*local **E**lectricity retail **M**arkets for **P**rosumer smart grid p**OWER** services*

Deliverable nº:	**D6.1**
Deliverable name:	**Market design**
Version:	**1.0**
Release date:	**29/09/2015**
Dissemination level:	**PU**
Status:	**Draft**
Author:	**SmartIO** Iliana Ilieva, Bernt Bremdal, Pol Olivella (UPC),
Contributors	Terje Nilsen, Stig Ødegaard Ottesen (eSmart)

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No 646476.

Document history:

Version	Date of issue	Content and changes	Edited by
0.1	25/09/2015	First draft version	Iliana Ilieva
1	29/09/2015	Version 1.0	Iliana Ilieva

Peer reviewed by:

Partner	Contributor
UPC	Andreas Sumper
St. Gallen	Moritz Loock

Deliverable beneficiaries:

WP / Task	Responsible
T6.2	SmartIO
T6.3	SmartIO
T6.4	eSmart

Table of contents

Abbreviations and Acronyms

Acronym	Description
CDA	Continuous Double Auction
DER	Distributed Energy Resources
DR	Demand Response
DRX	Demand Response Exchange
EMD	EMPOWER market design
ESCO	Energy system Company
EV	Electrical Vehicles
FLECH	Flexibility Clearing House
HAS	Home Automation System
IDPR -	Intelligent distribution Power Router
IoT	Internet of Things
MAS	Multi-agent systems
OTC	over-the-counter
PV	Photovoltaic
SESP	Smart Energy Service Provider
VPP	Virtual Power Plant

Executive summary

This report presents the results from T6.1 and lays the foundation for T6.2, T.6.3 and T6.4. The report encompasses an evaluation of existing work and provides a description of the market design chosen for further development. The document describes the foundations of an EMPOWER market design based on real world cases and experiences collected from peer reviewed literature and previous pilot projects.

To start with, this report provides an in-depth description of the concept of micro-markets and defines the Smart Energy Service Provider (SESP) as a key facilitator for realizing the local trade. Further, the report gives a detailed representation of the specific roles, entities and structures that build up the basis of the EMPOWER market design. Central in this respect are: consumers and prosumers, local community, level of customization (particularly with respect to services), operating SESP and aggregator, trade with flexibility, distribution of costs and benefits. The report signifies the variety of cases for local trade, focusing in particular on the possibility for operation in island mode or as a semi-constrained neighbourhood, and also comments on the specific trade steering instruments such as subsidies, green certificates and tax differentiation. Local patriotism, community benefits and specifically related to local service offers perceived added value are considered important motivators for the realization of local trade. In addition, the report describes the variety of factors that may have strong impact on the scale and scope of local trading – e.g. level of competition, community engagement, technology, service combos, and regulations.

Next, the report presents the basic functional framework that the proposed market design is expected to meet. Some main functional objectives and requirements are related to the market design's adaptability to community needs and different trading models, and the specific economic, operational and social characteristics of the environment.

Finally, this document provides a description of the EMPOWER market concept which includes the value stack offered to community members and the overall platform of the EMPOWER market design. It is shown how a local market, based on a neighbourhood, or a group of neighbourhoods, may use SESP and intelligent distributed power router to operate as an "island" or towards the central market.

1 Introduction

1.1 Objectives

The main objective of the EMPOWER project has been formulated as follows:

"Develop and verify a local market place and innovative business models including operational methods to encourage micro-generation and active participation of prosumers to exploit the flexibility that this creates for the benefit of all connected to the local grid."

The ambition behind this has also been defined as a set of sub-goals:

1. **Develop a new market design for local trading and involvement of the consumer/prosumer end of the distribution net by means of cloud based ICT**
2. **Develop prosumer oriented business models relevant for the market design developed**
3. **Develop an ICT based monitoring and management system that can be accommodated in the SESP control cloud**
4. **Develop full bidirectional and secure communication between the market and business part of the SESP control structure and the physical infrastructure below that controls the flow of energy**
5. **Integrate the different parts and demonstrate the viability of the concept created in at least two physical regions in Europe**

The purpose of this document is to expand on the concept of the local market place. The first sub-goal listed above will therefore be specifically addressed.

The local market place constitutes the arena for the business role that we have called SESP (Smart Energy Service Provider). The design of this market will be pivotal for much of the work to be undertaken in other parts of the EMPOWER project. For this purpose we will define the roles and relationships between these roles in such a market. Roles define a purpose in the market place that ultimately must be satisfied by some qualified business entity. Such an entity might adopt one or more roles depending on the choice of business model and contextual requirements and constraints. Each role will be related to another. These relationships will be described and the interactions taking place between the entities will be specified. In doing so we will relate to ongoing work on business models as specified for Task 2.1 "Business models providing flexibility to the grid“ in Work Package 2. We will also advance somewhat a deliberation on trading concepts that is the focus of another task in Work Package 6 (T6.2) and which is still in process. The rationale behind our proposed design will be explained and due references will be made to former projects and concurrent initiatives that aggregate into a state-of-the-art projection. We will make an effort to compare features of the local market with established market designs. For practical purposes we will apply the Nordic wholesale market, NordPool, and the adjunct retail market as the dominant reference. This will also help us to highlight how the local market can operate side by side with an established market regime and conventional business entities operating in it today.

2 The concept of micro-markets

2.1 The basic characteristics of the local market

The local market is rooted in a local community and based on a micro-market concept that includes prosumers and consumers of various kinds as well as storage facilities within such a community. Different forms of smart grid enabled services connect these and other players in this marketplace.

A set of micro-markets constitute a neighborhood system. A micro-market consists of the implementation of market rules in a medium voltage (MV) and low voltage (LV) scale. Multiple micro-markets may connect in different ways to constitute a structure of cells, each with a significant local generation of energy. The local generation may not cover in full the consumers' demands within the micro-market. A micro-market is typically characterized by periodic surplus and deficit that encourage interaction with its surroundings. This could include other cells as well as the central market. A micro-market is not the equivalent of a micro-grid, though the design and efficiency of a system of micro-markets could benefit significantly from micro-grid technologies (UPC 2015 (D3.2) and EYPESA 2015 (D7.1), Vytelingum 2010, Krovvidi 2010, Bühner 2015). In fact, like Cox and Considine (2011) and Abe et al. (2011) it is our belief too that micro-grid design could take advantage of business models that are likely to emerge in a micro-market. Our definition of a micro-market is therefore formulated as follows:

A micro-market is a local trading arena characterized by strong user involvement, a high degree of innovation and continuous customization.

In more elaborate ways we can explain an energy oriented micro-market as a marketplace set in a local community. It engages community members and those sharing the interest of the community in an array of commercial activities that all have in common that they serve to create a better and more sustainable energy experience for all parties involved. The micro-market supports energy related exchanges that are typically combined with services and products which are customized for the community and its members. Services encompassed by the market concept includes, but are not limited to flexibility services, aggregation support, energy efficiency measures, storage, 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 value of the energy experience generated rather than the price of energy alone characterizes a trade settlement.

This definition postulates that a micro-market distinguishes itself from the central wholesale electricity market with its focus on services in addition to energy. The service aspect related to smart grid technologies and innovations associated with the ICT support required could be also an important one. A micro-market is thus characterized by de-commoditization of energy sales at distribution level. The energy-service combos which are emerging, especially in low price energy markets, have long been heralded by some of the authors of this report (Ilieva and Gabriel 2014, Ilieva and Gabriel 2015). We hypothesize that a micro-market supported by smart grid technologies will inevitably gravitate towards sale and purchase of an energy related “service experience”. In this market energy as a mere commodity will therefore occupy an essential but less pronounced position. Relevant analogies could serve as examples of such a service experience. The retail market for coffee is one. In modern cities a retail market constituted by various chains of coffee bars has emerged. An array of different coffee products such as “café latte”, “espresso” and “americano”, supported by services emphasizing convenience, availability and to some degree, comfort, have emerged to associate such products with life style essentials of important customer groups all over the world. Still the essential commodity is coffee beans, but local brewing service, a local pastry industry and closeness to the user have created a local market with local competitors, all with a unique brand, competing for customers’ grace. Similar reflections could be made for bottled water as opposed to tap water. This is another example where a branded product is sold side by side with the basic commodity for a price 500-3000 times higher than the basic alternative.

A third analogy is constituted by the local bread market. In many North-European cities bread used to be considered a mere staple food and the price was closely associated with the wholesale price of grain and flour. Today, competing brands of bakeries compete for shelf space in local super markets. In a regular Nordic grocery a customer can choose between 30-40 types of bread each day. Each piece of bread is priced at a level 30-50 times higher than the price of flour. What defines this development is innovation that meets the needs of specific market segments. The “perceived added value” that customers experience when they can pick-up a freshly brewed "cordado" while waiting for the train to work is essential for the trade. To be able to buy a sealed bottle of chilled drinking water from a shop at every second corner also provides extra value for the local customer compared to that offered by regular tap water. The perceived “extra value” provides room for significant price mark-ups, even in highly competitive markets. At the same time, it extends the distance between the commodity market and the local product/service market as viewed by a customer who is relieved of a whole lot of otherwise required tasks. For an additional fee that extends way beyond the price of the basic commodity the customer is at liberty to enjoy the taste of high-quality coffee, fresh drinking water and newly baked, tasty bread whenever the need arises. The retail markets for energy are already heading in this direction. Especially in markets where low electricity prices demand innovative add-ons to survive. In EMPOWER we claim that smart grid technologies are likely to accelerate this trend. Micro-markets for energy based on smart grid equipment will be strongly influenced by the services and products offered. The real issue is whether it will be energy sales with some additional services or energy related service combos, thoroughbred for different participants in the energy market.

Local markets constituted by bakeries, beverage companies and franchises like Starbuck thrive one a-commodity-turned-a-branded-product. But the prosumer role in these markets is less pronounced, though existent. Half-baked bread to be processed at home yields a fresh breakfast experience even on Sundays. Self-service in the bread department of the super market and customer operated vending machines that provide cold water are good, but limited examples. The furniture market represented by a venue like IKEA stands out as an example. Local prosumers constitute an essential part of IKEA’s business model (Bremdal 2011b). For years IKEA has expanded world-wide based on the same concept where local customers come to contemplate, select and then pick-up their flat-packed pieces of furniture. They help themselves at the cashier desk, bring the purchased pack home and spend the night assembling it with all the delights and frustrations that go with the job. IKEA saves itself this effort and the associated cost. Part of this cost reduction is reflected in the price. But it can be argued that the bigger share lands on IKEA’s side of the table. It should also be noted that IKEA’s concept is heavily dependent on technology. Without a private car that permits the customer to bring home the furniture pack immediately after purchase, the IKEA business model would have been severely weakened. We will return to this later when discussing our proposed market design, but draw attention to the share of control between IKEA and the customer adhering to their offer. This determines the rules of engagement. A shift in control balance also implies a shift in market design.

To illustrate a key characteristic with micro-markets in the energy world we will also refer to recent work by Ilieva and Gabriel (2014, 2015) who have investigated the impact of innovative services offered by energy retailers in a competitive end-user market. Innovative services create a value perception among customers that permits increased price mark-ups. However, this advantage is reduced whenever competitors are able to match any offer pioneered by a retailer. Price alone, and not relative additional value, once more winds up being the single differentiating factor when buying. Consequently, innovativeness is necessary to retain margins. Yet innovative offerings can be both costly and risky. One way to maintain a competitive edge and to reduce cost and risk at the same time is to share the work, the cost and the risk with those who buy. There are strong reasons to suspect that the next step for retailers in low price markets will be to involve customers in some ways. This will help to gain and retain customers' attention and reduce the burden on their own budget. In return they will have to split the gains with their partners at the customer side. This is a development that may evolve regardless of the emergence of the smart grid, but enhanced and accelerated by the smart grid concept or related drivers such as Home Automation System (HAS) and IoT (Internet of Things).

2.2 The Smart Energy Service Provider

In the context of EMPOWER the local market is maintained and facilitated by a new business entity that we have called SESP (Smart Energy Service Provider). It will serve as a legal entity and will provide basically three things:

1. A consolidated and integrated ICT platform
2. A trading floor for energy and energy related services
3. The organization and facilitation of a neighborhood 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 hook into HAS systems that recognize standard protocols. The community or influential partners like the DSO might insist on a standard set of devices to cover basic energy trading and service tasks which should be managed by the SESP. In such cases this need to be provided for by the SESP. Compatible additions to the basic system can be purchased from suppliers through the service and service app market. All such additions can and should be compatible with the default system that the SESP provides for.

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 support of software agents, 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 first and foremost 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.

The community creates a forum for a neighborhood of households and the like that should encourage persistent solidarity, loyalty and engagement to achieve increased energy efficiency, better infusion of local renewable energies and improved economic benefits for the collective and individual.

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 functions associated with such tasks define part of the essence of the EMPOWER project and is the subject of this report.

The SESP will also facilitate exchange and execution of services in the local market for the benefit of the generator, consumer and the storage role within the community. This implies that the SESP will invite other participants, both internal and external ones, to become part of the marketplace offered and share the task of designing and producing such services. The SESP and the local market should help to increase the security of supply with demand side management and with islanding mode operations. The latter can be achieved with the support of a micro-grid approach. The market design will adhere, but will not be entirely dependent on the technical structure of a micro-grid.

The consolidated set of offers to the community will be supported by means of advanced ICT. 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 SESP role extends and somewhat revises the function of the more traditional VPP concept (e.g., as presented by Kok 2009). 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.

The market design will converge towards the specification of a set of software agents customized for trading within a local market. The agents should be accommodated within the SESP control area. Software agents that represent the various players in the market place under the strict supervision of the SESP serve three objectives. One is to alleviate the burden of continuous interaction and involvement. Another is to reduce complexity and lower the threshold for engagement. And a third is to help avoid gaming and undue market power by more dominant actors.

The proposed community concept implies a degree of end-user empowerment that is typically emerging as an important value driver for end-user in countries such as Germany, Holland and UK (Warren 2010, Schoor and Scholtnes 2015, Hess 2009).

3 State-of-the-art review

The electricity market designs and the associated government regulations differ among European regions. Yet, some common features of the power markets can be described. Electricity transmission and distribution are in almost all cases regulated natural monopolies. Electricity producers and retailers operate typically in a free market environment. At the wholesale electricity market generators compete to sell electricity to retailers and to large industrial companies, while within the end-user market retailers compete to sell to the final consumer (KU Leuven Energy Institute, 2015). The types of wholesale market trade that the actors participate in may differ. The commonly employed forms are power exchange and over-the-counter (OTC) trade.

The specific requirement that electricity generation should equal consumption at any time makes the timely aspects of electricity market models particularly important. The time of physical delivery constitutes a key reference point in respect to which the electricity wholesale trade is being carried on a forward and future market, day-ahead market, intra-day market and balancing market. Although liberalized to a high degree the currently existing market models could become insufficient when certain new trends in the power system are to be handled. In particular, the currently existing market models could face hardships when organizing the efficient operation and ensuring the mutually beneficial coexistence of electricity prosumers, innovative technology and electricity consumers with radically changing set of preferences. New market models that take into account the specific characteristics of power market participants on a local level could offer a solution to these challenges. The literature review to follow bellow aims to present some main local market concepts that previous literature focuses on and to reflect on the potential benefits of new market models, as they have been discussed in previous studies.

3.1 Virtual Power Plant

The concept of a virtual power plant (VPP) (Dietrich 2015) is highly relevant for a local market design. Kok (2009) defines the VPP as a flexible representation of a portfolio of distributed energy resources (DER) (distributed generation, demand response, electricity storage) that has the delivery of (near-) real-time balancing services as its main activity. According to Kok (2009) a VPP can operate optimally when a dynamic merit-order list of all participating resource entities is maintained and when the VPP's decisions are based on this list. Dietrich et al. (2015) provide a profound state-of-the-art on VPPs (presented as aggregators of DERs) and model the defined as "most common" objectives of a VPP - maximization of self-supply and market-revenue. As Dietrich et al. (2015) discuss previous literature associates the establishment of a VPP with manifold objectives, the main of which are related to:

- Better control of small renewable generators and thus improved integration of renewable energies in the electric system
- Reduced energy supply costs
- Decreased energy dependency from other regions through resource diversification

- Management of imbalances caused by intermittent renewable generation with flexible demand, CHP units or storage units
- Provision of ancillary services
- Market participation to optimize the value of local DERs
- Smart Grid market and agent trading

A development of a local market can be further grounded in the literature on Smart Grid market and agent trading. To design a well-functioning local market it is important to take into consideration the behavior of the agents it is comprised of and how the trade is to be organized. A wide spectrum of previous studies touches upon these issues. Gode and Sunder (1993) show that even “zero-intelligence” agents can provide for high allocative efficiency within a double auction trade, given the proper rules for trade are present. In this respect auctioning within a local electricity market can bring efficiency on an aggregate level even if individual agents are irrational. It also means that simple cybernetics can be applied that have no knowledge of the actual market or trading process (Carella 2014).

