PUSHING THE TRANSITION TOWARDS TRANSACTIVE GRIDS THROUGH LOCAL ENERGY MARKETS

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ABSTRACT

The goal of the DOMINOES project is to discovery new demand response, aggregation, grid management, peer-to-peer trading services and testing the best mechanisms for market transactions (e.g. Blockchain technology) by designing, developing and validating a transparent and scalable local energy market solution. This paper presents the concepts of local energy markets envisaged by DOMINOES and the Use Cases that will be demonstrated during the project as a proof of concept.

INTRODUCTION

The increased penetration of renewables and other distributed energy resources in the distribution grid, along with more active consumers and prosumers, bring forward new challenges for the energy systems. The traditional centralized approach needs to be reviewed to accommodate those challenges by creating a more distributed and dynamic approach.
Instead of the traditional load-following energy system, the future will be more dynamic and market-driven. The distributed resources need to be fully utilized to tackle the challenges of the future energy system. In order to maximize the use of the available flexibility of all resources, the flexible resources need to be available and visible at all levels of the energy system. They also need to comply with market requirements as well as with the existing limitation of the electrical grids.
Local markets are a potential part of the solution, enabling distributed energy management and addressing local congestions [1]. A local market could benefit from increased energy independence due to energy sharing within the local community [1]. In general, the local market provides a basis for new business opportunities for various stakeholders. For example, exploiting flexible resources could improve quality of services (QoS) and lower grid losses. Furthermore, these developments alongside with the Market Facilitator role of the DSO, can emerge new business opportunities for several stakeholders benefiting the system in various market levels.

DOMINOES CONCEPT

The DOMINOES[1] project aims to deliver a transparent local energy market structure that enables prosumers and consumers to contribute to a more stable and dynamic distribution grids by taking part in aggregation / demand response services.
Another view of the project is the transition from automated grids to transactive grids, which emphasizes the important role of the customers' loads, generation and storage in the management of an increasingly unpredictable power system. In this concept, the P2P (peer to peer) transactions of energy and flexibility will be possible and will require a growing attention to address not only the economic aspects, but also the control system implications to ensure grid reliability [2]. This is a crucial research item for the DOMINOES concept that will push the local market structures from the State-of-the-Art automated mechanisms to more transactive ones.

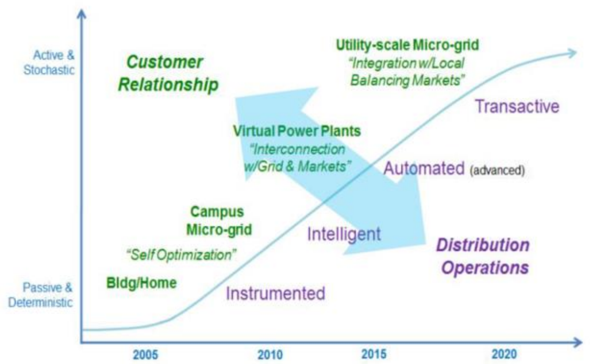

Figure 1 - Stages of adoption of transactive operations for industry [1].

Atamturk and Nilgun define [3] transactive energy with the following characteristics that are directly applicable areas of research for the DOMINOES concept:

- Economic and control techniques used to manage the flow or exchange of energy in order to

1 The DOMINOES project has received funding from the European Union's H2020 research and innovation programme agreement No 771066.

economic and market based standard values;
- Promotion of a network environment for distributed energy nodes as opposed to the traditional hierarchical grid structure;
- The network structure allows for communication such that all levels of energy generation and consumption are able to interact with each other;
- Enable involved systems to connect and exchange energy information while maintaining workflow and utility constraints (interoperability).

The DOMINOES concept includes three main innovation areas that together will establish the local market infrastructure. These areas are shown in Figure 2 and they are market services, control services and customer applications. The DOMINOES local market concepts enable the local sharing of energy, grid management as well as furthering the reach of distributed flexible resources from the local management to wholesale and system level use.

