IMPLEMENTATION OF A LOCAL FLEXIBILITY MARKET FOR SOLVING NETWORK ISSUES

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Keywords: FLEXIBILITY, DIGITIZATION, LOW VOLTAGE NETWORK, RENEWABLE INTEGRATION, VIRTUAL POWER SYSTEM

Abstract

The value of the flexibilities available in an electricity system is often considered for the only sake of balancing production and consumption in a variable environment. For instance, a system with a high penetration of unpredictable renewable energy production requires energy flexibility to keep the balance.

However, the activation of a flexibility has not only an impact on the balance of the whole system but also and in particular on a local scale, on the electrical network itself. For example, the activation of an energy flexibility to increase consumption – with the goal of absorbing high production of renewable energy facilities in one part of the grid – is changing the state of the grid at the location where the energy is being consumed.

This impact on the state of the grid can be positive or negative if done blindly.

One of the aims of the GIFT project is to address the question of this local impact and the possibility for a Distribution System Operator (DSO) to access the flexibility market. It would benefit from it purchasing flexibilities to solve network issues. There are two demonstration sites in the GIFT project, namely the Grytøya island, in Norway, and the island of Procida, in Italy. This paper addresses the implementation in the Norwegian demonstration site.

1. Introduction

The GIFT project, GIFT being an acronym for Geographical Islands FlexibiliTy, is a project from the European Union's Horizon 2020 research and innovation programme. It aims to decarbonise the energy mix of European Islands. It is coordinated by the Slovenian company INEA and gathers nine SMEs, two municipalities, one industrial partner, three research centres and two universities from seven different countries [1].

The GIFT project has started to build a replication board with associations that already gather 1640 European islands that will be able to study replication for their territories.

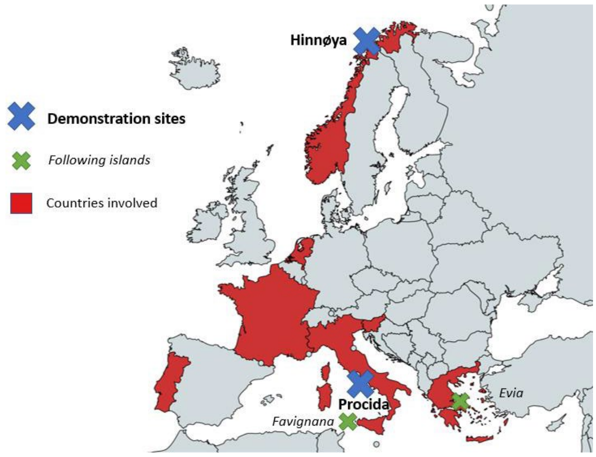

Figure 1 Project's partner and demonstration sites

The project develops multiple solutions that interoperate within a turnkey solution, enabling the provision of flexibility to foster the decarbonisation of the energy mix.

They will be demonstrated in the two pilot sites in Norway and Italy, while mitigating the impact on the distribution network. Because no matter what the selected technologies are, the network must be able to maintain a good quality of supply – that is to say good level of SAIDI and SAIFI through the reduction of Low Voltage (LV) power grid congestion as well as by maintaining the voltage limits.

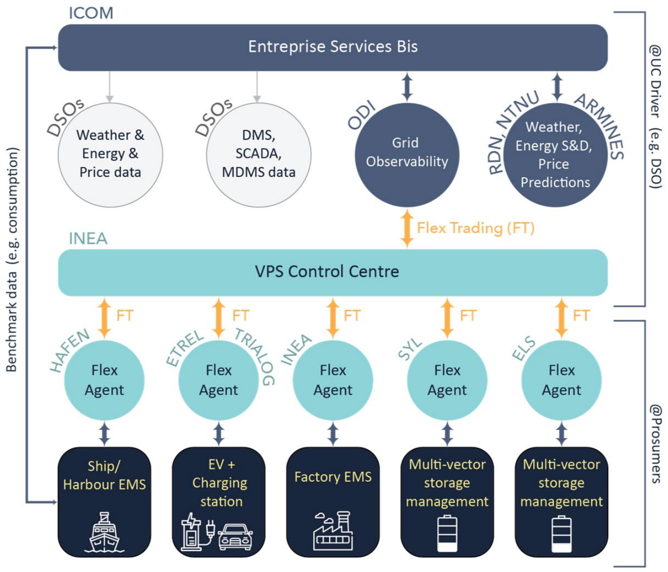

Figure 2 Initial principle of the GIFT project [1]

This paper describes the solution the consortium is designing and developing to operate in the Norway demonstration site, the Grytøya island. It presents the current functional specifications which were designed to tackle the impact of the flexibility's location, the future role of the DSO in this market and the necessary involvement of the various stakeholders to leverage the value of flexibilities on a second axis: on the local scale.