Kahrobaee et al. (2014) focus specifically on electricity trading within a neighborhood and customers equipped with smart grid technology. A multiagent model in which active customers that own electricity generation/storage facilities trade electricity with their neighbors to minimize costs is proposed. Kahrobaee et al. (2014) then use the model to determine the impact of neighborhood market transactions, demand diversity and load shifting on both the customers and the utility. In an earlier study Kahrobaee et al. (2013) describe how home agents prioritize their decisions based on the expected utility that the power generation, storage and trading features they possess provide. Through a set of case studies and sensitivity analysis the authors show how the overall performance of the home agents converges to an equilibrium that benefits market participants in different operational conditions and determines situations in which conventional homes profit from purchasing own systems for generation and storage. Vytelingum et al. (2010) develop a market-based mechanism and agent-based trading strategies for the Smart Grid. The mechanism is based on the Continuous Double Auction (CDA) which allows agents to make offers on the market continuously and improve upon them until a match between buyer and seller is found. Specifically, Vytelingum et al. (2010) consider each node in the electricity network as a representative of self-interested[1] buyers and sellers that aim to trade on a day-ahead basis. Baerenfaenger et al. (2014) describe the DREAM project in which solutions for active distribution networks with integrated DER are developed. The project engages partners from different European countries with the aim to create a novel heterarchical management approach for agent-based power grids at the same time as current and future designs of power market systems are considered. The DREAM project presents a framework where the roles of existing market actors are to change and there is possibility for introducing new market actors. In this respect, Baerenfaenger et al. (2014) discuss the necessity of a new "Flexibility aggregator" role that is to execute the aggregation of the individual DER flexibilities in order to collect, pool and market the flexibility offered by customers. An overview of distributed energy trading concepts in Smart Grid has been provided by Bayram et al. (2014). In particular, the authors focus on the motivation and desired outcomes of energy trading framework and the enabling technologies required, and present an array of mathematical frameworks employed, based on previous literature. Within the study the enabling technologies are characterized as renewable generation, energy storage, electrical vehicles and communication systems, while the mathematical frameworks are divided in three: game theoretic models used for multi-agent decision making, single objective maximization and simulation-based studies. A final important point to make refers to the work of Ilieva and Gabriel (2014) who describe the trading strategies that are specifically related to electricity retailers operating within a highly competitive market environment and a Smart Grid dominated power system. The authors provide a novel approach to retail competition by stressing on the importance of service in the retailers' portfolio of offers, as compared to previous approaches where retail competition has been modeled as dependent on purely pricing strategies. Service offering within a prosumer-based smart grid environment is among the essential concepts to be considered in the EMPOWER market design (EMD).

3.2 Multi-agent systems

According to Kantamneni en al. (2015) multi-agent systems (MAS) consist of multiple intelligent agents that interact in order to solve problems that are beyond the capabilities of single agents or system. Moreover, Kantamneni et al. (2015) show that MAS are well suited for application within micro-grids. Also, as Karavas et al. (2015)

[1] In Vytelingum et al. (2010) «self-interested» is descriptive for agents that may misrepresent their preferences (e.g. amount of electricity required, capacity to be supplied and prices to be accepted) in order to maximize profits.

prove, MAS could be successfully implemented in polygeneration micro-grids for the purposes of decentralized management and control energy management. In this respect, the benefits associated with use of decentralized MAS-based energy management architecture are considered particularly important, particularly when the autonomous character of the micro-grids and the improvements in the financial and operational terms are considered. The usefulness of MAS in energy management has been confirmed, among others, in the work of Saba et al. (2015) who describe the interactions among agents as such that revolve around cooperation, competition and coexistence, and introduce the issues of collective intelligence and the emergence of interactions across structures.

3.3 Trading of flexibility

Another key issue related to the market design to be developed by EMPOWER is the trading of flexibility. The trade with flexibility services has been discussed in a number of previous studies. Below we will present some contributions to earlier literature that are most relevant for EMPOWER. Zhang et al. (2013) propose an Aggregator-based Flex-market in order to utilize the DER as economically efficient as possible. In their study a Flexibility Clearing House (FLECH) is established so facilitate the participation of small DER (up to 5MW) in trade with flexibility services. According to Zhang et al. (2013) the aggregator is a new commercial market player with three basic functions: (i) aggregate, pack and sell the flexibility offered by DER; (ii) have full knowledge on electricity markets and put right price on flexibility; (iii) get paid by the DSO for delivered flexibility and pay affiliated DER according to contractual agreement. The FLECH (defined as an independent non-profit driven entity) ensures the Flex-market integrity by mitigating counterparty default risk and monitors the efficient and targeted carry out of contract. Heussen et al. (2013) also focus on FLECH and describe its key functionality to be the facilitation of flexibility services in distribution grids. This is achieved by streamlining the relevant business interactions while technical specifications are kept open. Harbo (2013) discuss the importance of proper flexibility contracts between the aggregators and consumers and propose a contract template with the core contract elements that need to be determined so that an enforceable, reliable and efficient relationship between aggregator and consumer is achieved. Ghafarifar et al. (2014) describe a concept somewhat similar to the FLECH one – a demand response exchange (DRX) where DR is treated as a public good to be exchanged between DR buyers and sellers. A DRX operator collects DR bids and offers in order to clear the market by maximizing the total market benefit subject to certain constraints (e.g., demand-supply balance). In addition, the authors describe in what way the various market players, in particular TSOs, DSOs and retailers, can benefit from DR.

3.4 Neighbourhood markets and local services

The EMD can be seen as related to models found in previous literature on neighborhood markets and local services. Ilic et al. (2012) describe a local market place where consumers and producers can engage into energy trading for their neighborhood. The results from their study indicate that a neighborhood market is a viable approach and that it can generate benefits for different stakeholders. Yet, the authors suggest that to delegate the users' interactions to intelligent agents that can act on their behalf is mandatory due to the heavy procedures within the end user-market relationship. In Ilic et al. (2012) are reflected the results from the NOBEL project[2] where a local energy market at smart neighborhood/district level is realized within the city of Alignet (Spain). Participating at the local market end users can take optimal advantage of local conditions and consume electricity produced locally. The "local" aspect of energy systems is also discussed by van der Schoor and Scholtnes (2015). They use a case study approach to describe how local community energy initiatives can contribute to a decentralized energy system. The case study includes thirteen local community initiatives in the northern provinces of the Netherlands in the period 2010-2013. As a result a variety of forms in which local community energy initiatives have organized themselves have been observed and these range from very informal to quite formal. The authors consider the important factors for strengthening the "local network" to be the development of a shared vision, the level of activities and the type of organization. In general, der Schoor and Scholtnes (2015) consider community energy initiatives to be an emergent phenomenon that can help many citizens to engage in the transition to a sustainable energy future. On a general note the value of national patriotism (Seiler 2002) in sale and marketing must be recognized. Indeed "localism" seems to arise in a global economy in ways that we have not seen before (Hess 2009). This provides new opportunities for local industry and regional businesses (De Rafelle 2014). Cox and Considine (2011) focus specifically on micro-markets and show how binding micro-markets to micro-grids enhances the balance of supply and demand. The authors compare micro-markets and macro-markets (wholesale energy markets) and describe the micro-markets as such that share many of the characteristics of macro-markets.

[2] http://www.ict-nobel.eu/

However, micro-markets are presented as more local and use simpler market rules and interactions, reducing the cost of entry and transaction costs. According to Cox and Considine (2011) using bottom-up approach on local needs, shortages and surpluses, the micro-markets can allow a more rapid self-structuring of the Smart Grid. In addition, within local communities, the access to specific value added services can become particularly important. Such services could be, for example, related to a specific end user need, or could aim at benefitting the community as a whole. The importance to offer innovative services to the final electricity consumers has been discussed in the previously mentioned work of Ilieva and Gabriel (2014). As the paper suggests electricity retailers who do not manage to innovate their service offers, aligned with the changing market environment and consumers' preferences, could lose their positions.

3.5 Energy cooperatives

The concept of local energy-oriented communities is considered particularly important for developing the EMD. In this respect, an overview of some key European local energy community initiatives, also called energy cooperatives, will be provided in this final section of the state-of-the-art review part of the document. Using real world cases the overview is meant to give useful insight on the pending power market developments and justify the path chosen for the EMD.

Throughout the last years energy cooperatives have been emerging across Europe with an increasing speed. According to REScoop[3] Europe has so far hosted more than 2400 community energy initiatives. 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. Examples of existing energy cooperatives from different countries are presented in Table 1.

	Name	Country	Purpose
1	Brithon Energy Cooperative	UK	Share the cost and benefits of installing solar PV

[3] http://rescoop.eu/

2	Bürger Energie Berlin	Germany	Give end users the right to own (through buying out) the power grid and operate as a utility; Invest the profits from grid operation into renewable energy generation.
3	Hashøj cooperative biogas and Hashøj Kraftvarmeforsyning Cooperative	Denmark	Produce biogas which is then fed into own cogeneration unit to produce heat for the cooperative's member
4	Enercoop Bretagne	France	Provide electricity directly and 100% from renewable energy generators (solar,wind, hydro and biogas). Its profits are reinvested in renewable energy
5	Coopérnico	Portugal	Engaging citizens and businesses in the creation of new energy paradigm - renewable and decentralized - to benefit society and the environment.
6	SEV - Südtiroler Energieverband	Italy	Advocate and lead decentralized and responsive use of renewable energy in South Tyrol
7	Som Energia	Spain	Produce and market 100% renewable energy resources (solar, wind, biogas, biomass, etc.)
8	Energetska zadruga Otok Krk	Croatia	Promote renewable energy resources in the property of local communities.
9	Sustainable Clonakilty	Ireland	Lessen the town's contribution to climate change and dependence on diminishing resources
10	Sifnos Island Cooperative	Greece	Organize the production and disposal of energy that can be derived from any form of exploitation of Renewable Energy Sources and the total capacity of the island. Organize the production, management, treatment and disposal of products and services on the island and promote socially responsible solutions and activities.

Table 1 – Examples of European energy cooperatives

The participation in energy cooperatives can be motivated by various factors:

- Participants are more eager to pay for a locally produced energy rather than paying prices that are imposed from outside. In some cases money paid by the consumers in the form of feed-in tariffs channel back into the local community.

- New renewable generation capacities, privately owned by the cooperative, could be providing profits that are then to be used for the benefit of all members of the cooperative
- The cooperative can be a driver for new service offerings that take into account the local conditions and specific characteristics of its members
- Local participants can better perceive their contribution to solving environmental challenges

The energy cooperatives are typically organized so that some main principles are followed (LakeCountryPower 2015):

- Participation is voluntarily and opens to all potential members that are capable of utilizing the cooperative services offered and are willing to accept the responsibilities of membership.
- The cooperative members actively participate in the decision making processes and policy setting and qualify the cooperatives as democratic organizations.
- Members of the cooperative contribute economically to the cooperative, but are also able to democratically control its capital
- The cooperatives are often responsible for education and training of their members, so that the aim of the organization is achieved in an effective way.
- An energy cooperative will work hard for the sustainable development of its community at the same time as it keeps strong focus on the members' needs.
- Cooperatives operate as autonomous and independent organizations.

Cooperatives would typically aim to strengthen the cooperative movement and may therefore work to coordinate activities with other cooperatives. Cooperation among different energy cooperatives may take place on local, national, regional or international level. Yet, the main ideas behind such cooperation is to increase the efficiency of the cooperatives' services, gain better positions within the social and regulatory structures and contribute further to the benefits perceived by their members. In Europe there has been a growing recognition that citizens have every interest in ensuring that their energy cooperatives work together on European level (REScoop 20-

20-20 (2015)). This fact can be partially associated with the REScoop 20-20-20 project and contact with members from the European Parliament and European Commission. Thus, federations of energy cooperatives being formed in Belgium, the Netherlands, Scotland, England, Germany, Spain and others (REScoop 20-20-20 (2015)). In addition, in some countries there already exist organizations to support and provide information to community groups and social enterprises that have the ambition or simply consider the creation of cooperatives (National Energy foundations et al. (2014)).

3.6 Value added services

And finally, this state-of-the–art section will refer to the importance of value added services as part of the local market design. Smart Grid technology and the organization of end users into local energy communities could be key facilitators for the development of specific “added value” service offerings. Such services could change the way consumers think of electricity – from a pure commodity that satisfies the need for power to a new configuration of “packaged” service that includes electricity delivery, security, energy efficiency and much more, and that is strongly dependent on the local sites’ situation and the particular customer preferences. In this respect, a reference could be made to the work of Ilieva and Gabriel (2014) who refer to a highly competitive electricity retail market and retailers that dare to set higher price mark-up while at the same time offering better and innovative services to their customers. Customers could be willing to pay the higher price mark if they strongly value the new services and if the services considerably improve their customer experience

Clearly, within a new local market design, the role of retailer and service provider can be taken on by other market actors. In EMPOWER it is considered that a new market actor, defined as smart energy system provider (SESP) could be the entity to facilitate local trade and deliver new services. It is important to note that the way through which customers access the services will be decisive for the extent to which customers are willing to get involved and to which their utility from using a certain service surpasses the price they have to pay. As an example, the use of various applications can help customers gain better control over various home appliances, and thus improve the end users’ experience. Yet, customers’ satisfaction can be even greater if the service provider succeeds in bundling different services through common interface, so that a consumer can save both time and effort. For instance, a demand response regime could be combined with a regular energy sales or purchase contract to deliver maximum satisfaction to the customer by enabling better control over own consumption and increased profit. Another example could be combining energy contracts with heat steering and security services (Such as the ones offered by DEFA's Hytta.Mi[4]). In these cases the easiness through which through which customers access the steering tools and follow up their energy contracts is of particular importance.

4 Foundations for the market design

4.1 Introduction

Prior to introducing more specific functional requirements for the market design research has been undertaken to extract essentials from other domains and relate these to the current developments in the European energy market as well as in other business areas. The ambition here is to highlight those aspects that are believed to be the most influential for the definition of the functional requirements. Another ambition with this task has been to look for resolves and ideas beyond the energy domain. Important principles that are adopted by the EMPOWER project have already been presented as the current state-of-the-art. The work performed extends well beyond what is presented here. Some of it will surface in other work packages. However, the foundation presented should serve as an essential rationale for the design we have derived at.

4.2 Closeness to the consumers and prosumers is essential

Closeness to the prosumer and the consumer constitutes an essential basis for the proposed market design. Today there hardly exists a universal market design for energy that would fit any population, regulatory regime and participants without the need for a degree of customization. With significant support from the literature (De Rafelle 2014, Findlay 2014, Seiler 2002, Hess 2009, Warren 2010) we will further postulate that the closer to the end-customers one gets the better the basis for customization and value increase becomes. An interesting study on art auctions shows how biases can build up in art auctions (Vorilov 2014). The food and agriculture business have already pursued localism for some time and combined this with ecological qualities (Earthwatch Institute 2009). This type of "eco-patriotism" constitutes an essential parallel to the work presented here. The need for localism customization

[4] www.hyttami.no

does not lie so much within the basic commodity being traded, but in the way it is delivered and applied. A market is first and foremost a group of customers that pay for the goods supplied. Without customers there would be no market. Closeness to the customer provides a better opportunity to ask what the customer needs and prefers. The agile supplier entering such a dialog is likely to gain a competitive advantage that will allow him to capture more customers, sell more and increase his customer retainment percentage. A local supplier is in a better position to gather vital intelligence that can be exploited for his business purpose than a more remotely positioned seller. In traditional commerce remote seller also has other challenges too. Higher transportation costs are among these. This usually places the local seller is in a good positon to fend off intruders from afar as long as the information gathered is transformed into products and services that better match the customers' requirements. However, if the customers are happy with average quality and low price alone the local seller has less to bargain with. In such a case the market is primarily pre-occupied with exchange of commodities where price alone defines the winners and the losers. Commodity trading lends itself well to economy of scale and big, global players will be in the front seat. As customers in such markets tend to be ignorant to other features than price given, the quality level suffices. Suppliers will look to resource dominance to secure and grow their trade. This is basic and required business strategy to maintain security of supply and achieve a high market share or even market dominance. Oil, gas, mining, grain, fisheries as well as electric energy, this strategy dictates the major companies.

4.3 A market design that best supports what is traded

Energy sales and procurement may take different forms depending on what is supposed to be traded. We have already indicated exchanges of assets that depart from the standard energy commodity, but may not lend itself altogether to pure product sales and procurement. Consequently, our initial design approach opened wide to allow different perspectives. So far, in this discourse, we have deliberated on the need for a value focus rather than mere price focus. This encourages new ways of thinking which take distance from the prevailing assumption that energy can only be traded as a mere flow of electrons. Consequently, a wide spectrum of market options has been considered.

At one end, we have the battery market. Due to an array of different qualities, brands and applications, "energy supply in a box" is considered a product, not a commodity. In the other end, we have wholesale markets like the Nordpool, MISO and EPEX SPOT.

Electricity can be provided by batteries alone and simple appliances found in households depend on them to work. The automotive and marine industries have been dependent on the battery business for years. In principle, the same concept could allow itself to households and buildings if the technology allows. In many rural regions in the Nordic countries and a few other parts of Europe batteries constitute the backbone supply of electricity (12V/24V) for remote, off-grid households and cottages. Simple barter trade can be experienced in such areas where a discharged battery is swapped with fully charged one for a cash price or a return favor. New batteries are packaged and delivered across the counter like most other products. Some sales require professional assistance, but in most cases the customer is in a position to select and install the battery of his choice on his own.

A parallel to the battery are the diesel generator and similar technologies. However, our focus has been entirely on renewable energy. Fuel cells offer an alternative to the regular battery, but have been treated here as a product similar to a battery.

Electricity wholesale markets are characterized with their real time concern and very high volumes of trade exchanged across the high, medium and low voltage infrastructure. Multiple market designs exist (i.e. NordPool, MIBEL, GME, EPEX, APX-ENDEX) (Schubert 2002), but several are built around a day-ahead market (Imran and Kockar 2014). The use of bilateral contracts is not uncommon. A secondary real time market is typically introduced to compensate for any imbalances that may occur. The wholesale market is truly commodity oriented.

While batteries are pre-priced and sold according to a “super market model”, energy sales in the wholesale market are typically based on auctions. The clearing price becomes a function of demand and supply for that particular day. However, bilateral contracts may dominate in some markets and consequently price setting follows a different pattern where negotiations define the pricing.

A retail market exists that is closely linked to the wholesale market. Most households and small industry buy electric energy through retailers which purchase their assets in the electricity wholesale market. Some operate their own portfolio of traditional power plants. A price mark-up defines the profit level for the energy supplied to the end users. When prices in the wholesale market fall it may be hard to maintain the same absolute mark-up level as when prices are high. This is currently the case in most Nordic countries, but may be foreign to traders in many Mediterranean areas.

The EMD should relate to the wholesale market, but primarily address the retail level. A persistent argument against a local market which is not off-grid is that it could jeopardize overall welfare considerations due to suboptimal utilization of the energy system. Later in the EMPOWER project we will address this issue more closely. At this time we will simply claim that the market design derived at will not threaten the efficiency of the wholesale market. Later we will support this claim through tests and analyses.

