DESIGN CHARACTERISTICS OF A SMART GRID DOMINATED LOCAL MARKET

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ABSTRACT

The purpose of this paper is to describe the roles, services and relationships that a local market would encompass, and the type of market interactions that should take place in it. The local market place constitutes an arena for a new business role - the smart energy service provider, which represents the entity with the most central functionalities with respect to local market operation. The local market is described as consisting of three key elements of brokerage/sale: energy, flexibility and other services. Three alternative market settings are considered: islanding mode, interaction with the wholesale market and a third one where other market agents (aggregators/retailers) carry the interactions with the wholesale market. Finally, the paper specifies the relationship between the smart energy service provider and the various local market actors and provides a clarifying user case.

INTRODUCTION

During the last years, the interest towards energy communities have been intensively increasing and Europe has so far hosted more than 2400 energy cooperative initiatives [1]. In a number of countries the creation of the energy cooperatives has been driven by the inability of utility companies to deliver the type of energy and services that the end users desire, and also by the ambition to fight back the lobbying power associated with their positions. Not surprisingly, the small locally situated actors (consumers, producers or prosumers) are eagerly taking the case in their hands and creating local energy communities.

The establishment of local energy market can be a good solution to some of the economic and efficiency challenges that these cooperatives face. The local market is grounded on a local community and includes different types of prosumers, consumers and producers, as well as storage facilities. It engages community members and those sharing the interest of the community in an array of commercial activities that serve to create a better and more sustainable energy experience for all parties involved.

The local market supports energy related exchanges that are typically combined with services and products customized for the community and its members. Services encompassed by the market concept include, but are not limited to flexibility services, aggregation support, energy efficiency measures, storage, financing, generation efficiency aid, installation services and maintenance programs – all which are typically bundled with the basic commodity in a given retail contract. A principal contributor to customization is the community itself with its prosumers. The service aspect introduces quality measures such as timeliness, reliability, degree of convenience, ease of use and more. All cater for a de-commoditized energy market where the value of the energy experience generated rather than the price of energy alone characterizes a trade settlement.

The aim of this paper is to describe the roles, services and relationships that a local market would encompass and the type of market interactions that should take place in it. Several important aspects are taken in account when laying the foundations of the market design: closeness to consumers and prosumers; combination of energy and services to enable customized energy experience; level of competition; price considerations; civil engagement and community benefits; technology as a differentiator; flexibility services; dominance and gaming; regulation and policies. The highlighted aspects are believed to be among the most influential for the definition of the functional requirements that a local market would satisfy.

The paper is structured as follows: The next section describes the local power market focusing on its structure and its possibility to operate in three alternative market environments. A consequent section describes the relationships and interactions that take place within the local market. The final section provides concluding remarks.

THE LOCAL POWER MARKET

The local market design presented in this paper is based on EMPOWER[1] project's deliverables D6.1 [2] and D3.2 [3] and is going to be further described and tested in the

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course of the project work.

Smart energy service provider

In the context of this paper the local market embraces local producers, prosumers, consumers and storage, and is maintained and facilitated by a new business entity – the smart energy service provider (SESP). The SESP is to serve as a legal entity and will provide basically three things: a consolidated and integrated ICT platform; a trading floor for energy and energy related services; organization and facilitation of a neighbourhood community.

The ICT platform enables non-professional and professionals alike to monitor in real time individual and collective status related to local and central energy generation and demand. The SESP will provide the backbone infrastructure, but should be able to hook into home automation systems that recognize standard protocols. The consolidated ICT system is designed to support multiple tasks and interactions between parties that want to assure a sound energy experience and economical gains for themselves. This includes the involvement of software agents and novel power electronics to support operations in the LV and MV of the grid. It also implies functions that ensure risk management and proper remuneration for participation. In short, ICT will manage the control of energy flows, and optimize activities that lead to a better energy experience for the community, its members and the society beyond.

The trading floor is a virtual concept supported by the ICT system that allows non-professionals as well as professionals to make exchanges of energy, services or a combination of such within the context of a distribution grid. The SESP takes ownership and controls the ICT system. The SESP institution is a role that can be assigned to new as well as established parties in the energy domain. This will imply different set of business models, but not change the basic functions of the SESP or the underlying ICT system. However, businesswise it will make a difference whether the SESP role is owned by the community itself or an incumbent utility.

When it comes to organization and facilitation of a neighbourhood community, the SESP is to contribute for the creation of a forum that is to encourage persistent solidarity, loyalty and engagement. In this way it will help to achieve increased energy efficiency, better infusion of local renewable energies and improved economic benefits for the collective and individual. For the purpose the SESP may also serve as an aggregator and combine, among other tasks, the common aggregator role with a service providing mission. The SESP aims to facilitate internal trading within the community as a complement to «across community border» trading in the day-ahead market to assure proper value management.

