working modes and different set of restrictions defined by the ESCO/user are taken into account to outline the behaviour (of whom?) in the demo.
Thus, the main objective of the algorithms is to obtain an optimized operation program for all the components of the microgrid. This goal is reached through a two-stage process: the first remotely calculates the optimal operation program for the next 72 hours in 15-min steps.

Later, this operating program is locally applied in real time according to the current status of the installation. Optimization algorithms have been developed using GAMS platform due to the possibility of modelling complex and large systems. On the other hand, the solver used is CPLEX, a high efficiency and reliable tool that allows to solve quickly big problems of high complexity. Such advantages are really important when dealing with programming of microgrids constraints.

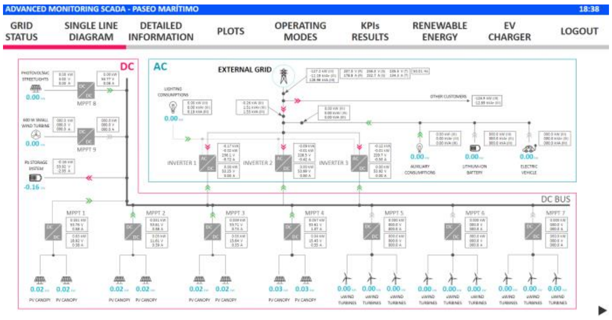

Figure 2. Paseo Marítimo SCADA

Considering a real deployment of the solution, the chosen location was the Paseo Marítimo microgrid in Málaga (Spain). The Microgrid is monitored by a SCADA system (in **Error! Reference source not found.**) in order to store and broadcast the information needed upstream. The real devices are commercial power equipment such as MPPTs, Inverters and grid analyzers, attached to standard channels such as Modbus-RTU, Modbus-TCP or other serial or networked communications.

Figure 3. Energy Box

The SCADA monitors and stores the information in soft real time and processes, represents and communicates the data. On the other hand, the SCADA receives information from the EMS (Energy Management System) algorithms and writes the set points in the devices using the aforementioned communication channels. This scheme is reproduced in other microgrids (Tabacalera, etc.) in a simplified way: The SCADA system is replaced by a low-cost gateway (i.e. Energy Box), which performs both directional communications (monitoring and setting) without graphic user interface and storage features (**Error! Reference source not found.**).

AUSTRIAN DEMO

The Austrian demo is performing a set of field tests across the member states and DSO regions involved in the project. Independent companies acting as Energy Retailers, Demand Response (DR) and Distributed Generation (DRES) Aggregators and Energy Service Companies are connecting their service platform to the EU Market Place. Upon connection, they deliver innovative services to industrial, commercial, and residential customers across DSO and TSO areas of responsibility and their respective EU member states.

A set of use cases are focused on the pan-European aggregator services which manage flexibility providers of commercial and industrial customers and use aggregated flexibility for balancing and grid optimisation purposes.

cyberGRID, a team member of the FLEXICIENCY project, facilitates the European Market Place (MP) by simulating a pan-European aggregator with its flexibility platform. In today's electricity market, if aggregators want to participate in the new balancing market (e.g. in another EU country), they must consider a variety of regulatory and technical barriers which can prolong new business implementations. The MP helps to remove these barriers and defines standardized interfaces. It also provides an aggregator two major benefits: 1) faster and cheaper integration with the balancing markets; and 2) communication with the end-devices.

cyberGRID's flexibility platform technology is offered to the market players as a SaaS (Software as a Service) platform through the European MP. Its architecture is developed in a highly modular way. This approach allows users to customize the settings and create tailor-made services to meet their specific business needs. This flexible platform provides open access via FLEXICIENCY B2B standardized interfaces, thereby enabling faster and more agile access of all data.

Figure 4: cyberGRID's flexibility platform

By utilizing flexible energy units (e.g. commercial/industrial units, photovoltaic, wind, and batteries) the flexible platform is able to exchange smart meter data between various project members via the standardized B2B interface. Further, the flexibility platform performs energy unit forecasting with the help of advanced Artificial Intelligent (AI) algorithms.

To increase the profitability of the pan-European aggregator, the flexible platform provides open access to the forecasting data. This enables micro-grid owners to more precisely better predict future amounts of available flexibility and helps them secure the power grid. With help of FLEXICIENCY project, this service is offered to the market players on the European MP platform in a standardized B2B interface for exchanging flexibility forecast data.

Finally, based on the smart meter data and flexibility forecasts the flexibility platform regularly builds the best suitable flexibility offers. Offers are based on factors such as the flexibility unit availability, costs, and success probability. The offers are then published to market players including TSOs, DSOs, micro-grid management, balancing services, and retailers. The data, forecasts, and offers can then be used to engage market players who can provide the flexibility at the requested time.

INTEGRATION

Within the scope of the FLEXICIENCY Horizon 2020 project, a B2B communication standard has been specified in order to unify the workflow in the exchange of flexibility.

SIEMENS, a partner of FLEXICIENCY, contributed in the specification of the B2B communication protocol. It implemented such specification inside Monet, the Energy Management System used as Market Player platform by several demos within the project.
The B2B protocol specification includes the description of the methodologies to be used to allow different software platforms to communicate among each other. Such protocol also defines the data-model of the documents to be exchanged.