Another argument, that is supposed to discourage the type of market development presented here, is that, whenever a local community of consumers and prosumers is connected to the central system, the incentives for local trade are torn away. In a competitive market failure to perform is always imminent. Every retailer knows this already If a local market fails to offer better conditions for trade then an institution like the SESP shrinks to a mere broking facility. This is still likely to provide value. However, we will show that the combination of a local exchange platform, a service provider and broker and our proposed market design provides advantages that may make the local market very competitive. A number of these things have already been highlighted. The most important being the closeness to the buyers and the sellers, the community aspect and the loyalty that this imposes. The combination with services that enables the creation of customized energy experiences for the end user is important. It yields a sense of empowerment. At the same time it allows other than the market operator and central service provider to offer the basis for this. This is likely to expand the scope of offer and spread the risk. A likely consequence is then increased benefits for the individual and the community as a whole.

4.4 The case for local trade

The case for closeness to the market has already been highlighted and the markets for commodities and non-commodities have been discussed. Even as part of a combined product it is necessary to address what encourages local trade for the basic item. In a way similar to that in which clean water from local resources and grain from local farmers can facilitate the local bottled water and bakery industries alike. The two important questions to be asked are what the EMD needs to relate to and when a local market for energy is most relevant? Reflections around this question are given below while this will be part of the ultimate test that the pilots will shine more light upon in Work Package 7

4.4.1 Islanding mode

Islanding mode is the most obvious case for local markets. With or without micro-grid technologies an isolated neighborhood could benefit from mutual exchanges given a certain degree of diversification.

This has in fact, been going on for hundreds of years with prosumers and consumers interacting to sell and purchase fuel for heating and cooking. Woodchoppers and dried manure collectors are just a few examples. A recent African development program[5] illustrates well that this might also happen in 12V and 24 V islands of interconnected buildings where surplus from wind energy and solar power is exchanged. Exchanges are typically made through bilateral contracts or rules of conduct defined by a community council or leadership. With the introduction of micro-grid technologies in the low and medium voltage energy system in any European state we can expect the same. The US military has demonstrated how off-grid local markets could be established (Lane 2013). It should, however, be noted that independence from any central market is not a case for technology only. Geographical remoteness is still an important factor. Players 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 (Abe 2011, Sørdalen 2015) where exchanges also take place across the frontiers of adjacent neighborhoods. The technical provisions for this will soon be demonstrated by the FP7 Project Smart Rural Grid (UPC 2015 (D3.2) and EYPESA 2015 (D7.1), Smart Rural Grid project, Girbau-Llistuella 2015, Gallart 2014)Temporary modes of island operations supported by micro-grid technologies during outages in the principal distribution system can prove to yield a very viable case for local trading, also after the termination of the black-out simply to assure the household, public service or commercial activity in times of poor, central supply.

4.4.2 Semi-constrained neighborhood

Bottlenecks in the infrastructure caused by different physical limitations can also invoke local trade. Parallels to this can be found in the wholesale world too. Constraints in the high voltage infrastructure require extraordinary measures beyond what the spot market is capable of handling. The relief is achieved by means of nodal or area pricing that compensate for the lack of free energy flow. Consequently, most of Europe is divided into different price zones. When constraints are experienced in a branch of the distribution net on a sunny day during summer excessive surplus suppliers may look for local customers to relieve them of the surplus. In order to encourage increased demand the local price is forced down. This assumes that no storage facilities are available. An alternative could be to disconnect the generation facilities and loose whatever revenue that could be obtained unless this activity is related to a demand

[5]

response regime. Similarly a high demand could suffer from the same problem. In such a case the price would go up. Yet, demand response could be introduced to alleviate the problem and dampen the price. Indeed a sufficient energy buffer could achieve the same thing. This case illustrates well how a flexibility service can be integrated with energy sale to handle physical constraints that impose limited access to the central market.

4.4.3 Differentiated distribution costs

Power tariffs reflect the cost of connectivity and transmission. Like physical constraints different tariff structures may encourage local trade too. The influence of high transportation costs on the market development has already been discussed. Tariff policies may have the same effect. Feed-in tariffs that benefit local consumption are an obvious case. The CEO of the DSO Trønder Energi in Norway has illustrated this well (Uthus 2015). High tariffs to compensate for the costs of the DSO may encourage local initiatives of the type that we have discussed here. People will try to find “work-arounds”. In some regions rooftop PV panels, wind or micro-CHP present an ever more attractive alternative as prices of such are falling while tariffs are increasing. People will consume what they can produce and be inclined to sell the surplus where grid tariffs will not ruin the margin. Complete, physical disconnection may also be the answer for some. Consequently, the remaining group of ordinary customers needs to cover the expenses of the DSO, which in turn will raise the tariffs again to compensate for the loss of subscribers. A snowball effect is produced. High power tariffs to encourage load shifting may be particularly instrumental in this process. Their usual aim is to introduce an incentive for demand side adjustment. At the same time such demand side adjustments will influence the free market and the opportunities for consumers, prosumers and common retailers alike.

4.4.4 Tax differentiation

Tax differentiation is used to turn markets in a specific direction. Like tariffs and physical constraints it may encourage local transactions rather than cross border trading. In the case where a prosumer understands that export across the local boundary implies increased taxation he or she is likely to shift attention inward. A consumer that realizes that local energy is cheaper as a consequence of reduced taxation is likely to turn inward too and seek out a local supplier.

4.4.5 Local high-frequency trading

In the type of local market that EMPOWER addresses the available technology will be able to support high frequency trading. The advantage of this has been demonstrated by the EcoGrid[6] project which exploits the advantage that five-minute market offers have as compared to the central day-ahead market. In the day-ahead market hourly prices are fixed within the time frame of 24 hours. The price set for an hour in the day-ahead market may serve as a reference, but real-time fluctuations in the local market, as a consequence of variable demand and supply, can be managed by local trade. In spite of the fact that a local market will most likely lack the volume and capital, that generate significant profits when price volatility is exploited, the parallel to the financial day trading market exists. The principle will, nevertheless, be highlighted here and contemplated for future applications. Most likely, there will be three major players in such a market. One is the entity that aggregates the surplus generated by small prosumers and shared community supply. The other is the ordinary retailer that offers consumers energy. The third would be a major supplier such as a commercial or an industrial building belonging to the community which could be more exposed in the central market than others. Thus, gains can be made if the retailer can purchase and deliver local surplus at a price lower than the one defined in the central market the day before. Retailer's policy will determine whether such gains will be split with the clients. The aggregator and the major player(s) will do similar things albeit for opposite reasons.

4.4.6 Green certificates & guaranteed green energy

Green certificates tend to produce the same consequences as taxation, though in different directions. Green certificates issued for locally produced, renewable energy are likely to boost interest among a group of local consumers. As EMPOWER assumes that locally generated energy is green the same effect could happen without the certificates. People would be inclined to understand that in such a market no encouragement is given to power plants based on nuclear or fossil fuel. Like for ecological food substantial market segment would emphasize this and be willing to pay more as they consider the quality of such energy as higher than anything for sale.

[6] www.eu-ecogrid.net

4.4.7 Community benefits

Assume that every 1000 kWh procured from the local supplier would qualify for a discount coupon that would stimulate the customer to purchase local energy. Loyalty is achieved. The cost is covered in part by the membership fee paid annually and on deals for associated services negotiated by the community management. Similarly, the prosumer may be given extra bonuses by the community for every kWh traded internally. Again, the cost will be covered by other income that the community may have. In this way user engagement will be encouraged. Those who are active will win. Those who prefer otherwise will lose.

4.4.8 Perceived added value

Community benefits is just a particular case of the more general aspect of trading based on perceived added value. Ravald and Grönroos (Ravald 1996) states that there are two basic ways to create added value. One is to increase the benefits by adding something to the core product that the customer perceives as important, beneficial and of unique value. The other is to reduce the customer-perceived sacrifice. This forces any selling enterprise to look at things from the customer's perspective. This is an essential thing in customer relationship marketing. It also implies that the seller has to get close to the customer to be able to understand his needs, preferences and all the activities that constitute the customer situation or value chain. If an asset is presented in a market and the perceived added value allows a high price mark-up suppliers would make preference for that market rather than others. Historically this principle played a significant role in the triangular trade where common glass beads and trinkets produced in England was significantly more appreciated among African natives in the 18th and 19th century. The local African market was willing to pay far more for the beads than anywhere in Europe (Thomas 2015). In the context of EMPOWER it can be assumed that energy sales supported by privileges related to membership of the trading community and associated recognition alone could add such value. Security and quality of supply could also play an important role. Finally services that enhance the energy experience could produce even more goodwill. DEFA[7] is a company that offers a HAS system and associated service that allow people to remotely monitor and control devices in their homes and second residences. The latter implies cottages and summer houses (Bremdal 2015). The company offers comfort, convenience, cost savings and security. The three former pertains to "timely energy consumption"

---

[7] www.defa.no

meaning that energy is not wasted when the residence is not in use. Comfortable temperatures are ensured before arrival still. The convenience factor should be apparent as things can be controlled by means of the smart phone. When the residence is vacant temperatures are controlled to avoid frost damage during winter, damage due to electrical failure and security against anomalies that can yield undesired side effects (such as a detecting a broken window that could cause water damage or invasion of rodents). The local aspect is reinforced through local weather forecasts, local snow and ice reports, local temperature reports etc. It can be customized for the neighborhood. Their customers pay more than €300 for a basic kit and an annual subscription fee of €100 which provides a significant mark-up compared to the basic energy cost. Sales records indicate a higher valuation of the concept in mountain areas than in the low land due to the fact that temperatures there are particularly low and accessibility during the winter can be restricted due to much snow. DEFA offers a fixed price regardless of the geographical area. The system is proprietary and does not allow external services to be added to the bargain offered. However, it shows how a concept like comfort and security builds an energy experience. Each concept can be traded, keeping in mind that the basic ingredient is “timely energy” and “real time status”.

4.4.9 Subsidies

Subsidies on locally generated energy may lower the threshold for consumers and reduce energy costs. The difference between community benefits and subsidies relates to the fact that community members basically finance the stimuli for local trade. Local and national authorities typically provide for the cost of the subsidies and expect nothing in return, but a political reward.

4.4.10 Local patriotism

The importance of localism (Hess 2009) has already been introduced, but also observed in the energy business by authors of this report. Bremdal and Hagen (2014) have shown that local patriotism can be a powerful mechanism for involvement in demand-response regimes. Similar observation have been made in other domains where customer tend to buy from local brands even when other offers are even or better (Seiler 2002, Bremdal 2014). Local suppliers can also relate to local aspects such as the local football team, the local fire brigade to appeal to certain emotions that kick-in when local buyers need to decide. Being able to develop deeper feelings about local trade should also be possible (De Rafelle 2014), but need to be explored in more depth.

4.4.11 The impact of local services

It has already been shown that pertinent services can support and boost local trade. Energy storage is an important example. Allowing people in the neighborhood to deposit energy to use or sell it later is likely to boost both community member engagement and economic benefits. The energy storage equipment could be centered in the community or placed at the location of the generating facility. The important thing is that it needs to be centrally controlled. This kind of energy banking would allow community members to store and withdraw energy at their own will. The service may take on two quite different practices. One is to charge the users for the storage space used. Another is to pay an interest for it. This would allow the storage management to use the stored energy as a means for restitution and balancing. The former would work well when bids need to be followed up by firm deliveries. With intermittent energy sources inaccurate forecasts that support bids may pose a risk that can be reduced or completely alleviated by the storage facility and the compensating service. To even the consequences of physical constraints storage can help to achieve balance.

In the absence of energy storage, or as a complement to this, demand response may help to assure firm matching between the obligation made in the market and the actual delivery. Here it will be illustrated how local trading can be provoked even when attention is directed towards the central supplier. Assume that an aggregator, on behalf of a portfolio of prosumers makes a commitment to sell a volume of energy in the central market the next day. Due to erroneous forecasting the aggregator fails to deliver as planned. In most cases that would force him to buy expensive compensation in the balancing market. If the aggregator, or someone representing it, also has access to consumers (and prosumers) that are part of a demand-response group the aggregator could invoke their services. Lichtblick is a German aggregator that practices this (Loock 2014). Once members of the community compensate for their fellow member's failure to deliver a local market will automatically emerge. Once the beneficiaries have compensated the providers of this flexibility service a trade settlement has been completed.

The local energy market can also embrace securities associated with energy trade. This suggests a local future market. Futures are common in the high voltage domain where large industries operate. For the sake of economic security suppliers of energy and consumers alike can sign contracts that provide them with stable prices over a period. The contract holder will absorb the uncertainty and risk that fluctuating demand, supply and prices may produce. Of course, a secondary market could be established where such contracts are traded too. A contract holder can then transfer the rights defined in the contracts to others for a given price. What is more interesting is the fact that a region or a neighborhood embraces both producers and suppliers. A professional entity can lessen the his risk exposure and that of the local players by letting the uncertainty in the future market be mitigated by means of forecasting, assessment of reputations, and other historic records. For local consumers exposed to high price volatility future contracts of this type could become very attractive and make local high frequency auctions of physical volumes superfluous. Owners of intermittent energy sources in the same areas should also welcome this. A side effect could be a secondary market for futures where rights to buy and sell and to hedge exposure change hands in a similar way like we see in the financial and OTC market.

4.5 Level of competition influences design

The response to price differences in the wholesale market depends heavily on the level of competition. In some end-user markets the choice of retailers is limited and even absent. Electric energy must be purchased solely from the utility that also provides the transmission. There is no separate invoicing for the energy consumed and the transmission costs constituted by the grid tariff. In some areas the wholesale market and the retail market are represented by the same company and constitute a monopoly. As previously described smart grid technologies and different forms of distributed generation have been welcomed in many such areas and initiatives to establish a sound legal framework for citizen initiatives of this nature is in the making (Roberts 2014). This represents an alternative to the sole energy provider and makes available a degree of choice that could lead to losses for the incumbent utility. Henceforth, emergence of DER and SG technologies has triggered counter actions among the dominant players who have turned to the national authorities to reverse any incentive that could create such competition between the utility and its existing customers.

EMPOWER will address issues related to competition in a free market as well as in a restricted market under the assumption that the proposed market concept described has something to offer for all. An essential aspect is that the concept must cater for a degree of adaptability that makes it suited to more than one type of energy system or regulatory regime. This is an ambitious undertaking, but is highly relevant for future adoption in practice.

4.6 Considerations related to prices

Prices in the local market are likely to be strongly influenced by price settlements in the central market regardless of the design of the local market. Even when we assume that the local market is isolated and physically disconnected from the main grid. The principal reason is that the local market will embrace both consumers and prosumers. Consumers are interested in low prices and prosumers are likely to desire the highest possible price for the surplus that they sell. It is in the human nature to look for better opportunities. This has been the quintessential driver for trade at all times. If the reference price in the central market has a price *p1* and the local price *p2* is persistently lower than the *p1* local prosumers and other suppliers will grow discontent and seek the better opportunities in the central market. If *p2 is higher than p1* the local consumers are likely to be attracted to opportunities offered in the central market. This emphasizes the need to offer more than a common commodity and to encourage local content through the community concept. A solution for this will also have to be accommodated within the design.

4.7 Concerns related to dominance and gaming

The small size of a micro-market and the possibility that bigger players will be able to dominate is a concern that must be taken seriously. Lack of insight among non-professional players can be a challenge too. According to Fama (1970)[8] and his “efficient market hypothesis” (EMH) prices in the stock market incorporate and reflects all relevant information and it is therefore impossible to beat the market and capitalize on biases. This hypothesis has been challenged by many, but there is general consensus that information sharing is essential and that this must be conducted according to strict rules. In fact Gode et al. (1993) show that the rules governing the market, if well specified leads to satisfactory market efficiency, regardless of the professionalism (read: intelligence) and insight of the players. In the context of EMPOWER it has been assumed that a high degree of market efficiency can be achieved through proper market rules, control of trading and sound information sharing. The aim is to achieve a price regime (regardless of the form of trade) that is exempt of biases and where the value of the items sold is immediately reflected in the price. This does not imply that the market price will be equal to the true value at every point in

[8] Fama, Eugene F. “**Efficient Capital Markets: A Review of Empirical Work**.” Journal of Finance 25, no. 2 (1970): 383–417.

time. What is important is that any deviations occur randomly. This means that no player in the market should be able to consistently determine whether an asset is under or overvalued. In the longer term there should be an equal chance for the value of an asset to be under or overrated. By means of the technology available and the design of the SESP operational mandate the market efficiency objective has been pursued. Transparency to actions and transactions, both past, present and future will be essential. The ICT supports the use of software agents even so. Barriers that create disadvantages for the non-professional players such as the regular household owner will be removed or bridged.

4.8 Leveraging civil engagement

In a liberalized economy "market" means a free market. That implies freedom of choice for the customer. When freedom is restricted a percentage of the buyers are likely to be unhappy and seek different solutions to meet their preferences. This has been witnessed in many fields. Where legislation imposes limited choice the rise of a "black market" is not uncommon. Where a large corporation seizes control and takes the role of a monopolist dissident consumers often organize themselves in popular movements. US software giant Microsoft has experienced the market force that "open source" movements like Apache and UNIX represent. We see the same thing happening within agriculture where small, but persistent groups of people for years have embraced ecologically grown food. The media and music industry has strived for a decade to reposition their businesses after taking blow after blow from communities such as Napster, popular bloggers and creative YouTube pioneers. This is currently also happening in the energy business.

As pointed out above energy cooperatives are emerging across Europe and want to protect their interest and use the newfound market power. In fact, civil movements like these have given rise to a whole new energy industry in some parts of the world. The rise of wind power in Denmark is just one example (Roselund and Bernhardt 2015). Laymen initiatives are more likely when the threshold for entering the market is lowered. Easy to use and affordable technologies are essential elements in this context. When the price of PCs dropped in the 90'ies and availability of Internet connectivity increased it was also an invitation for the general crowd to enter an arena that previously had been reserved for professionals, such as journalists.