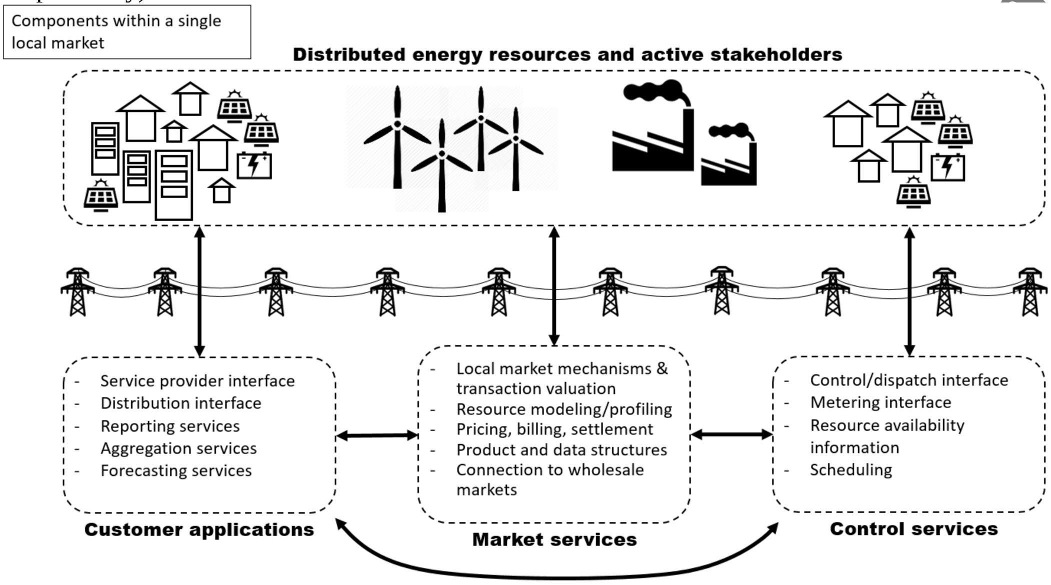

Figure 2 - Three innovation areas of DOMINOES project: market services, control services and customer applications.

In general, the main stakeholders involved in the local market are the prosumers and local communities formed by consumers, the DSO, the TSO, aggregators, retailers, regulators and service providers. These stakeholders could take various roles related to the local market processes. One of these roles is the energy community service provider (ECSP) who can potentially manage the supplier, grid service and balancing service contracts, and represents the community as a whole on the local and the centralized markets. This role could be taken by several stakeholders.
The DSO can act in the role of a procurer of flexibility on the local market. Furthermore, the DSO acts as a data manager for providing relevant operational data to the local market such as forecasts. In addition, the DSO could potentially act as the ECSP in facilitating the local community, but this could also prove to be potentially difficult due to regulatory constraints. These regulatory issues include e.g. the ECSP role in maintaining supplier contracts as well as its role in procuring and providing any kind of existing information on local markets. The DSO can also have several internal roles, which define its interaction with the local market. The distribution grid optimizer is the role within the DSO's operation for optimizing the operation of the network operation with the resources procured by the distribution constraints officer from the local market. Furthermore, the DSO is in the role of technical validator by validating the market transactions and in extraordinary emergency situations invalidating the transactions and directly issuing commands or constraining the network access of resources within the affected area.
Prosumers with flexible resources can act on the market either directly or through an aggregator. They can be part of a community which is managed by an ECSP (such as an aggregator).
The aggregator can potentially act as a balance responsible party or as an independent aggregator. In case the aggregator is not balance responsible, the effects on balances of other market parties are considered and suitable processes developed. The aggregator is a procurer of flexibility and acts as an intermediate party by selling flexibility to other market stakeholders. It could also be in a flexibility providing role by managing the resources of the local prosumers towards a local market set up by another stakeholder. The aggregator could also act as an ECSP by managing the supplier, network and demand response service contracts of the local community.
An external service provider could provide several services required for the local market ranging from

forecasting services to general ICT solution and integration services. An external service provider could also be in the role of the ECSP.

USE CASES (UCs)

In order to tackle the abovementioned issues, several use cases were designed.

Local market flexibility and energy asset management for grid value (UC1)

This use case aims to clarify the definition and implementation of technical grid support services, in different timeframes, regarding voltage control and congestion management within the local Low Voltage (LV) grid, taking also into account that some of the constraints can have an origin in the Medium Voltage (MV) grid (MV constraints due to abnormal LV loads).
The scope is concerned with the interaction between DSO, as flexibility procurer, and local users/resources that may provide the required flexibility. These interactions run through the project Local Market-Hub, designed to provide adequate signals and market processes to regulate the use of flexibility for both grid and commercial applications.
In this use case, the DSO will act as just one more market participant with no discriminatory treatment trying to leverage from the flexibility market to maximize grid efficiency, to solve forecasted constraints and ultimately for investment deferral.