The processes of a local marketplace designed to manage those flexibilities are depicted, detailing interaction with the different types of actors e.g. municipalities, individual or corporate flexibilities providers, storage providers, supervision and control tools providers.

The benefits of an extension of this market in active energy flexibilities into a reactive energy flexibility market is considered as well.

2. Methodology

The cornerstone of this solution is the recent availability of data. This availability plus the use of applied mathematics and machine learning techniques bring new possibilities for the operation of the network, especially the LV one which is little known.

Using those techniques on the electrical network allows to digitize it and to better assess the local impact. From the analysis of sensors' data from the field (e.g. smart meters) real time supervision can be provided as well as a near real time and day ahead forecast of the grid state.

The aim of the solution is twofold:

- Ensuring that the activation of a flexibility will not create issues on the network
- Providing access to the flexibility market for the DSO as well as appropriate insights so it can purchase flexibilities to avoid issues on the network.

Two kinds of issues that might disturb the proper operation of the grid are monitored here, the voltage excursions and the overloads of grid assets identified as critical. Mitigating those issues avoids or delays investments and allows to focus on more strategic action plans.

To reach those expectations, different technology providers have joined forces, offering tools on forecasting, network modelling, management of a flexibility pool and of a flexibility market as well as their integration.

2.1 Smart Grid Architecture Model (SGAM)

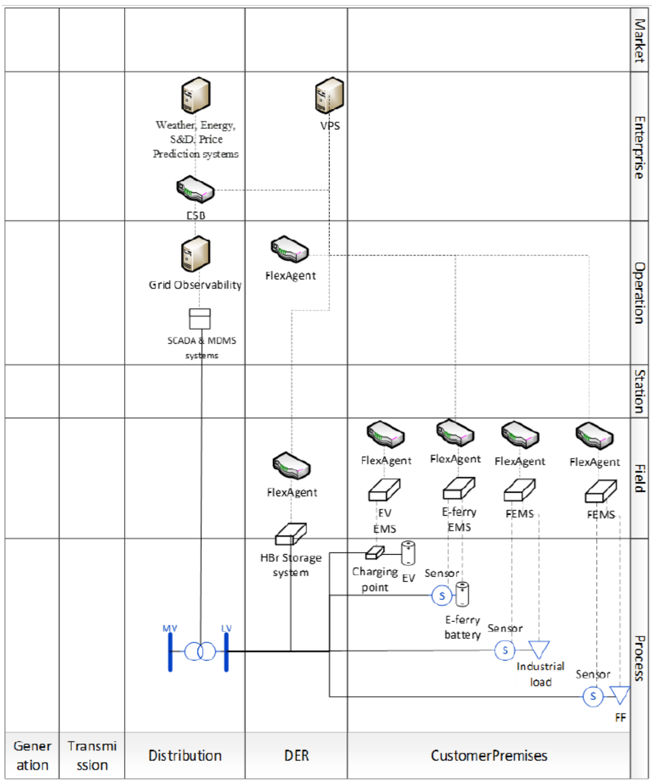

Figure 3 SGAM component layer [2]

Those technologies which are hereafter described are depicted in Figure 3, mapped in the component layer of the SGAM framework [3]. The use case addressed by this solution covers the zones from 'Field' to 'Enterprise' and the domains from 'Customer Premises' to 'Distribution' and interfaces all the technologies providers for one same objective.

The identified flexibility providers are fish farms located near to the seashore, EV charging stations, an E-ferry, industrial prosumers and a battery deployed during the project. They will be activated to match market request and to limit congestion and voltage excursion on the network.

2.2 Prediction System

The Prediction System (PRE) delivers the following services in a day-ahead horizon, with intraday updates:

- The energy supply and demand forecast
- The reserve needs
- The voltages
- The predicted operation profile for each type of flexible resource
- The locational marginal price

Those prediction are based on machine learning techniques, online and historical data, as well as external data such as weather data.[4][5][6]

2.3 Grid Observability System

The Grid Observability System (GO) aims to provide some features of a Medium Voltage SCADA to the LV network, as well as an impact prediction tool. Since, currently, no data from LV grid is being transferred on a real time basis, the challenge here is to compute a reliable estimation of its state without requiring a capital-intensive deployment of sensors. The decomposition of the system's main operations is elaborated below.

2.3.1 The topology: The first step to provide this service is the retrieval of the topology. It is not available for the LV network and provides an accurate understanding of its connections to compute the currents that pass through it. This includes the connection between smart meters, phase, feeder and MV/LV transformer. [7]

2.3.2 Near real time or predicted state estimation: It is performed in two phases:

- The learning phase – based on historical data.
  On one hand data from the field – unavailable in real time – are collected, mainly from smart meters. On the other hand, data from existing real time data source (e.g. SCADA) are collected. The model which connects the two datasets is trained.
- The operation phase – based on the real time data.
  The real time data is collected and used within the model previously computed. It provides an estimation of the field data which is not available in real time. Once available, this estimation is compared to the measured value and the model is re-trained.