The “grassroot movements” demand attention for multiple reasons. A paramount one is that they make transparent the user needs that mainstream suppliers fail to observe or are unwilling to meet. The popular Bürger Energie movement in Berlin[9] is a case in point. Their essential parole being: *“We want an energy system in Berlin that facilitates local renewable energy and that allows people to get a share of the economic benefits. The change must come now, not later.”*

Popular movements like this does, in fact, constitute a basis for new business models that are inherently prosumer oriented. However, they require a form of control. Where control cannot be achieved very tight communication is required (Bremdal 2011). In other words, civil initiatives of this nature pose a new business opportunity for companies and others that want to play along. They are not a threat if they are met with understanding. The common message that many of these cooperatives send out create a market transparency that can hardly be achieved through other means. Toffler (1980, 1990) was not the first to recognize these possibilities, but he defined an operational basis for businesses who struggled to maintain their shares in a market that was saturated with standard goods. He coined the term “mass customization”, seemingly a paradox, but absolute logical when customers are made part of a business with a value chain pointing directly towards the same customers. The professional enterprise provides an arena where the customer can take part to suit themselves and others. Although this basically suggests self-service the element of customization is strongly connected. If people are allowed to serve themselves in a way they prefer within liberal geographic, timely and economic boundaries the outcome that one customer winds up with is likely to be slightly different from the next. The IKEA example has already been mentioned. Another simple example is the ice cream parlor. The vanilla tasting ice cream constitutes the mass produced part of the final product that the customer pays for. Yet, a portion of this bulk can have other tastes mixed in, for instance pecan and strawberries. The manager of the parlor knows his customer base well through daily interaction and keeps a dozen of the most popular tastes in store. If space and inventory economy allows the number of tastes are likely to increase. When the buyer turns up he is exposed to all the tasty options. From there the customer creates a combo that serves his personal preferences. In that minute the parlor has managed to provide a personal experience that is cherished by many. In a limited way the customer may also serve others in the same manner. But his greatest contribution as part of the parlor’s business is to display the creative result of his customization to pending customers in the neighborhood who still have not made up their mind.

---

[9] http://www.buerger-energie-berlin.de/

By introducing customized self-service options for ordinary people standard value chain activities traditionally performed by professionals can be eliminated. This saves cost. Two things are achieved concurrently. The customer gets exactly what he wants and the seller saves costs. The wise seller split some of the cost savings with the customer to achieve an even higher degree of customer satisfaction. Participation in sourcing and co-production (i.e. fruit harvests for cider production, music production, and blogging), transportation (i.e. bring home the goods purchased with a private car, carry the super market basket around in the shop), sales and marketing (i.e. bloggers, video gamers, and technology testers) are not uncommon. It may be assumed that customized self-service provides the easiest way to engage people and increase their sense of value like the ice cream buyer does. In recent years, major tech companies have realized this. The parallel to the ice cream parlor in the tech world could be Apple and Google. With their smart phones people are allowed to combine multiple “service as an app” in a fashion that suits the owner of the phone. Google Play allows an enormous freedom of choice that enables users to combine the basic commodity that a regular telephone call has become, with hundreds of other services. Unlike the manager of the ice cream parlor Google does not suffer from lack of storage space. Inventory costs are relatively low. Unlike the ice cream parlor Google Play also encourages people to produce part of the selection offered. People’s own apps which are traded on Google’s smart phone platform, increases Google’s collective offering, rises the degree of customization and innovation and effectively spread the risk of failure. The basic feature associated with phones, namely the ability to engage in a conversation across a telecom network is taken for granted. The real value lies in the customized combo constituted by all the original and purchased services that can be harbored in the phone. While Nokia lingered in the personal communication business both Apple and Google (and Android allies) captured major shares in the socialization and personal entertainment market with their smart phones.

4.9 Turning community into commerce

Jeff Howe (2009) has articulated why communities can be turned into business. The proliferation of the Internet and cheap tools gave consumers an amateurs a power restricted to companies endowed with vast capital resources. But it was the evolution of online communities – with their ability to efficiently organize people into economically productive units – that transformed the amateurs with their production methods due to new technology into an irrevocable force. This defines the basis for the community concept promoted in this discourse too.

Our design objectives and central functional requirements circulate around the concept of local communities. The concept of co-operatives has already been discussed. The EMPOWER market design will adopt the business essence reflect in several cooperatives. The design strategy therefore hinges on 3 important aspects.

1. The fact that a community represents a social body that can influence its members and create a kind of shared cause. This body can help to balance out current market powers and increase people's wish to take part. This alone can yield a basic value for many that cannot be ignored. But the community defines important relationships that yield a basis for increased value perception on its own.
2. Secure long term relationships founded on trust and that cater for a forum for learning and lasting engagement.
3. The he need to assure proper compensation for every contribution and to assure that the members as part of the community gets its fair share of the profits that can be made in both the central and the local market.

In this context we assume that a neighborhood or a similar loosely defined branch of the distribution grid adhere to the community concept. This could be a group of farms, a residential area, a village or even a suburb or small town.

It is our aim that community members and any kind of community leadership define the primary audience for the EMD design. In the context of the EMD a community may resemble a co-operative, but not according to its strict definition. In EMPOWER we assume a strict business purpose and platform and the leadership may have different roots, not only recruited among the inhabitants.

Yet the essence of the historic pledge "for the people by the people" stands firm and defines a relevant reference in this project. A community organized within the framework of the EMPOWER concept can also be considered a kind of club where a small entry fee and contribution may lead to greater returns in the form of personal and collective benefits. This is an approach practiced in many different domains, but is not so common in the energy business. We will expand on this to make its rational more transparent.

Frequent flyer programs and frequent visitor programs have boosted sales and customer retainment for years. In fact they engage and entertain a community of loyal customers. Sometimes it can be hard to understand that trinkets, such as a drink on arrival at a hotel and a free morning paper, should be so instrumental to seize the lasting engagement and loyalty of customers[10]. But it happens. This is very much helped by an order of merit concept where the most loyal excel in privileges while the less faithful have their membership status demoted. What these programs lack is the social aspect. A simple card with the hotel chain's logo and access to a personal web page to view the membership status are the only tokens of a community attachment. Social media and gaming treat this differently. Here the community concept encourages peer to peer involvement and capitalizes on that. The whole point is to allow a member to see how he or she is connected. In LinkedIN[11] this drives an interesting form of trade. The basic one is the exchange of information and ideas. The other is related to personal endorsement of competence. The driver behind much of this is career development and peer recognition. In a sense it works according to the principle "you scratch my back and I will scratch yours".

On-line multi-player games like EVE[12] and World of Warcraft[13] thrive on a similar community concept, though often each member is represented by an *alter ego*, namely an avatar. The interesting thing about this is that communities of this type have developed their own local market. Here things that are considered beneficial and valuable for continued progress within the game are traded among the players. The individual incentive for buying is that it could help to increase game status and yield increased power in future scrimmages that the game continuously offers. All of these define an important bag of references when defining the role of communities in the EMPOWER market concept.

4.10 Technology is a differentiator

EMPOWER is in its true sense a technology oriented project. Technology part of the project provides the most important element in EMPOWER besides the market aspect. Technology is essential for the market design. In EMPOWER micro-grid technologies have been targeted, but should not be imperative for the design of a local market. Another aspect of great importance is who controls the different devices such as demand-side switches, batteries and connectors between micro-grids and the main system. The one who provides for and consolidates available smart grid technologies

---

[10] Nordic Choice hotel chain

[11] https://no.linkedin.com/

[12] https://www.eveonline.com/

[13] http://eu.battle.net/wow/en/

in a given region establishes a unique position with that community. A large industrial player may very well achieve monopoly and dominate the ICT platform. The SESP, owned by the community itself or someone close to this may create an effective defense.

A wide selection of affordable devices for metering, visualization, monitoring and control, storage as well as energy generating equipment that can easily be operated by the energy user himself or a community of which he or she is a member must be taken into account when assuming full control. The design and consolidation of the ICT platform occupy a significant concern in WP3 and WP4.

The availability, price and simplicity of different smart grid technologies will greatly influence to what degree people will involve themselves. At the same time new technology can be a driver for innovative solutions and services that could yield competitive advantages for different actors in the market. One important lesson learned from other domains such as the Internet is that the turnover of ideas and prototypes that regular people are responsible for are far beyond what a regular business is able to achieve.

Another aspect that must be kept in mind is the disruptive potential that technology and especially ICT carry with it. The turnover and learning rate of such technologies provide an uncertain variable as the technology basis for a current effort might be severely challenged. Hence it is important that the market design is able to take advantage not only of state-of-the-art technologies, but cater for a degree of enhancement and anticipate future changes in the technology basis. This also assumes a degree of independence between the technology platform and the market aspect and suggests a liberal design which can be customized to some degree, depending on the available technology now and in the future.

4.11 Service combos provide added value

As pointed out before, the basic objective is to create a market place where services are offered in conjunction with the basic commodity, namely energy. The principal form of energy that is addressed in this context is electric. However, other forms of energy constitute part of the full picture and cannot be entirely neglected. Services may be related to all kinds of user flexibility both on the demand side as well as the supply. Services may relate to optimal generation of energy. This objective may not necessarily be related to annual generation of energy measured in kWh/year. Other services relate to energy efficiency programs and such tasks as maintenance, failure detection and technical user support. Financing, security (financial) and storage (vaulting) services are two other examples. Some of these offers have previously been related to the role of ESCOs and the concept introduced is in that respect simply an extension. Other types of services extend beyond the energy domain itself. Some of them can already be found among the retailers' product portfolio and include insurance, discounts on air travel and entertainment[14]. Depending on the choice of technology we could foresee propositions for added user value related to health, elderly care, security, media, sports and life style exchanged in the same arena as pure energy related offers. To distinguish more basic services from the rest we have introduced a distinction. Primary services include support for distributed generation, storage and flexibility. These are essential. Secondary services are also rooted in the energy domain but relate primarily to such things as financing, support and maintenance. Sales and broking services could span across multiple forms of hard assets sold and bought in addition to and in combination with services. This could include gadgets, generation systems, led bulbs and similar, often found on eBay or other web based markets. A high value asset controlled by the prosumers and consumers that could possibly be traded in association with flexibility services and energy would be data related to consumption, production, and storage.

Services that take advantage of the technical infrastructure found in a given area, but belong to a domain not directly related to energy are called tertiary services. It is important to note that the value potential of tertiary services can far exceed that stemming from the energy domain itself. Entertainment, health and elderly care may be just a few examples. Currently, however, we will defer attention to this. This is to reduce complexity of the concept that we wish to describe.

The EMD thus places great emphasis on services and the assets associated with them. The idea is to specify any combo as a true and complete asset that allows a form of trading that distinguishes itself from the central market and which is rooted in the local community. Another important issue that must be recognized is the need to define mutually supporting services to assure a coherent offer that yields the anticipated value for the customers in this market. This can be assured by encouraging the development and simple presentation of matching offers. This will allow the buyers in the market to easily combine offers and customize their own "energy experience".

[14] www.fjordkraft.no, www.los.no

4.12 Flexibility services are essential in most regions

Faithful to the smart grid paradigm we assume flexibility services to be a principal asset that can be traded and is therefore central to what we propose here. Sufficient evidence can be found in the literature that shows that user flexibility offers significant value to DSOs, TSOs and markets alike (e.g. Magnago et al. 2015, Bouckaert et al. 2014, Aghaei and Alizadeh 2013). We have, however, taken the position that the value of flexibility is elusive to many. If not, a value chain that recognizes the household or the estate owner as the true suppliers and the DSO or the society as the factual beneficiaries, would have established itself as a default world wide a long time ago. But only when a systematic revenue stream that honors the *de facto* supplier for his participation is established, can it be claimed that such a value chain has been created. The positive impact of successful exploitation of user flexibility on the energy systems across Europe and the European society can be proven (Bolkesjø 2013 , Roos, A. et al. 2014). However, several authors have pointed out that the immediate benefit to the user is marginal. In fact, it has been documented that users may be forced to sacrifice certain values, such as privacy for the energy system to capitalize effectively on a contrivance such as demand response. Sharing the benefits of aggregated flexibility as a mechanism for peak load reduction and price leveling requires recognition of the energy user as a supplier of flexibility and flexibility must be recognized as a true asset together with energy. This also suggests that flexibility can be traded both for long term and for short term purposes as discussed earlier (Zhang 2013, Harbo 2013, Heussen 2013). A systematic means of compensation must be established in association with this. In basic economic terms this implies a reversed cash flow where the providers of the flexibility asset are compensated for their contributions by the benefitting parties.

4.13 Regulations and policies

Regulations and policies may have a profound impact on any market and trade. Historically politics and free market principles have frequently proven highly incompatible. Trade is driven by personal incentives that seek to exploit the value potential related to the asset traded. A price settlement in a free market reflects an agreement between seller and buyer based on their assessments alone. Regulations may tilt this to assure benefits for others, especially the society. This may lead to a reevaluation of the original incentives and change the trading behavior in profound ways. It is not said that regulations will alone hamper free trade. There are plenty of examples which show that government actions can spur new forms of investments, trade and commercial behavior. Multiple examples of this can be found within the renewable energy sector where subsidies and revision of tax legislation have been instrumental in various part of Europe to turn interest away from fossil-fueled energy to wind and solar based. Wind power in Denmark and Germany, solar energy in Portugal and Germany and electric vehicles in Norway are just, but a few examples. Our design approach has addressed several issues of this nature to understand in what way the proposed market design can be accommodated in different regulatory regimes across Europe. A mandatory design requirement is “adaptability”. However, the many different policies faced will also suggest the need to abstract away from the idiosyncrasies of national regulations. A case in point could be the present subsidies for distributed energy generation in Germany. In reality the present regulations in Germany seem to discourage a general market approach among local suppliers who in several instances are likely to be paid the same price regardless of how they perform. In a regime like this a stronger focus may be placed on the consumers. In the Nordic countries the responsibilities of the distribution system operator (DSO) role and the retailer role have been formally divided to assure that the monopoly of the grid owner will not create barriers for free competition in the retail market. The importance of this division has recently been emphasized by the Norwegian government (Olje- og energidepartementet 2014). This stands in stark contrast to legislation in many other European countries where the retailer role and the system operator role are controlled by a sole commercial entity. This leaves a community or its individual members no other choice than to get involved as a competitive factor. Grid tariffs play a major role. In all markets transportation and inventory costs may influence trade and competition. High transportation costs may force remote players to give up certain customer groups and a local market will emerge as a consequence of this. In fact, on an abstract level, high transportation costs and physical congestions along the transportation group can yield the same effects. In some European countries like Germany present tax regulations favors short travelled energy. Green certificates will in many instances favor purchase of energy that is guaranteed “green”. In Norway the regulator has heralded a prosumer oriented regime that favors self-consumption, but will also allow the prosumer to sell any surplus in the general market by means of an aggregator as long as the power is limited to 100kW (Norwegian Water Resource and Energy Directorate 2014). The surplus being fed into the system and market will be exempt from the regular net tariff. In Spain legislation forces the independent prosumer to pay net tariff along with regular customers regardless. These examples should serve to explain why the market design should include a degree of submissiveness that enables it to be customized and accommodated. This also suggests that the market design needs to be kept on a fairly abstract level at this stage of the project.

5 The basic functional framework

A list of functional requirements that the proposed market design should meet has been compiled. The principal ones are shown in Table 2. These requirements define the intended performance of the EMD.

Table 2 – Functional requirements for the EMD

Functional objectives and requirements	Remarks
Define a commercial and social community related to a specific part of the distribution grid that will benefit the consumers, prosumers, the DSOs, retailers/aggregators and other service providers.	The concept should be able to operate within one or more neighborhoods and defining ways to organize and contain people in this area within one common local market is an ambition.
Be community oriented and engage its members.	Take advantage of the sentiments and ambitions that currently drive energy cooperatives across Europe. Look to other domains where user engagement is vital for businesses.
Members of the community should divide and share benefits in accordance to common market principles and the degree of engagement demonstrated by the members.	The market concept should provide a way for community benefit enhancement and profit sharing in line with what cooperatives advocate
Create incentives for local trade of energy and energy related services.	This implies that benefits that are achieved through the EMD are measurable as better than the ones obtained in the orthodox way.
Support and encourage prosumers and local energy generation based on renewable sources.	The philosophy here is that short travelled; green energy is good and preferred. Facilitate efficient integration of demand response, services and prosumers.
Facilitate integration of consumers who wish to purchase locally generated, environmentally friendly energy.	Promote energy localism in information and define ways to prefer trade of locally produced renewable energy.
Support the welfare and social development of local regions.	Assure added value for all participants including high quality of supply and timely support. Provide due compensation for the individual and community

	alike.
Be an arena for exchange of local energy and energy related services.	The balance between energy and energy services will depend on multiple aspects such as the general price level for energy, innovation level of DSOs and retailers as compared to service providers, and available technology
Be adaptable to different trading models	The market design should be able to work with and accommodate different models of trade
Support exchange of energy and energy related services and settlement of such exchanges.	The exchanges can be in the form of energy, flexibility services or other types of services where focus will be on the combined value rather than on energy or service prices alone. Exchanges can be supported by auctions, bilateral contracts or super market type of models.
The frequency of exchanges must support the need for balancing power and event driven requests.	Both long term and short term exchanges should be supported. Short term could mean down to 5 minutes.
Assure fair trade and avoid gaming.	Balanced and timely information sharing and crisp market rules are essential
Be adaptable to variations in the size and number of participants in the region.	Obviously a critical mass is required, but even a branch in a rural grid with a small number of participants should be able to benefit in part from the concept proposed here.
Encourage consumers' preferences for local generation and consumption of renewable energy.	Consolidate and make transparent benefits.
Provide easy access to available storage facilities and services offered in association with these.	Cater for the accommodation of central community storage.
Provide easy access to optimization of generation and risk mitigating services	This also includes forecasting and optimization with different objective functions: revenue, profits, ROI, annual kWh produced/consumed, low volatility, maximum local and renewable energy sold, etc.
Relate to the central wholesale market, but not require changes in it.	Observe that there is a central market. Whenever the central and the local market are connected and no constraints exist the central commodity price is likely to determine the ceiling for suppliers and the floor for consumers.
Support efforts to suppress price volatility in the central	Effects caused by intermittent energy generation in

energy market.	the neighborhood can be locally contained.
Provide easy access to services for condition monitoring, legal issues, repair, maintenance, security of supply.	The service aspect should be integrated with any other means to increase production, assure secure exchange of energy and reduce uncertainty and risk related to failure, change of weather etc.
Support exchange of services consolidated with energy sales and procurement.	An important added value aspect aside from the fact that it can help to address issues rooted in the local community.
Should cater for efficient load management and support the local DSO and TSO.	This includes all kinds of flexibility services.
Integrate demand response with energy sale to mitigate vulnerability to volatility and congestion.	Recruit the necessary end-users and consolidate and integrate relevant technologies to achieve this.
Allow and encourage different service providers' access to the EMD.	The SESP should not be the sole provider of services. EMD allows prosumer to prosumer interactions as well as participation of external professional service providers. Here it is important to look to market arenas like Google Play, eBay, Finn.no and similar on the net.
Capitalize on available monitoring and control technologies, but not be fully dependent on the most advanced technical solutions.	The philosophy being that that more control and insight yield more options in terms of design. However, the design should not collapse as a consequence of a leaner technology suit available. This will subsequently constitute an essential test for the EMD.
Take advantage of available micro-grid technologies that could possibly embrace the community.	This suggests that a neighborhood could be disconnected from the main grid for shorter or longer periods. It also implies the use of storage. Connectivity to other cells should also be catered for.
Be adaptive to different ownership and control	The SESP and the underlying ICT system must be able to operate under different business interests
Be adaptive to different regulations and policies.	It should be possible to customize the EMD for different regimes.