Local Market Data Hub Manager and technical validation and flexibility tool (UC2)

This use case describes the necessary roles of a data manager and a technical validator in connection to a local market. The data manager is responsible for managing, metering and technical data collection from the smart metering infrastructure as well as other data from market participants (e.g. permissions and service subscriptions). The data manager should be also able to receive the requests for verified data from the local market. The technical validator should technically assess all transactions intentions (market transaction program) provided by the local market in a defined timeframe. On the DOMINOES project, the DSO will perform the role of technical validator.
This use case defines the basic functionalities and requirements of the local market with the purpose of successfully collect requests from all market players registered in the local market, in order to successfully reply to all registered market players and provide and verify all requested data, to guarantee that all the legal obligations (customers' consents, contractual relationships and privacy and security constraints) are respected, as well as to ensure proper registration of external stakeholders in the local market. In addition, the purpose is to establish processes to enable the technical validation of transactions between the providers and procures on the local market that require the use of the distribution grid.
In the data management section of the use case, the processes for management and validation of market data are described. Several stakeholders, such as forecast service providers, can request access to data (such as metering data) from the local market. The relevant contracting information and permissions are validated for each data access.
The use case also describes the steps for validating the transactions in the local market and describes the role of the DSO as the technical validator, who sets the initial limitations for every transaction period on each existent local market. After the local market has cleared, the market transactions are validated, and in case of any grid constraints is detected, the DSO has the power to activate an emergency state and make use of available flexibility to solve the problem.
Furthermore, the use case describes the necessary steps for validation of metering data from the metering infrastructure. The smart meters and other metering devices provide the metering data to the data manager, who validates the metering data. When the local market requires metering data, the data manager provides the required data based on performed transactions.

Local community market with flexibility and energy asset management for energy community value (UC3)

This use case investigates the functioning of local energy markets that are managed by a retailer, who will take advantage of the local flexibility to manage the local market with the ultimate goal of creating economic value for all the participants, namely the energy clients. Notwithstanding, all transactions made inside the local market have to be validated by a technical validator (DSO).
First, the retailer runs the forecast tools to understand the load diagram and the generation profile for the day ahead. The flexibility of each client and DER is also known. Based on the aggregated amount of flexibility, he computes the value of the available flexibility and sends the DR set points. Customers must decide whether these orders are accepted or not and inform back the retailer. Then, the retailer buys the electricity accordingly to maintain the local market running without constraints.
For the intraday scenario, the story is similar. Instead of running the forecasts tools, the retailer runs continuously a tool to verify the existence of deviations from the plan designed on the day before and then initiates the process of collecting the available flexibility and sending DR set points.
Apart from participating in the demand response schemes managed by retailers, energy clients and prosumers could prefer to establish P2P transactions with the remaining actors inside the local market.

Thus, energy clients have the opportunity to play an active role on managing their own energy and participate in a market environment enabled by communications and control systems to empower them to be one more asset in the market. A fundamental requirement consists on end users having access to information related to the current status of the distribution grid, allowing them to access to real time data such as prices, congestion, failures and current issues to solve.

Prosumers and system operators that count with ESS (Energy Storage System) could make use of it to serve the grid or local market and allow the connection and disconnection of different services making use of demand response services when needed. Platforms and systems enable prosumers and consumers to make more efficient and more independent decisions into the market, leading to a more efficient energy local market.

Local community flexibility and energy asset management for retailer value (UC4)

This use case investigates how retailers could take advantage of local community energy markets flexibility for valorising it in the wholesale market and optimise its portfolio at the same time.

In this use case, the retailer will not establish a contractual relation with the active participants of the local market, e.g., participant who can either provide flexibility or are electricity producers. Instead, retailer contacts the ECSP directly, who is managing the local market, to inquire him about the amount of flexibility that is available at each time and how much it costs. Based on those conditions, retailer decides whether he will make use of that flexibility to optimise the sourcing of electricity in the wholesale market and to correct deviations incurred by the portfolio.