The SESP role extends and somewhat revises the function of the more traditional VPP concept (e.g., as presented by [4]). Whereas the VPP is often seen as the link between the prosumer and the market, the SESP might also be seen as an entity that mitigates the risk and the lack of technical awareness of other market players. In addition to its three basic tasks, the SESP may fuse VPP role with the traditional ESCO (Energy Service Company) role in order to provide end users with the tools to operate beyond the local electricity market. The local market will thus allow the creation of two negotiation levels: local level and outside level. The SESP could participate in the wholesale market by considering both of these levels.

Structure of the local market

The proposed local market concept is centred around a stack of products and services that constitute an energy oriented and coherent set of offers. It is described as consisting of three key elements of brokerage/sale: energy, flexibility and other services (Figure 1). The set of offers is specified in contracts presented to the community members. Increased attraction and better retainment of participants are important in this context.

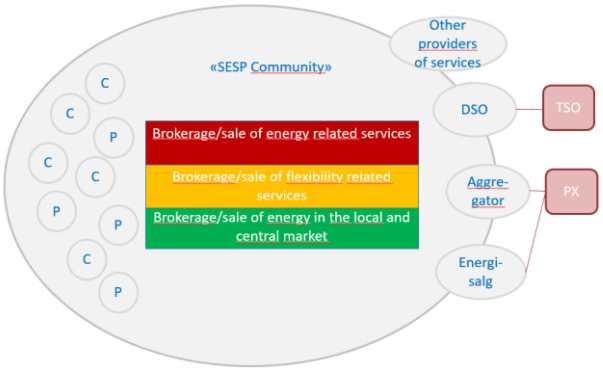

Figure 1 – The overall value stack offered to community members

The base of the value stack is energy and energy exchange. Focus here is on kWh. Above that other services can be added. These are flexibility services that allow for better utilization of resources while maintaining the members' comfort and that are to bring about benefits for both the system and the individual providers of the flexibility resource, as well as services that manage the fluctuations of intermittent, local production. And also third level services that can relate to comfort management, energy efficiency, security of property, insurance, and others. In tact with the above characteristics, the local market can be seen as a composition of local energy market, local flexibility market and a local market for other services.

The local energy market

The objective of the local energy market is to schedule the

local resources at minimum cost during the day-ahead to get an optimal balancing between local demand, local supply, and grid exchange. Therefore, the SESP can take advantage of this information to determine if it is necessary to sell or buy electricity surplus or deficit respectively in the day-ahead electricity market. Additionally, the SESP can avoid grid bottlenecks during the energy scheduling if the SESP has information about the distribution grid.

The local flexibility market
Once the first schedule is established in the local energy market, the local flexibility market is the trading platform to adjust the energy resources to correct forecasting errors or to increase the participants' profits in balancing markets. There are two possible flexibility arrangements: internal and external. Internal arrangements can be energy exchange between local market participants and they are organized and supervised by the SESP. External arrangements are offers or bids to the wholesale electricity markets when participants can make profit from them. The SESP has to aggregate offers and bids, and it has to send them to the markets as an aggregator.

The local market for other services
In addition to the previously described local markets, other services can be included in the local market – e.g., maintenance, failure detection and technical user support. Secondary services like financing, broking services and support services could be included as well. Treatment of prosumers, consumers and producers data could be another asset.

The local power market in different market settings

The local power market proposed in this work can be present in three contexts: island mode, and direct or indirect relation with the wholesale market.

Islanding mode
Islanding mode is the most obvious case for local markets. By employing micro-grid technologies such as a power router [5], an isolated neighbourhood could benefit from mutual exchanges given a certain degree of diversification. In this respect, geographical remoteness is an important factor. However, market participants will always look to other markets for a better opportunity if prices there are higher or lower. This could create incentives for development of a cellular market with the aid of micro-grid technologies ([6], [7]) where exchanges also take place across the frontiers of adjacent neighbourhoods. Islanding mode requires sufficient internal energy resources to sustain supply. In many cases this may be hard to achieve, thus making islanding mode only possible for part of the day or certain periods.

SESP interacts with the wholesale market directly
The SESP acts as both a retailer and an aggregator, and trades energy and flexibility provided (or demanded) by local market participants internally within the community, towards the central market (e.g., at the spot, intraday, and balancing markets), and also towards the DSO, TSO and over the counter.