6 The EMPOWER market concept

6.1 The value stack

The EMPOWER market concept centers around a stack of products and services that constitute an energy oriented and coherent set of offers (Figure 1). Such submissions would be specified in a contract presented to the community members. Increased attraction and better retainment of participants are keys in this context.

The framework is the community concept which borrows a number of key elements from the energy cooperative, but which can also be found at the heart of the value propositions that companies like the previously described DEFA and Lichtblick[15]. The community defines insiders and outsiders in a very pronounced manner. At the same time voluntary participation in this community must be emphasized. In some parts of the world this kind of community concept could be adopted in full by a small municipality or similar with a legal governing body. This body could take on the full responsibilities of the SESP. The consequence would be then that collective participation could be both wanted and required. Democratic processes would then govern whether people belonging to that municipality would become jointly member of the community.

The community embraces both ordinary consumers and prosumers. Both new and established commercial roles could be associated with the community management and its members in various ways. In fact, some of these roles could be fully absorbed by the community itself.

Figure 1 - The overall value stack offered to members of a community

15 https://www.lichtblick.de/

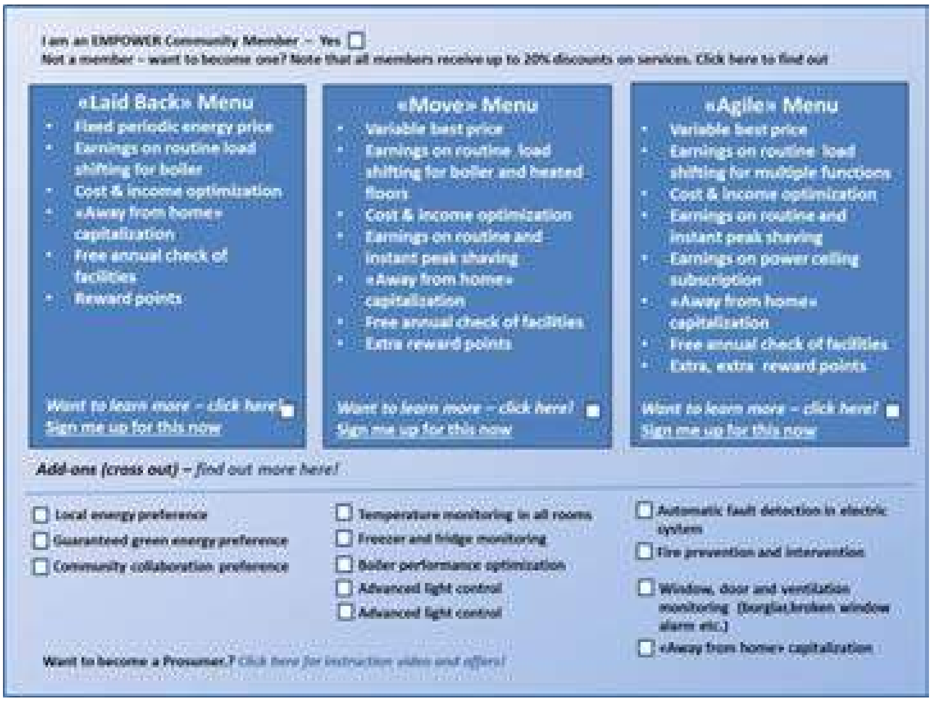


Figure 2 - An example of how the value stack or part of it could be presented to an energy consumer. Similar offers could be made to prosumers in the same community. Note: "Away from home capitalization" implies that the SESP can operate the building or household freely to increase earnings and savings of the contract holder and the community. Many would assume that "Local Energy Preference" and "Guaranteed Green Energy Preference" would be an inherent part of the three basic offers. Here we have included such preferences among the additional options just to show that such inclusion would not need to be mandatory.

The base of the value stack is energy and energy exchange. Without this the market would become something quite different. Focus here is simply kWh. However, in addition to this we may build other services. In a low price market the fraction of the energy part in the of the overall stack would be lower than in a high price market simply because economical gains for energy alone are likely to reduce the incentives for added value elements. On top of the energy sale part trade in kW, sometimes called "negawatts", can be established. These would be services integrated with the energy sales part. Above that other services can be added. These could relate to comfort management, energy efficiency, security of property and other things that we have discussed already. Flexibility services would not be mandatory. Third level services could be combined with energy and energy sale only. However, much of this would require products related to visualization, control and management that also could support flexibility services. Demand response services should be integrated with other things that reduce apprehension and fear for overruling if they are combined with offers that could provide cheaper energy and contribute to an easier and better home and life style. In Figure 2 we have tried to illustrate how the value stack could appear before a regular consumer in a neighborhood. Here three basic offers are presented. One is associated with less risk exposure and user involvement than the two others. Add-ons can be chosen *ad lib* by the user. Some may be for shared for free; others will require purchase for an extra cost. In sum the consumer should experience an additional value beyond ordinary energy sale and spot long term benefits as member of the community. Despite the oversimplification the illustrated example is also meant to show that decisions can be made on the fly with a tablet PC or a smart phone. Once a contract is signed (by crossing out and clicking a button like for an airline ticket) for a combo like this, a script is created that is accommodated in a personal software agent. We will discuss this later and in D6.2 too. The point to be noted here is that direct energy involvement is avoided for the convenience of the user, but also to avoid gaming or undue manipulation. This is part of the market design that we propose. Further research around proposals of this nature is pursued in WP2. In the discourse of business development and modelling value propositions of this kind are pivotal.

6.2 The overall platform

Agents, services and trade of different kinds will be accommodated in the cloud based SESP platform. The main components there will be the “Local Market Place”, “The Metering Cloud” and the “SESP Control Cloud”.

The Local Market Place will allow agents, defined according to contracts signed, to operate on behalf of community members and their associates. All available information will be equally shared among the participating agents and participants may request associated services to benefit their trade. Such services could include forecasting, individual resource optimization and risk management. The Local Market Place will manage settlements of all trade and contracts. It may gain access to real historic as well as real-time data form meters and other instruments such as thermometers, barometers, traffic (relevant for EV charging), wind speed etc. Based on the activations and settlements made the SESP will issue operational requests that will be channeled through the control cloud to the devices controlling energy generation, energy consumption, energy flow and energy storage. The interaction between the principal elements of this operation will be addressed in detail in WP3.

Figure 3 – Overall platform of the EMD

6.3 Modes of operation and the role of technology

By means of micro-grid technology such as a power router[16] (UPC 2015 (D3.2), Smart Rural Grid project) it will be possible to disconnect the neighborhood from the central market entirely (Figure 4). The isolated neighborhood will effectively form a local market managed by the SESP. Storage and demand response capabilities within the control of the SESP and the neighborhood will be essential to maintain the necessary power balance and frequency.

[16] In the 7th FP project Smart Rural Grid an Intelligent Distribution Power Router (IDPR) is under development. For the purpose of conceptualization we have used the IDPR as reference, but operations of the kind discussed here are not solely based on this invention.

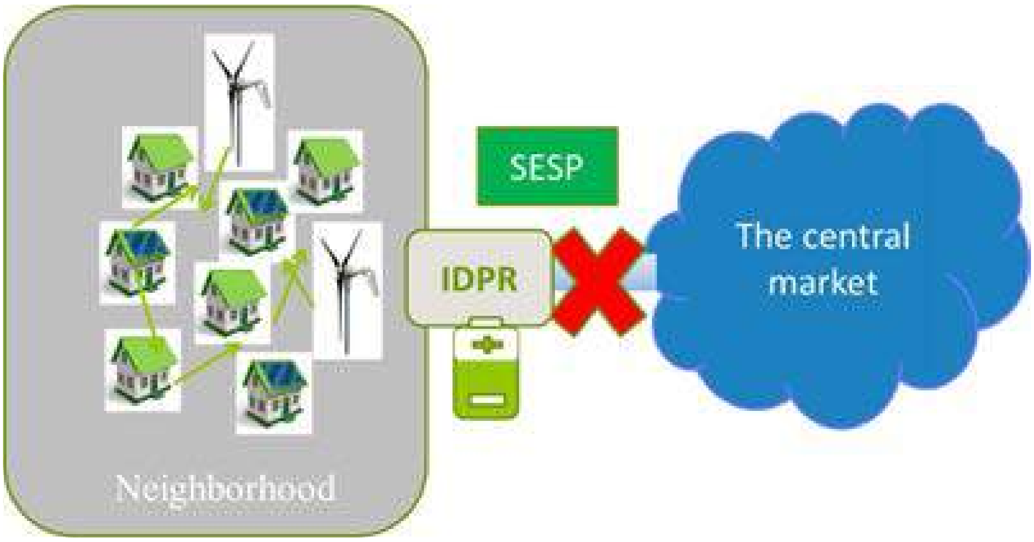


Figure 4 - Disconnecting the neighbourhood from the central market with the help of IDPR

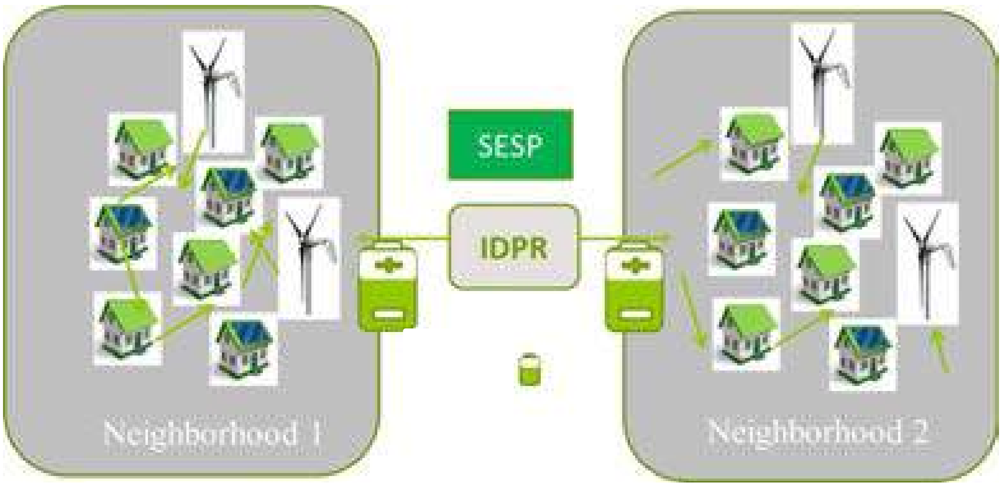


Figure 5 – Connecting neighbourhoods by means of IDPR

The switch represented by the IDPR in the diagram can be operated as a tactical device too. In such a case the SESP would operate on behalf of the entire community. Tactical dispositions of this nature could be essential if the DSO needs demand side adjustments or when central supply is weakened or closed down. It can also be used to hedge the community's own interests for different reasons.

Cellular structures of this kind will on its own yield relatively little impact on the central market. The differences in volume will be far too extensive. However, as Figure 5 shows different neighborhoods can connect by means of the same technology. This proposes a local market consisting of several neighborhoods that each constitutes a micro-market. At some point the cellular structure will reach "critical mass" and create a profound impact on the central market.

In a case like this one the local market can combine different modes of operation. By enabling closure and opening of different IDPRs, export and import across some cells can be achieved, while other cells remain isolated and more inert (UPC 2015 (D3.2), Smart Rural Grid project) . This will enable directed transactions. Once batches of energy are transmitted in ways like this quality aspects such as origin and timeliness will be an inherent part of the transaction, thus building up under the concept of future energy as a non-commodity. This also introduces a hierarchical structure. The micro-markets cater for themselves and assure balance by means of export and import across boundaries as well as by means of storage. We hypothesize at this stage in the project that such a structure will better be able to take advantage of the local qualities and idiosyncrasies rather than regular aggregation typically associated with classic VPPs. Deficits in one area due to shaded PVs or little wind can be recompensed for by others with a surplus. In fact, the supplying can route its surplus across a preferred path.

In many cases, at least in the foreseeable future, the neighborhood may lie completely open to the central market. This is illustrated in Figure 6. Periodically, or as infrastructure becomes gradually exhausted due to increased energy activity, constraints may ensue or be imposed by the grid owner. Power ceilings may need to be introduced. Physical congestions may occur and grid tariffs may impose costs on transmission that yield the same effect. In EMPOWER we will show that local markets are still valid. We will also prove that a good market design can be adaptive in the sense that it can absorb new technology to improve its functions and objectives as a haven for local, renewable energy and related services.

Figure 6 - The local market directly connected to the central market with no or some obstructions.

To control the energy generation, consumption and flow to operate tactically both in the local and central market would generally speaking involve devices and operations that can also be applied for the benefit of both a DSO and a retailer/aggregator. Hence the technology presents a platform for integrating the basic energy exchange with both demand side and supply side management (Figure 7). It will be an ambition for any SESP to ensure that the technology deployed will not only be customized for the particular neighborhood, but suited such that it can serve the associated grid owner, retailers and aggregators too. As such the SESP becomes an agent that operates on behalf of the community. The SESP negotiates a contract with the DSO which includes different forms of load shedding and possibly also frequency control. In this respect we have looked to iPower[17]. The relationship between the community members, the SESP and the DSO will be explained later. Next, an aggregator operating on behalf of pure producers as well as prosumers could benefit from the same technology and concepts that the SESP controls. Previously, we have described how aggregators can use demand side regulations to ensure that bids are followed up with the required volume of energy instead of buying dearly in the balancing market.

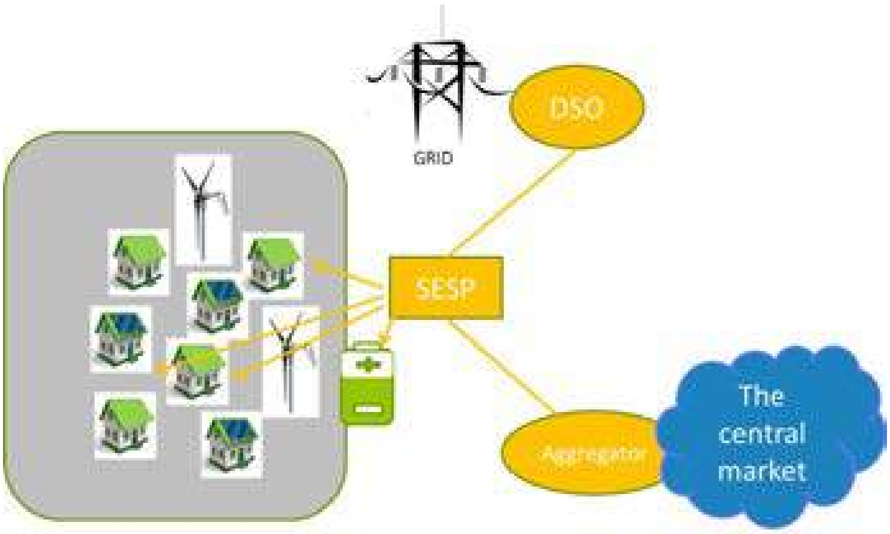


Figure 7 - The SESP operates on behalf of the community towards the DSO and the aggregator.

In addition to serving the established actors in the energy market the SESP will also be able to maintain related services that are typically offered by enterprises which are more remotely placed. Appliance monitoring, fire prevention and fault control are types of services that can use the same system as the SESP controls. Hence, the technology platform becomes an enabler for a range of services that can be consolidated the way

[17] iPower represents a strategic platform where universities and industrial partners consolidates innovation and research activities for the purpose of developing intelligent control of decentralized power consumption http://www.ipower-net.dk/

we have explained. This can happen if the SESP is an independent commercial entity, owned entirely by the community, the local DSO or any other party.

6.4 The overall market design

The basic market design has been depicted in Figures 8.1-3. As can be seen the local market is divided into three sections. They are characterized by their differences. But they also blend in to support offers and bids, depending on the principal concern at a given moment. Together they make a whole that should make it attractive to be member of the community.

There are four types of internal participants in the local market consisting of one hub like the one shown in the figure. These include:

- The pure supplier/producer
- The pure consumer
- The energy prosumer
- Other service provider

In order to characterize the participants' basic actions we have used a terminology typically applied in the financial markets. Suppliers ask a price at which they want to sell. Buyers bid for what they want to buy.

Here the regular supplier/producer could be a small wind or solar park that belongs to the community or a single member of it. The supplier/producer is a seller of energy. However, this participant may also be a principal buyer and seller of flexibility. Moreover, the supplier is likely to request or bid for local services. Such services could encompass temporary energy storage space, services that boost output, forecasting, instant fault detection and risk reducing services.