Local community flexibility and energy asset management for wholesale and energy system market value (UC5)

This use case considers the utilization of flexibility and management of energy assets of the local community for the wholesale and energy system market value. The scope of the use case includes processes for sale, purchase, allocation and settlement of distributed flexibility for use on the wholesale level and overall energy system value. The flexibility is to be used for e.g. regulation and balancing services. The objectives include the aggregation of resources from local community (or multiple communities) for the benefit of the energy system in local grid balancing services, system level balancing services and community benefit through compensations or decreased costs. Furthermore, maintain balance responsibility and grid constraints are considered.

There are three different scenarios defined for the use case. In the first scenario, the aggregator sets up a local market for procuring flexibility for wholesale and energy system market value use. In this scenario, the prosumers offer their flexibility to the market, from which the aggregator purchases the flexibility for resale to e.g. the TSO's regulating or frequency restoration or containment reserves. The DSO can simultaneously limit the transactions based on the distribution grid limits via the processes defined in the first use case. This enables the prosumers to independently affect how and for what purpose their resources are being utilized.

In the second defined scenario of this use case, the aggregators offer flexibility of its contracted prosumers to the local market. The flexibility can then be directly bought by the TSO or the DSO.

The third scenario defined for the energy asset management for wholesale and energy system market value use case is called the retail services scenario. In this scenario, the retailers can acquire flexibility from the prosumers/ community. This scenario differs from the previous retailer value use cases in the way that the prosumers within the community can have different retailers. These retailers can then acquire flexibility from the local market in order to manage their market positions.

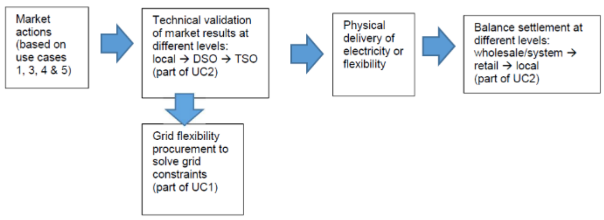

Figure 3 – Use Cases relation to events and market actions.

Each use case represents different perspectives [4] of usage of a local energy market but they all work together on an interconnected system. Figure 3 shows the overall relationship between the operation and market actions.

For the efficient use of available resources, it is important that all resources can have access to all possible market services. Local markets as the ones described in this project provide services for grid value (use case 1), for energy community value (use case 3), for retailer value (use case 4) and for wholesale and energy system market value (use case 5).

In the case of local markets, grid constraints always need to be considered. In the proposed model, local community markets handle the trading according to its rules and procedures. In order to ensure operation of the local, distribution and transmission network, technical validation has to be an important part of any market process, regardless of voltage level and market type.

CONCLUSIONS

The DOMINOES project aims to enable the discovery and development of new demand response, aggregation, grid management and peer-to-peer trading services by

designing, developing and validating a transparent and scalable local energy market solution. This paper presents the concepts of local energy markets envisaged by DOMINOES and reviews the use cases that will be demonstrated during the project as a proof of concept.
The use cases defined in the DOMINOES project cover different applications of the local market. The developed use cases are categorized based on how the resource value can be used. The resource information and flexibility value can be used for the benefit of the local distribution grid, for the benefit of the community, the retailer or for the benefit of the wholesale and energy system level. In addition, the data management and validation required for the operation of the local market is considered in its own use case.
To complement the view of the use cases, several business models were also established for the DOMINOES concept [5]. The developed BMs considered different stakeholders relevant for the successful operation of the local market. The list of business models is as follows:

1. Aggregation of small-scale flexible loads as a universal virtual power plant
2. Aggregator flexibility provision to DSO for network management
3. Using transactive energy for network congestion management
4. Sharing the exceeding PV generation in the scope of energy communities
5. Retailer as user of the local market
6. Energy service provider in enabling / assistive role for local markets and providing ECSP capability for retailers, communities or other service providers

All the stakeholders co-exist in the so-called local market. Therefore, the definition of business models is of crucial importance to explore and delimitate the efficient use of DER in local energy communities and how these interactions impact the system as a whole.
Next steps of the project encompass the development of all the tools to run/ simulate the use cases and its further validation and related business models. Moreover, the main guidelines and architecture for the implementation will be defined as also it will be identified the better mechanism to use for the market transactions in three complementary demo sites: (1) Évora (Portugal) site – distribution grid environment with DER and residential clients; (2) Lappeenranta (Finland) LUT facilities – laboratory and test benches (Green campus environment) and (3) Virtual Power Plant validation environment - VPP of distributed commercial sites.

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