The communication is based upon the usage of HTTPs RESTful APIs exchanging payload in JSON format. The market players can act as Service Offeror or as Service Requestor. Typically, the former exposes REST endpoints to provide data, the latter performs HTTP request towards the exposed endpoints to retrieve data.
The data-model is a subset of the CIM European standard. The proposed B2B communication protocol defines which classes of the CIM standard have to be used depending on the various specified REST endpoint.

The APIs are divided into functional packages each one taking care of the exchange of a subset of the overall data-model, namely:

- Individual meter readings
- Aggregated Consumption/Generation curves
- Consumption/Generation Forecast
- Flexibility Offers

In the following paragraphs, a description of such scenarios is provided.

Individual meter readings

In this scenario, the Requestor can ask for meter readings regarding one or more devices (including PODs). In case of requests that include personal data, a user consent must be collected before the exchange can happen. The consent is obtained using the standard protocol OpenID Connect. There is also the possibility to ask for anonymized data not requiring user consent.
The Offeror checks if the requestor has the rights to perform such inquiry by matching the request with the service agreement obtained from the EU Market Place; after that, it checks for the satisfaction of privacy related constraint and collection of proper user consent. Only at this point the data can be transferred from the Offeror to the Requestor. The protocol foresees polling for new data by the Requestor, and the data timeframe and the devices of interest can be specified.

Aggregated Consumption/Generation curves

In this scenario, the Requestor can ask for aggregated consumption or generation curves. The aggregation configuration is declared in the scope of the offered service directly on the EU Market Place, and the most important parameters are:
– Time Step: specify the granularity of the curve by time buckets (e.g.: 1, 10, 15, 30 minutes)
– Aggregation Level: the geo-spatial level of aggregation (e.g.: country, city, street)
– Aggregation Method: the applied operation (e.g.: sum, average)
From a technical standpoint, the exchange is quite close

to the previous scenario. However, since data is in aggregated form, user consent is not required in this scenario.

Consumption/Generation forecast

This scenario is related to the forecast of consumption or generation and includes both the individual and aggregated use cases. It follows the same mechanisms of the two scenarios above, but with data-points' timestamps in the future.

Flexibility offers

This use case enables exchange of flexibility offer to allow DSO, TSO or retailer to acquire necessary flexibility for balancing national grid (TSO) or for internal technical balancing (DSO).

By means of the B2B communication protocol, the Offeror is an Aggregator able to calculate the flexibility offers based upon consumption/generation trends and forecast regarding determined geo-spatial areas. Such data is collected from various local operators that can also put in place procedures in order to guarantee the actuation of the offered flexibility when needed.
The Requestors are many TSO/DSO that want to take advantage of the offered flexibilities in order to keep its grid in balance. In the scope of FLEXICIENCY, the offers are distributed on first-come-first-served basis.

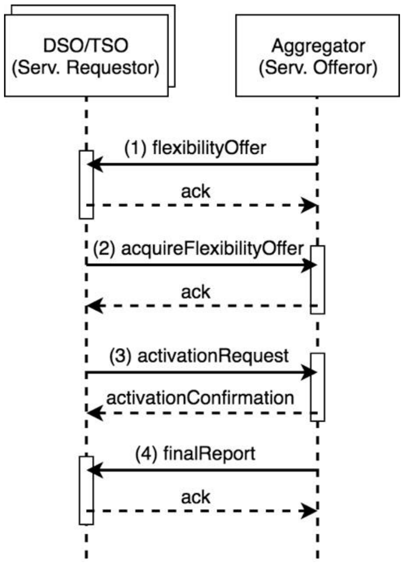

Figure 5. Flexibility B2B sequence diagram

A simplified sequence diagram is depicted in **Error! Reference source not found.**. It clarifies the messages exchange between the various DSOs/TSOs and the Aggregator. A description of the four phases is provided in the following:
(1) The Aggregator sends to the participants the list of all the available Flexibility Offers. An Offer is characterized by a market (area) of interest, a period of time, an amount of consumption/generation flexibility and a price.
(2) From the user interface, the DSO operator can accept (or "acquire") and offer; the acquisition message is sent to the aggregator that will flag the offer as "reserved", following the first-come-first-serve policy.
(3) Upon the flexibility period, the DSO sends the flexibility activation message. The aggregator informs the required partners to actuate flexibility and gives a confirmation back to the DSO.
(4) At the end of flexibility period a load profile is sent by the Aggregator to the DSO in order to certify the results of the provided flexibility.

CONCLUSION

Microgrid and flexibility solutions have been developed in the FLEXICIENCY project and tested in different demos to optimally manage local resources while providing flexibility services to the electricity system.
As the implementation of a pan-European market requires energy systems from different countries to communicate, a B2B communication standard has been specified to unify the workflow in the exchange of flexibility - such as flexibility availability, offerings and acquisition messages - possibly contributing to make it more accessible and easy to implement.

ACKNOWLEDGMENTS

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REFERENCES

[1] Project website: http://www.flexiciency-h2020.eu/