The pure consumer does not have facilities for generating energy. Naturally the consumer's agent would bid for energy. But as a participant in the flexibility part of the market the consumer might be a seller of his service and therefore ask a price for it. Again, the pure consumer would possibly bid for energy efficiency services or help to monitor its consumption. This could be permanent or a highly temporarily. Sudden price developments or problems with the household's energy systems could demand instant relief.

The energy prosumer would typically be active both as a buyer and seller depending on the amount of surplus that is generated at any time. As for dedicated producers and

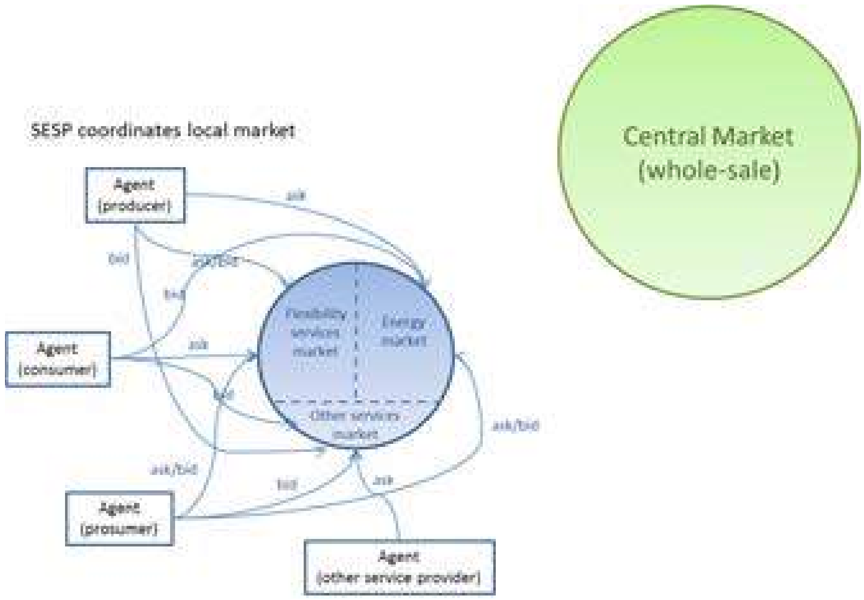


Figure 8.1: The local market in islanding mode

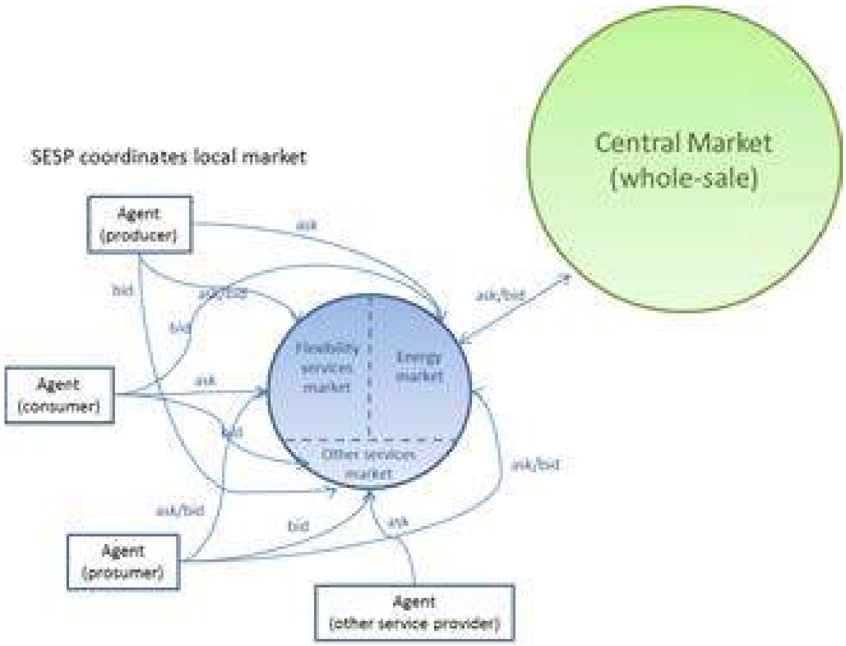


Figure 8.2: The local market with a SESP that also trades in the central market

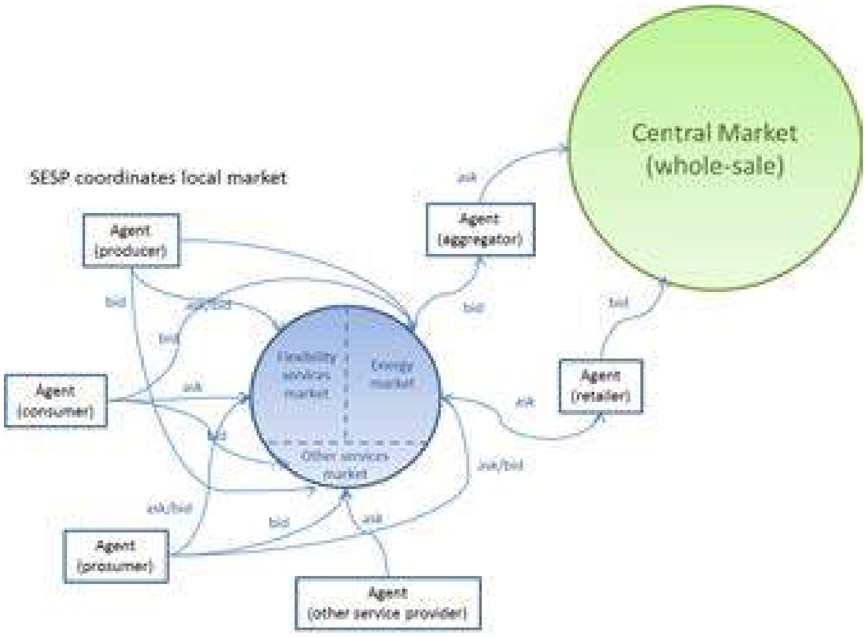


Figure 8.3: The local market where the SESP offers a general trading floor, but leaves interactions with the whole sale market to others

Figures 8.1-3: The basic market design, presented by three different alternatives

regular consumers the prosumer might need long term services or instant relief to fulfil its commitment to the market or to avoid losses, liabilities or similar.

A fourth participant is the “Other service provider”. IT can be an external as well as internal participant. As a member of the community this participant is likely to be one of the three others already described, but in a different role. This is highlighted to make transparent that community members can provide services in addition to what they otherwise do. A smart phone app that offers a fault detection service whereby the app is allowed to communicate with the sensors or control units already installed in a household or building could be shared or sold in this market.

Various revenue models could be imagined and competitive offers could be a part of the whole thing. Apps that are already accommodated in the cloud need only be activated. Set up can piggy-back equipment that is already installed. Services of this kind may be turned on and off in a liberal fashion, depending on the short and long term needs.

Figures 8.1-3 also show how the local market can be disconnected from the central market provided that pertinent technology is available to secure the necessary balance. From a market point of view it makes less difference whether the local and the central market are connected or not. Suppliers and consumers loose some options that could in certain cases meet their expectations in better ways. Moreover the ask-bid spread in the central market would impact decisions in the local market. We have assumed in the basic case that the community could have some kind of direct access to the wholesale market. This would have to be made part of the composite set of roles the SESP may have. However, as can be seen from Figure 8.3 ordinary retailers and aggregators could be invited into the local market. Without their own resources they would have to sell or buy in one market and do the opposite in the other. Time aspects could be exploited for this purpose. From the perspective of the community and the local market there would, in principle, be just another seller and buyer. Differences in volumes may require particular market rules and governance measures. From the viewpoint of the SESP physical constraints may require certain measures to handle congestions and load peaking. But the basic operation would be the same. The real issue in terms of business considerations is whether the retailer and aggregator can be competitive. This depends heavily on what price mark-up they will require to survive economically. The SESP is better positioned as it can offer more for less. It can use its platform to consolidate much more than the regular retailer and aggregator and thus increase value for the community members that are engaged. If regulations permit it could take the role of both the aggregator and the retailer and use the central market as a compensating instrument to cater for deficiencies and surplus that cannot be absorbed within the community. Moreover, it can stimulate internal trading by creating a more favorably ask-bid spread in the local market. Where the regular retailer fights for a profit margin the SESP might ignore this and rather use that margin to increase liquidity in the local market. Different revenue concepts can be applied and related to the number of transactions per period in the local market.

6.5 Roles and relationships

Figure 9 shows more details. We have used the Nordic system to illustrate the interaction with the central market. This makes it very pronounced that the EMPOWER market model does not upset the present wholesale market, but defines some additions. It also shows that the proposed design allows a retailer or other external parties to compete for attention of community members alongside the SESP. What is important to note is how the SESP functions as a sole hub for the combined exchanges. As previously argued this dominance may not necessarily be a product of legislation. The ambition must be to create a facility for broking, trade and mitigation that is so attractive that even established players find it profitable to become a participant. Note too, that the concept allows the SESP to serve the external Retailer/Aggregator, the DSO and external service providers. In such a case the SESP does not have direct access to the whole sale market. However, we may assume that this option could be viable for multiple reasons. As a consequence, the SESP will also act as a kind of aggregator and retailer with the sole purpose of finding a way to deal with the deficiencies and extra surplus that might occur in the local market. We will call this the Base Concept and go on to explain the relationship between the different roles. Apart from the prosumer, consumer and the specialized producer there are all the other familiar roles. The novelty of the concept lies in the relationships with the SESP and what these relationships imply for commercial activities.

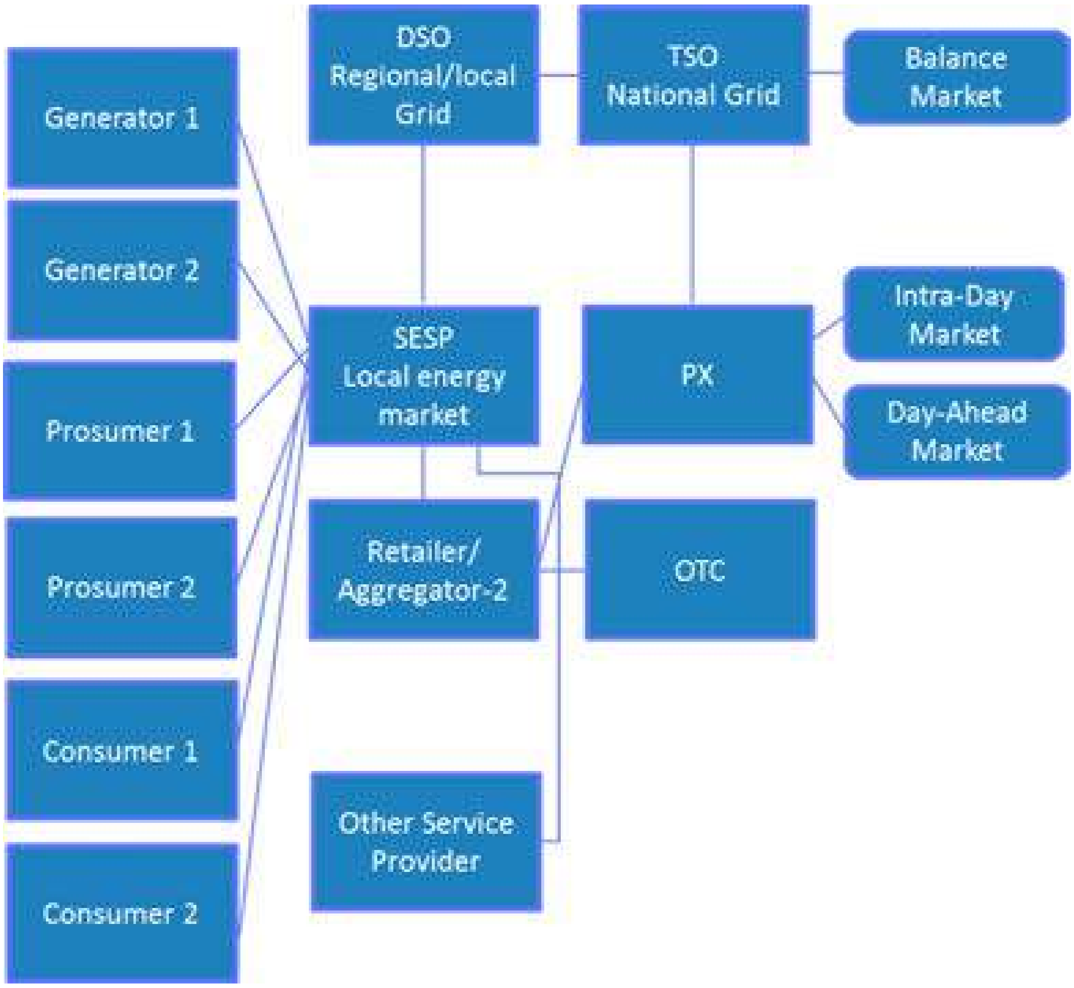


Figure 9: Base Concept: The local market and the SESP relationships to other market and energy system operation roles.

6.5.1 SESP – Generator

As explained earlier 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 technical infrastructure which the SESP can offer. Some services are more likely to be generated and maintained by the SESP itself, but broking is essential. Other service providers, both internal and external will be invited in to seek better opportunities as part of the Basic Concept. The producer will be able to establish a long term bilateral contract with an aggregator or any other local consumer through the SESP. Acquiring a local consumer might be beneficial for multiple reasons that have already been touched upon. However, as many consumers, prosumers and aggregators might be hooked in to the local market it could be a more promising outlook for the prosumer to actually take part in daily, hourly or even 5 minute auctions to mitigate risk and to maximize economic benefits. What the best strategy for the producer would be will depend on multiple variables. As described in the chapter on state-of-the-art concepts that facility energy exchange between a producer and consumer has been explored in different ways. The entire mentioned can fit into the relationships described here. This will be further explored in more depth in task T6.2 of the EMPOWER project.

6.5.2 SESP – Consumer

The local consumer may prefer a local supplier. However, with a high degree of intermittent supply the consumer’s foremost concern is to ensure consistent supply to cover his or her demand. The consumer’s personal agent in this regime may be agile enough to handle very short term transactions to secure the best possibly benefits and take advantage of volatility caused by variable production. This flexibility can be strategically applied for other purposes that could benefit the consumer. The local patriot may go further than anyone to adjust his consumption to ensure local supply. Yet, the SESP will provide incentives to formalize and systemize the use of the latent flexibility for broader application. Consumers may be offered contracts whereby demand is adjusted according to the needs of the local suppliers, the DSO, the need of the retailer, the aggregator, the retailer and even providers of other services (in the case of fault detection, energy “banking”, maintenance etc.). DSO’s might want to resolve peak load problems, local suppliers may want security due to variable generation and those roles facing the local market might want to resolve problems arising from mismatches between forecasts and real volumes and prices. A long term contract with the SESP on behalf of the community that honors the participating consumer with a preparedness reward and a price for different types of activations constitutes the basic relationship. This contract reflects whatever the SESP believe is essential for the local market. It reflects what is formalized with the DSO, the retailer and the aggregator role. It is common to use an “order of merit” approach to determine the proper pricing for involvement. For the time being we will stick to this approach, but the dynamics that we can anticipate may demand a different approach. People’s behavior and needs may be unpredictable and instantaneous responses might be required that cannot necessarily be met by a fixed price regime based on a rigid order of merit concept. In such cases we are likely to see mitigations as the need arises based on Dutch auctions (on behalf of the DSO or a single aggregator), double auctions (i.e. with more than one supplier or aggregator) or similar that take place within the framework of a long term agreement. In Task 6.2 we will explore this in more detail and assess the trading concepts presented by Vytelingum et al. (2010), Kahrobaee et al (2014), Baerenfaenger et al. (2014) and Ilic et al. (2012) within the framework established here.

6.5.3 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 concern and interests of the consumer.

6.5.4 SESP – Retailer

The SESP offers the retailer continuous or sporadic access to the local market. The retailer may not be given any privileges and will in principle be treated like any other buyer or seller. The incentive for a retailer to take part would be relief of a management overhead and risk, although this may also be catered for in other ways. If bottlenecks should occur the retailer might find it beneficial to buy local energy to meet pending obligations with local customers. If taxation or tariffs favor consumption of local energy a professional retailer may operate all within the local market and only use the central market as a relief measure. With no generation of its own the retailer might be exposed to a different type of competition in the local market. This calls for novel thinking. In such a case it is highly likely that the retailer would invest in local storage and service creation too.

6.5.5 SESP – Aggregator

The common commercial energy aggregator might find himself in a similar position to the one of the retailer. It can be assumed that an aggregator would prefer to establish direct contact with the prosumers and suppliers. But there are also incentives for working through the SESP and seek better opportunities there. Assume that the aggregator has established his base portfolio beyond the community controlled by the

SESP. The aggregator can then use this local market and similar ones as a short term flexibility market in order to make sure that he can make his commitment in a cheap way. The aggregator may place a bid in the local market to ascertain that a certain volume can be delivered in the next hour or hours. The request made may be settled in several ways directly or indirectly with the local consumers, prosumers and producers. The aggregator has no obligations beyond that particular exchange, and it may pose a better opportunity than requesting the same support elsewhere. Even the aggregator operates solely in local markets like the EMPOWER it may be convenient to use the integrated flexibility market to assure that the local portfolio of producers and prosumers with surplus can deliver the requested volume on time.

It is important to note here that the mechanisms of engagement and principles of trade that the SESP offers to the retailer and the aggregator will be the same as the ones customized for the local community members.