Interactions with the wholesale market carried out by others
It may be the case that the aggregator and retailer roles are carried on by the respective actors and not by the SESP. Thus, the SESP will be an intermediary that ensures the community recruitment, facilitates demand response thanks to its ICT platform and forwards its members' flexibility resources/energy needs towards the respective aggregator/retailer.

RELATIONSHIPS WITHIN THE LOCAL MARKET

SESP-Generator

The SESP may offer the producer a set of community benefits and access to the local market. In association with this the SESP will be able to offer forecasting services, flexibility services, problem solving services, metering and accounting, all in one place and all using the same ICT platform which the SESP provides.

SESP – Consumer

The SESP will provide incentives to formalize and systemize the use of the latent flexibility at consumers' premises for broader application. Consumers may be offered contracts whereby demand is adjusted according to the generation provided by local suppliers, the needs of the DSO, TSO and the possibility to make profits/save cost through trading at the spot and the balancing market.

SESP – Prosumer

The prosumer has double interest depending on the level of surplus that this participant generates. In one instant the prosumer plays the role of the supplier. In another he or she shares the concerns and interests of the consumer.

SESP-DSO

The DSO may want to outsource the load reduction and load shedding task to the service provider. Three basic alternative DSO requirements can be considered: curtailment of morning and evening peak loads, load control during highly unexpected situations (emergency measures) and feed-in control (associated with the feed-in of power generated by DER). In addition, voltage control may be included. It can be expected that the SESP will engage with the DSO based on a long-term contract that gives the DSO an option – i.e., the right, but not an obligation to call for flexibility. This legal framework agreement will support periodic call-offs which specify activation frequencies and ceilings that the DSO needs. Prices are negotiated accordingly. At least three price

elements should be considered: a sign-on fee (strike price) that honours preparedness for the whole period, an activation fee and a penalty fee to be paid in case of failure. A prototype example is provided in Figure 2.

ATTRIBUTE	SPECIFICATION	EXAMPLE
Name of DSO	string	Fredrikstad Energi Nett
Type	string	Scheduled
Date of endorsement	date	Feb. 1, 2016
Date of initiation	date	Feb 8, 2016
Date of termination	date	April 1., 2016
Contract renewal type	{automated | by negotiation}	Automated
Max load per activation	number	100kW
Max number of activations in period	number	60
Days of activations	Calendar days	Monday, Tuesday, Wednesday, Thursday, Friday
Permitted interval in morning	{hours | DSO signal}	6:00 – 12:00
Permitted interval in evening	{hours | DSO signal}	15:30-20:30
Max allowed activation time	Number of hours	2,5
Tolerance	Percentage deviation of requested load shedding per activation	+/- 1%
Strike price	NOK exempt VAT	40.000
Activation fee	NOK exempt VAT per hour activated	4000
Non-conformance clause	text	See small print

Figure 2 - A tentative template for defining the legal agreement between a SESP and a DSO in the case where scheduling flexibility for curtailing morning and evening peak loads is required.

The SESP offers community members similar options, broken down into proper tranches that suit the local participants. A prerequisite for participation is that suitable control devices have been installed and can be controlled by the SESP.

SESP-Other service provider

The SESP can encourage other service providers to enter the local market in different ways. Similar contracts to the one negotiated with the DSO could assure long-term engagement. These could be related to, e.g., energy efficiency, storage and financial services, online diagnosis, and maintenance of PV. Again, a sign-on fee could be asked and fixed activation fees negotiated. The SESP, through the sign-on fee or by other means assures an attractive discount compared to procurement beyond the local market. However, it is also possible to cater for auctions too. The latter could be well suited whenever there are two or more that can offer the same service.

We assume that the SESP is to take on both the roles of an aggregator and a retailer and in this respect the possible interactions between a SESP and an aggregator/retailer will not be commented on.

Involvement of end users and contracting

Within a general user case the process of local trade is divided into the following three steps:

Community recruitment

The recruitment process could encompass: promotion, signing up membership (payment of membership fee) and a preference survey (e.g., to quantify the interest and potential in demand response). Membership will allow participants to buy and sell energy with the support of the SESP. The community benefits offered should encourage local exchanges.

Negotiate contract with the DSO and information sharing

In the case where the DSO does have a problem the SESP may carry profitability analysis and then offer to the DSO a standardized contract template – e.g., such that includes the attributes presented in Figure 2. It may as well be the TSO or other market actors who find the local market resources attractive that sign a contract with the SESP.

Bilateral back-to-back contracts

These contracts are to be facilitated by evaluation of the end-users' flexibility potential based on the DSO's /retailer's data and the preferences specified for each end-user. A professional representing the SESP is to connect all controllable devices.

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