In order to provide a predicted state estimation, the computed model must be used with a forecast of the real time data sources. In the project these predictions are provided by the PRE.

2.3.3 Flexibility Impact: Once the state estimation forecasts an issue on the network, the solution provides an action plan to mitigate this issue. This is made through a tool which assesses the impact of the activation of a flexibility. It estimates the state of the network when a load curve is knowingly modulated. In the first place, this engine has been developed to assess the capacity of PV insertion. [8]

2.4 Virtual Power System

The Virtual Power System (VPS) consisting of the KIBERnet [9] solution is a trading platform where the different systems of the stakeholders – prosumers, DSO, Balance Responsible Parties – meet in order trade flexibilities in order to reduce imbalances or overload on the network [10][11]. It consists in two levels (cf. Fig.2):

- The FlexAgent which interfaces each stakeholders' system with the solution. This part ensures the universality of the solution.
- The Virtual Power System Control Centre which centralises and manages the flexibility offers proposed by the FlexAgents.

2.5 Enterprise Service Bus

The Enterprise Service Bus (ESB) is a middleware that provides message transformation and content-based routing capabilities as well as other features that allow seamless integration among enterprise applications.

It will integrate different solution that will be implemented in the project (i.e. PRE, GO, VPS), with legacy applications (e.g. SCADA, MDMS) and external services (e.g. weather service) through standard interfaces, at the level of the control centre. Its design [12] follows the service-oriented architecture paradigm, as well as IEC 61968 standard series for the integration of systems of the DSO.

3. Results

While the different technology providers have standalone solutions which ensure the realisation of their own offer, the GIFT project represents the opportunity to combine them all.

The definition of the interactions between technologies give the step by step flowchart in Figure 4.

The left part of Figure 4 represents the process of a flexibility market in which stakeholders exchange flexibility capabilities. It is meant to be improved so the engagement of said flexibility does not negatively impact the operation of the network. For instance, if a scheduled flexibility – let us say increase in consumption – is expected to bring the voltage level under the regulatory threshold, the flexibility is not accepted and is rejected. As this process is designed for a market which objective is to keep the balance within a defined network or perimeter, it only deals with active energy.

The right part of the Figure 4 represents the process which allows the DSO to access the flexibility market and use it with the proper insights in order to solve the issue predicted on its network. As voltage is being considered as an issue here and as reactive energy has an impact on it, this process creates a market for reactive energy flexibility which will compete with active energy flexibility on this segment.

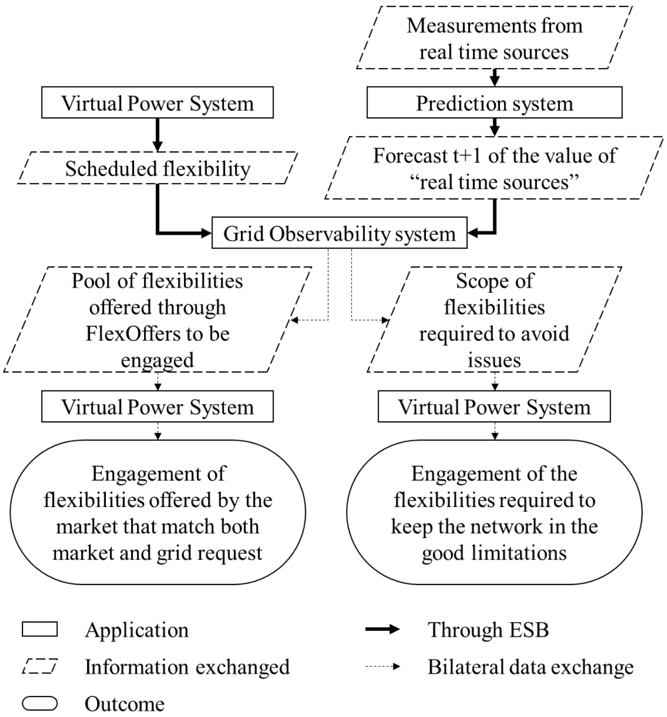

Figure 4 Interaction between technology providers

4. Conclusion

This paper describes how the different partners fulfil the functional needs of such a market and how their solutions interoperate in order to provide a turnkey solution for DSOs. This is currently under development and is meant to be demonstrated on the island of Grytøya in Norway.

5. Acknowledgements

The activities described in the paper are part of the GIFT project. The GIFT project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824410.

This paper reflects only the authors' view and the Agency and the Commission are not responsible for any use that may be made of the information it contains.

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