6.5.6 SESP – DSO

The technology and principles that could be beneficial for basic energy trade in the description above could also be beneficial for the system operators and vice versa. The DSO for the benefit of his own operation or on behalf of the TSO may want to outsource the load reduction and load shedding task to a service provider. Also voltage control could be included in this. The SESP would be a prime candidate for this task. Either the community is all “wired up” already and can take on the task requested or a long term contract with a DSO could initiate such development. Regardless of in which sequence this ends up the long term contract with the DSO could be a very important for business development. In EMPOWER we have so far adopted the iPower flexibility market principles (Zhang 2013). First of all the SESP will engage with the DSO and negotiate a long term contract for mutual conduct. This legal framework agreement will support periodic call-offs, typically every 3 months. The periodic call-offs specifies activation frequencies and ceilings that the DSO needs. Prices will be negotiated accordingly. There will be at least three price elements discussed. One is a sign-on fee that honors preparedness for the whole period. Then there will be an activation fee. In addition there will be a penalty fee to be paid in case of failure. A prototype example for this has been shown in the Figure 10 below.

	Scheduled power cuts	Instant cuts urgent	Power reserve	Guaranteed ceiling (Power Cap)	DER Limits (Power Max)	Voltage support (Var Limits)	Reactive support
Contract period	3 m	3 m	3 m	3 m	3 m	1 year	3 m
Number of activations	60	40	3	40	60	100	50
Max load	50kW	50kW	150kW	240kW	50kW	?	?
Max duration per activation	4 hrs	3 hrs	3 hrs	3 hrs	4 hrs	Until end of critical situation (& max 3 hrs)	Until end of critical situation (& max 2 hrs)
On-trigger	Monday-Friday at 16:00	On signal from DSO	On signal from DSO	On signal from DSO	Monday-Friday at 16:00	On signal from DSO	On signal from DSO
Off-trigger	Monday-Friday at 20:00 or at signal from DSO	3 hrs or on signal from DSO	3 hrs or on signal from DSO	3 hrs or on signal from DSO	Mandag – fredag kl. 20:00 eller på signal fra DSO	3 hrs or on signal from DSO	2 hrs or on signal from DSO
Max allowed activation time							
Quality requirement for service							
Price	€1200/kW €50000 Max	€1200 per subscription €120 per activation	€2400 per subscription €1200 per activation	€2400 per subscription €1200 per activation	€6000 per subscription €1200 per kW	€1200 per subscription €60 per activation	€1200 per subscription €60 per activation

Figure 10: A tentative template for defining the legal agreement between a SESP and a DSO. The remuneration concept is important and must consist of a “subscription fee” and activation fees.

The SESP will turn around and present a similar framework for the community members. In the same way the SESP might involve other service providers. To ensure technical stability and failure protection and some degree of redundancy the SESP will also be compelled to ensure technical soundness of the technical system to meet to allow community members to meet the challenge. One obvious element in this technical system would be investment in a storage capacity that the SESP controls. The storage capacity could be distributed around in the neighborhood or located at a central spot. Nevertheless the necessary storage capacity must be a challenge of expected failure to meet activation requirements, price of activation and penalty of failure. In the ultimate case a given request from the DSO might require full decoupling of the community from the grid. This suggests more extensive storage capacity and micro-grid technologies such as a power router. The storage capacity would have to be a function of both expected deficits and expected surplus at any given time within the community. The use of a centrally controlled storage facility can be alleviated by means of internal mitigation using both auctions and fixed price techniques. The periodic fee defined in the contract with the DSO would serve another important purpose for the local market. It can provide a capital basis for stimulating local trade in a certain way and to purchase local balancing power. An obvious application would be to reduce prices for local consumers and increase prices for local production. If local and balanced trade can be achieved in this way routine activations will not be needed as the demand is managed at all times within the branch of the distribution grid that constitutes the community boundary.

6.5.7 SESP – Other Service Providers

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 association. Again a sign-on fee could be asked and fixed activation fees negotiated. This suggest a kind of super market model where customer spick what they need. 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. With the available ICT it could also be potentially advantageous to allow instant auctions alongside, for instant, demand –response.

An example will be provided to highlight this. Assume that a significant producer or prosumer has made a commitment in the local market or with an aggregator. Assume that since the commitment was made a significant and unexpected thunderstorm reduced generation and left leaves on parts of the PV panels. The capacity of the PV could be severely hurt as current PV panels would be shunted even if only a small area has been covered. The producer could make a bid in the local market for short term relief. This could be answered by another local producer that could compensate for the loss, an owner of a local storage facility (even the SESP) and a local service that with a short activation time could eliminate the problem entirely. The same ICT infrastructure and cloud based market place will enable this combination. The principle for settlement would be basically the same as for a regular energy transaction.

6.6 Mitigation through the SESP

As already pointed out the proposed market concept could cater for different models of trade. As such it is adaptive. The technology that will drive demand-response can be used for various purposes. In principle the type of contracts proposed for the SESP and the DSO could be applied for most of the exchanges that have been addressed so far. A long-term standard contract and predefined activation fees. However, a concept like this may not prove sufficient for all situations. A portfolio of flexibility suppliers could fail to step up to the occasion. This might be due to technical faults, erroneous definition of order of merit, deliberate or non-conscious use of back-up systems (Bremdal 2015) as well as conflicting interests. Instant mitigation might then be needed. With the technical facilities planned this could still be well be taken care of by means of other forms of negotiations or auctions.

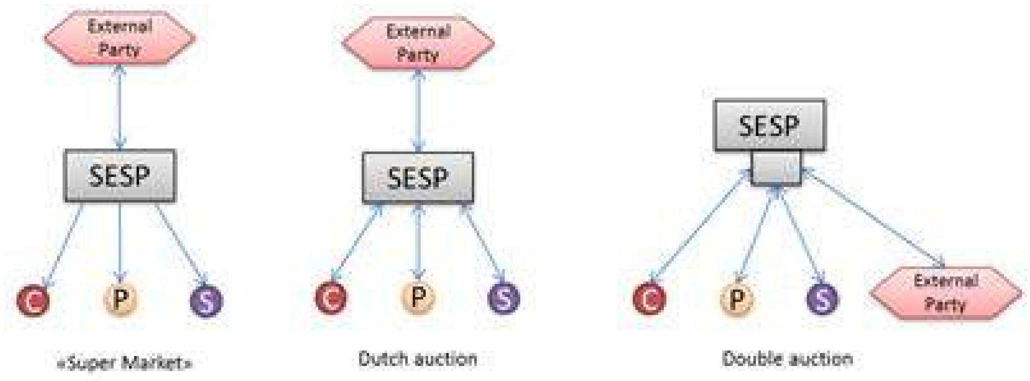


Figure 11: Different models of trade can be accommodated within the EMD

The proposed concept can harbor different forms of trade. This has been shown in Figure 11 above. It illustrates how the community participants could interact with the SESP and between themselves to form the market. An external party could be anyone of the roles that have already been addressed. However, whenever a local market would consist of several connected micro-markets a third party could also be a connected micro-market.

The SESP may simply define a set of prices and it is basically "take it or leave it". This requires good knowledge of the community, the situation onwards and should be well suited in a stable environment. It could be well suited for long term contracts. The super market and the single auction option have been addressed by Zhang et al. (2014) in the iPower project.

The SESP may also negotiate with the external world and then ask a volume and a price in a variant of a Dutch auction. Any participant may prepare an auction with the SESP for a particular offer or need. Participants are invited to bid or ask accordingly and the best offer gets the deal. External parties like the DSO could benefit from this type of Dutch auction. Finally the SESP may step more to the side and simply offer a trading floor where more direct interactions take place. This caters for different forms of double auctions which have been commonly proposed for local markets which Kahrobaree et al. (2014) and Ilic et al. (2012) have investigated in detail. For this to work well a sound set of market rules need to be defined to assure governance and market efficiency (Ilic 2012, Kahrobaree 2013, Gode 1993). Recent work reported in the literature has also explored trading of stocks and commodities based on models developed within the field of control engineering (Carella 2014, Gandolfi 2012). The work in Task 6.2 will investigate the benefits of the various models in more detail.

The relationship to the central market is also important. This is depicted in Figure 12.

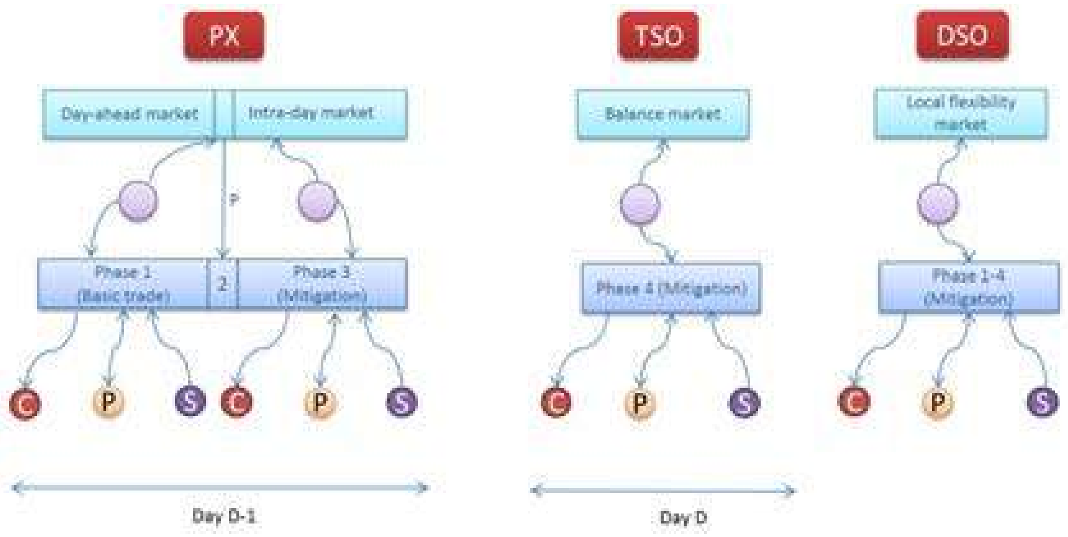


Figure 12 Illustration of how the local market can be aligned with the central market. As the local market can be continuous

We assumed a classic market with discrete phases for trading. The local market, however, can support continuous trading down to 5 minutes if the technology allows. Consequently much of the trade in the local market can, in principle, go on quite independently of the activities in the central market. Price projections in the central market can be forecasted and high quality information can be obtained in real-time as well for the next day. In comparison the local market might be a lot more exposed due to unexpected incidents, change of local weather etc. We have identified 3 phases that define the relationship:

Phase 1

Phase 1 in Figure 12 relates then to the basic and ongoing trade in the local market which may, in principle, never stop. Depending on the trading model applied the price can vary continuously or stay fixed for longer periods. The participant also operating in the central day-ahead market will have to make a decision whether or not to take part in the local market. In such a case this participant will seek out desired volumes required in both markets and make a qualified estimate on arbitrage possibilities. In fact this entity might simply bring forward to the central market the accumulated bids or asks in the local market.

Phase 2

Phase 2 defines the status for the next day in the central market. The energy price for the next 24 hours has been settled and commitments are fixed.

Phase 3

Phase 3 is basically a mitigation phase. Promises need to be fulfilled. Forecasts failure, technical problems or other issues can threaten deliveries. The local market could possibly provide an efficient problem solving instrument for the central market. The local market participants are themselves heavily exposed to uncertainties and mitigation will need to be an inherent part of the internal trade anyhow. However, high frequency trade is in itself a proper instrument of mitigation and thus the local market will be well prepared to cope with mismatches that might occur in the central market.

An additional effect is that the value of the flexibility provided will automatically relate to the energy price level in Phase 1. This relationship will also influence flexibility negotiations with the DSO. A similar influence, albeit in the opposite direction, should be anticipated too.

Phase 4

Phase 4 relates to the adjustments required by the TSO. The community could potentially become part of a portfolio that offers flexibility to this market too. A legal construction between the SESP and the TSO similar to the one proposed for the DSO will then need to be established.

Other forms of mitigation

All through Phase 1-4 the concerns of the DSO may kick in. Rather than operate solely in a reactive day-after mode the DSO operating in a smart grid could have sufficient information to send the SESP activation signals both before and under the trade. In that sense the flexibility trade initiated by the DSO becomes superimposed part of the ongoing mitigation. It is worth noting that other services like failure detection, containment and repair could be activated in similar ways in all 4 phases to pursue some kind of low cost self-healing effect that ensures generation and timely deliveries.

To finalize the discussion on the market concept proposed here we can sum up.

- It is community oriented, capitalizing on important principles that trigger cooperatives and collective citizen initiatives. A community provides benefits, but requires a small membership fee to sign on. The community shares profits and provide extra rewards for participation/good reputation ().
- The concept is voluntary for producers, prosumers and consumers to enter contract with SESP.
- It will allow different models of trading that will be investigated further in a subsequent work package.

- Technology will allow exchange of energy, flexibility services and other services separately or in an integrated form.
- Technology will enable high frequency trading that allows the local market to operate more independently of the central market.
- The price levels in the central market will always define a reference for settlements and incentives in the local market.
- The SESP provides for the technology together external service providers and the community members themselves.
- The SESP does not sell or buy net energy at PX or OTC, but it could be possible (see later paragraph). This is taken care of by ordinary retailers or aggregators.
- The SESP organizes a local trading floor and creates market rules to increase liquidity and market efficiency.
- Trading in the local market is voluntary for members, but the SESP creates incentives for participation
- The SESP may operate on behalf of the DSO in the local market. This is important where regulations demand a distance between the DSO and the market. In other regimes the DSO could be involved directly.
- SESP offers added services or serves as a broker for such
- Community members can also offer services of different kinds either as an app or as a trigger for on-site work.

6.7 Synthesizing the three parts of the local market

How energy trade, exchange of flexibility services and other services can operate together in the local market is perhaps best illustrated by a cybernetic illustration. Figure 13 shows an example for a producer in the community. A similar projection can be made for other participants too. In the case of the producer (and the prosumer with a surplus) three distinct feedback loops exists.

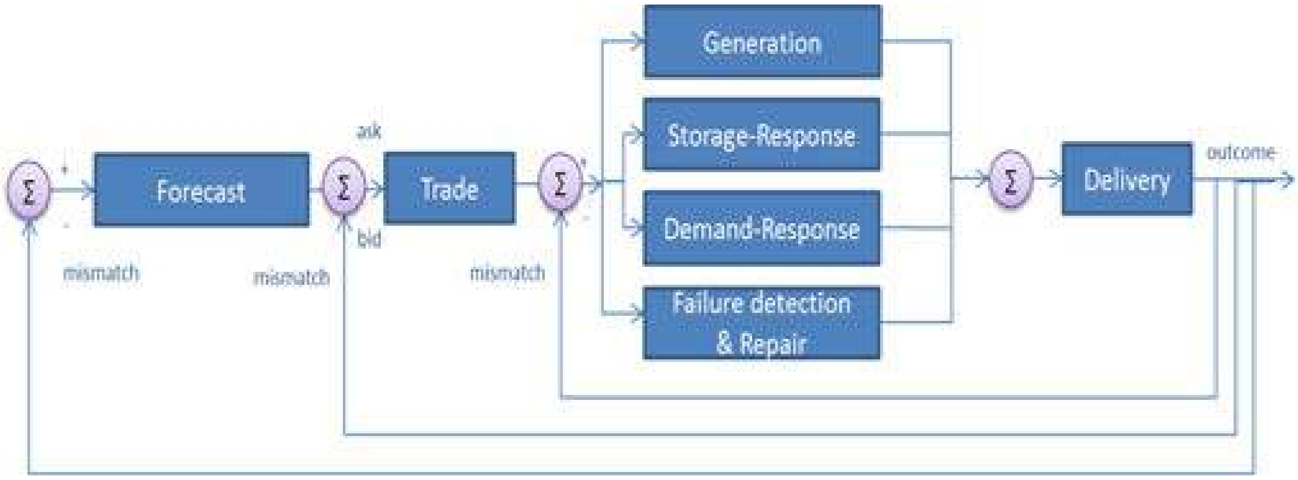


Figure 13: The market concept involves a triple cybernetic loop that simultaneously *synthesizes the options in the three part of the local market*

A customized forecast is produced that promises a certain outcome. This specification defines the set point for the overall process. This precipitates into an offer and an initial settlement with a price that the producer must oblige to. A dedicated volume of energy promised at the given price must be delivered accordingly. This volume defines a set point for the delivery process. However, some generation may be only marginal controllable and possible only in a downward way. Failure to meet he required delivery may require the simultaneous deposit or withdrawal of stored energy. It may also require bidding for demand side operations and possibly repair to ensure that periodic obligations are met. As deviations are experienced the need to compensate is imminent. Some adjustments lie within the control of the agent operating the plant. This is indicated by the inner feedback cycle. However, further compensation can be associated with a cost as bids for relief are required. Hence new trade is required. This time a bid for a service available in the market is in demand. This type of feedback is represented by the second loop. With one or the full set of adjustments made the delivery is expected to be fulfilled and with this an outcome that specifies a reward or a penalty. Now this must produce consequences for future forecasting. The deviation from the expected and realized income is fed back to the forecasting and applied as basis for the next ask. The feedback cycles are likely to reduce mismatches between expected and realized outcome, expected and actual activity in the market and finding economic balance between the different co-producing elements that yields the final outcome. An inherent feature of the three feedback cycles is optimization over time that closes the gap between what is realized and what was expected. Similarly the increase in trading cycles may reduce the time between each step in the overall process. As a consequence deviations will also be reduced and the amount to be corrected at each cycle will decrease. Even more important will be the tight coupling between the energy trading process described in Phase 1 and the mitigation process based on different types of services that will influence the value of flexibility at any given point in time. The three feedback cycles will depend strongly on each other. In effect energy trade, service exchange and flexibility will coalesce. Under some regulatory regimes the relief process to solve congestion problems of the DSO and failure in the grid could be superimposed on the mitigation process here too and be part of the market driven mitigation process. Price of flexibility and other services for the benefit of the grid will then be tightly coupled to the energy price too and vice versa. An ICT system that supports this can have profound impact on prosumers and management of intermittent resources. It could make demand-response more attractive because the time intervals between adjustments will be shorter and less severe. For a community participant this could be embraced almost as a “box on the wall” type of application. An illustrative metaphor could be the flight captain who provides the general course of direction while the autopilot handles the actual operation. The autopilot compensates for strong winds and turbulence, while at the same time keeps control of the resources spent to reduce the cost of the flight accordingly. Any deviation is instantly corrected for with the least cost possible.

These ideas are all central to the objectives explored in T6.2 effort and the analogy to control engineering lies close. The work of Gandolfi et al. (2012) and Maktepour (2013) will serve as a prime references for further probes into the cybernetic model presented here.

6.8 A theme with variations

6.8.1 The SESP as a seller and buyer of energy in the central market

The proposed market concept described above is a theme with certain variations. The SESP may trade in the whole-sale market like any other aggregator or retailer (See Figure 14). This yields better control and can help to avoid biases in the local market. As a consequence the SESP will pick up the responsibilities and work that the aggregator or retailer have and which were described earlier. When this happens, any retailer or aggregator that wants to enter the local market will have to compete with the SESP. This might be controversial as the SESP also provides the trading floor, organizes the community and defines the market rules. These elements distinguish the SESP from the ordinary retailers and aggregators. Assume that regulations will allow this the SESP will be in such an advantageous position that it is likely to discourage other aggregators and retailers from entering the local market.

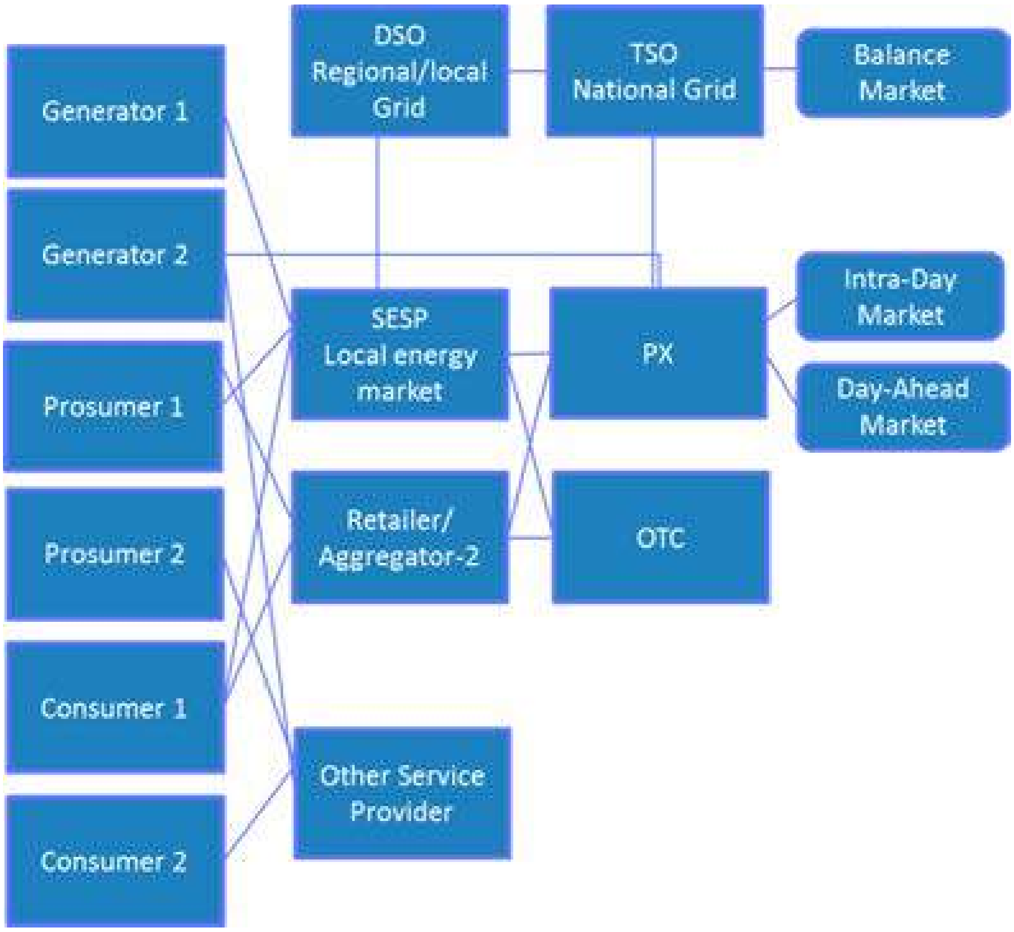


Figure 14: The SESP can purchase and sell surplus in the central market too

As membership in the community and interaction with the SESP equally voluntary it is likely that retailers will seek direct interaction with prosumers, suppliers and consumers in the neighborhood. Competition is stimulated and the added value that the local market and the community will have to offer must excel in comparison with other propositions. This will be one of the principal tests that the pilots in WP7 will have to address.

6.8.2 Islanding mode – a decoupled local market

Islanding mode leaves little latitude for other players than the SESP (see Figure 15). Microgrid technology here would be mandatory. This model would also demand participation from everyone connected to the local branch of the distribution net. Freedom of choice is basically reduced to a single vote whether or not the neighborhood should form a community and establish a SESP. If the majority votes for a construct that has been explained it will be compulsory for everyone in the

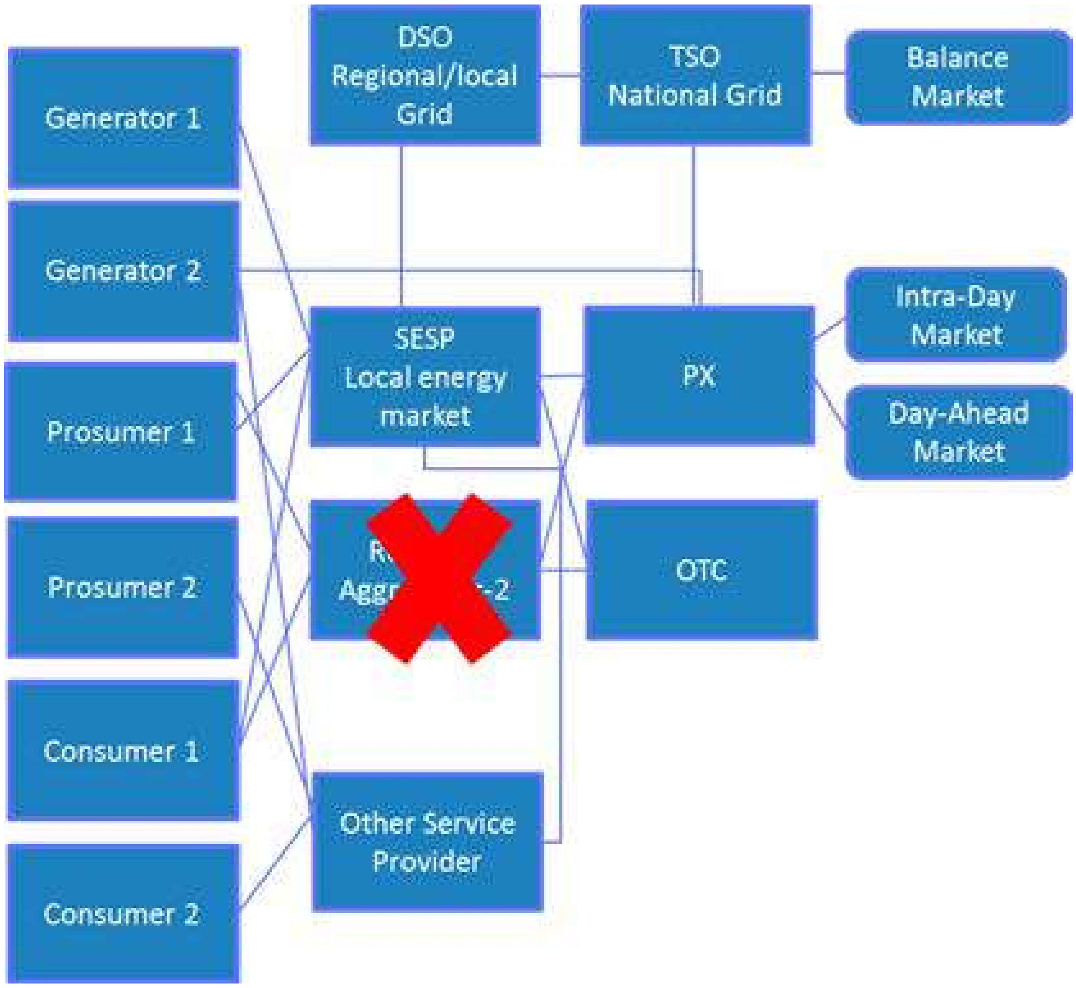


Figure 15: In islanding mode the SESP operates entirely on its own with all the responsibilities that follow the need for high quality and balanced supply.

neighborhood hooked up to that part of the distribution grid to join. This could be a business case for communities where extensive surplus and where the production is not indifferent to variable prices in the energy market. Communities organizing extensive wind farms in rural areas in UK, Ireland and Denmark could benefit from this model. In other regions where there is a sole utility that owns the grid and provides the energy to villages, farming communities and small towns the model could offer an alternative. The incentives for doing so would increase with the capacity problems and quality issues experienced. It is not unlikely that the utility itself would be a promoter of this in order to avoid or postpone investments in infrastructure upgrades. In both cases sufficient local generation and local storage controlled by the SESP will be absolutely essential to maintain such an isolated market. It should be added though that isolation for 24/7 would not be required to benefit from the local market. Isolation mode when the grid is loaded or when voltage drops could be sufficient to yield a return on investment.

6.8.3 Another case for local markets

Is there a case for local markets even when the structures proposed here collapses and the institutions that the SESP and the community represent are banned? The answer is clearly "yes". A Virtual Power Plant organized by an aggregator could benefit significantly if it included ordinary consumers in its portfolio (Loock 2014). Even service providers offering extenuation from failures and independent storage space providers could take an active position whenever bids and asks in the whole sale market should be followed up. The equivalent of the Phase III above could help the aggregator to effectively ensure that obligations are met. In the regular case the VPP/aggregator would have to make forecasts before placing the bids and asks. The more accurate prognosis, the more benefit can be harvested by the aggregator. However, a pre-auction could prove to be much more accurate than a forecast, at least in combination with such. The settlement price and associated volumes in a pre-auction can reflect information that is not immediately available for any forecast model. Concerns about local weather, possible technical failure, temporary events that can drive local demand and supply, apprehension with respect to prices etc. can be absorbed in this. The individual voices in the aggregator's portfolio form a base for crowd sourcing (Howe 2009) that can give a more reliable basis for interactions with the whole sale market. If this happens a local market is in the making and brings value, at least for the aggregator. The aggregator will then inevitably enter the role of the SESP. This is important to note, because it suggests that the type of local market can evolve from the more traditional focus on VPPs and aggregators.

7 Conclusion

This document has proposed a design for local markets in the distribution grid that is believed to support neighborhood oriented trading and facilitate the involvement of consumer, producers and prosumer alike. Central to the design is a community construction that is believed to generate added value for all participants through closer relationships and improved customization of services. This is believed to ensure both trust and dedication. The community concept should also cater for better economic rewards, something that the individual and the collective should benefit from. The design and operation of the local market hinges on advanced ICT whereby cloud based services and software agents that operate on behalf of the different participants are included. A commercial role that has been termed the Smart Energy Service Provider consolidates and integrates ICT systems at different levels within the community to assure maximum technical support for all members of the community. This constitutes the principal and most competitive asset of the SESP. The SESP also provides a trading floor and mechanisms that will support agent based trading. The architecture defined will accommodate different models for trading. Trading concepts will be further explored in task 6.2 of Work Package 6. A final trading concept will be proposed when this task is concluded. It has been shown here that energy and service markets can be synthesized to support a coherent form of exchange. We have deliberated that it is possible to address energy and energy related services in combination to pursue a less commodity oriented form of trade. In fact our mission to pursue a form of trade that enhances the participants individual energy experience.

The market concept proposed should be flexible and adaptable to different judicial and regulatory regimes. However, this must be further addressed in Work Package 7. What is important is that the concept proposed does not upset the existing market structure. The SESP and the local market have been defined so that it can co-exist with other roles such as the DSO, the retailer and the aggregator/VPP. The basic design offers retailers and aggregators a novel platform for local involvement that should sharpen competition. Still the SESP may choose to take on the role of both the retailer and the aggregator. Surely any incumbent utility could adopt the role for its own benefit. Yet, we see the greatest opportunity where the SESP operated by a third party and possibly co-owned by the community. The SESP may adapt to different business models. However, important assumptions on value propositions and revenue gain have been essential for the work done. Continued efforts and more profound work on business modelling are undertaken in Work Package 2. An interesting observation made during the research reported here is that the local market is less dependent on microgrid technologies than was originally expected. Technology and advanced power electronics are absolutely essential, and the more control achieved through technology the more options and benefits should be anticipated. In spite of this we can firmly argue that the local market will degrade gracefully as technology elements are peeled off. Yet, this need to be further tested.

The market concept proposed her and its foundation stand firmly on top of previous work reported in the literature. A substantial corpus on local markets, communities, multiple agent systems (MAS, cybernetics, localism, value generation and trading concepts have been investigated and related to. As an initial activity in an extensive project the results achieved in Task 6.1 in Work Package 6 presents itself as mere hypotheses that need to be proved through further analyses, lab tests and field pilots.

The resulting main hypotheses can therefore be listed as follows:

- The community concept will be essential for the organization of a local market in the distribution grid.
- The local market design proposed here can handle a synthesized form of trade based on more service oriented form of exchange that should yield more added value i.e. improve the benefits and rewards for prosumers.
- The market concept described here is not suboptimal. We will show that market efficiency is very good under a variety of conditions and that welfare and benefits for the user-side in the distribution net is better off than with existing alternatives.
- The local market and the SESP described here is adaptable to different types of ownership, control regimes and regulations. It could possible lend itself to a franchise type of business model.
- The local market can accommodate different trading models based on fixed pricing, auctions or models gathered from the domain of control engineering.
- The concept proposed can cater for a kind of trade that could synthesize energy exchange, flexibility and service trade. This could possibly yield a unified price in the local market.

8 References

Abe, R.; Taoka, H.; McQuilkin, D., "Digital Grid: Communicative Electrical Grids of the Future," in IEEE Transactions on Smart Grid, vol.2, no.2, pp.399-410, June 2011

Aghaei, J. & Alizadeh, M.-I., 2013, Demand response in smart electricity grids equipped with renewable energy sources: A review. Renewable and Sustainable Energy Reviews, 18 (0): 64-72.

Alwala, S., Feliachi, A., Choudhry, M.A., 2012, Multi-agent system based fault location and isolation in a smart microgrid system. In: 2012 IEEE PES Innovative Smart Grid Technologies, ISGT. IEEE, Washington DC, pp. 1–4

Baerenfaenger, R., Lisanti, B., Kamphuis, R., 2014, Extending the electricity marketplace to distribution entities, CIRED Workshop, Rome 11-12 June 2014, Paper 132

Bayram, I.S., Shakir, M. Z., Abdallah, M., Qaraqe, K., 2014, A Survey on Energy Trading in Smart Grid, IEEE Globalsip Conference 2014

Bolkesjø, T., Martinsen, T., Tveten Å.G., Assessments of electricity demand flexibility in the future energy system. Potentials and market impacts. IMPORSUME series #5, NCE Smart Energy Markets, 2013. Available at ncesmart.com

Bouckaert, S., Mazauric, V. & Maïzi, N., 2014, Expanding Renewable Energy by Implementing Demand Response. Energy Procedia, 61 (0): 1844-1847.

Bremdal, B. and Törnqvist, M: "Manage Smart in Smart Grid – research on the end-user perspective," Presentation for leaders in the Swedish energy business. Strategitorget, March 2011.

Bremdal, B., 2011b, Prosumer Orietned Business in the Energy Market, Energy and Finance Conference, Erasmus School of Economics, Rotterdam, October 2011.

Bremdal, B. A., Hagen, M., Unleashing Consumer Flexibility: A Business Oriented Recruitment Process, CIRED Workshop, Paper 0232, Rome, June 10-13, 2014

Bühner, V., 2015, S. Martinez: «Lösungen für Smart Grids - Vorstellung einer europäischen Studie zu Smart Grids», IKEM Symposium Energie, Sep 9, 2015

Cox W.,Considine, T., 2011, Energy, Micromarkets and Microgrids, Grid-Interop Forum 2011
DEFA, DEFA HyttaMi - den smarte måten å styre varmen på, http://www.hyttami.no/om_hyttami, Accessed 22 September 2015

De Rafelle, F., 2014, Localism is the New Patriotism, www-businessatworking.com, April 28, 2014, Accessed September 2015

Dietrich. K. ,Latorre, J. M., Olmos, L., Ramos, A., 2015, Modelling and assessing the impacts of self supply and market-revenue driven Virtual Power Plants, Electric Power Systems Research, Volume 119, Pages 462–470

DnV KEMA , 2014, Microgrids – Benefits, Models, Barriers and Suggested Policy Initiatives for the Commonwealth of Massachusetts

Dohn, T., 2011, The business case for microgrids, White paper: The new face of energy modernization, Siemens AG

Earthwatch Institute, 2009, Eco-Patriotism and Stimulating Your Local Economy, www.treehugger.com ,March 14, 2009

Estabanell y Pahisa Energia, 2015, D7.1, Operation modes and metrics, Smart Rural Grid project
Fama, E. F., "Efficient Capital Markets: A Review of Empirical Work." Journal of Finance 25, no. 2 (1970): 383–417.

Fama, E. F., 1970, Efficient Capital Markets: A Review of Empirical Work, Journal of Finance 25, no. 2 (1970): 383–417.

Findlay, D., What is the real marketing profitability of patriotism?,Available at: http://marketing-sciences.com/real-marketing-profitability-patriotism/, Accessed September 2015

Gallart, R., Specifications for a resilient electrical operation. Deliverable D2.3, FP7 Project "Smart Rural Grid", June 30, 2014

Gandolfi, G., Sabatini, A., Rossolini, M., An Innovative Systemic Approach to Financial Portfolio Management via PID Control, in Introduction to PID Controllers Theory, Tuning and

Application to Frontier Areas, Intechopen 2012.

Ghafarifar, Y., Zare, S., Hashemi S.M., Demand response market-concepts and challenges, CIRED Workshop, Rome 11-12 June 2014, Paper 0265

Girbau-Llistuella, F., Sumper, A., Buehner, V., Gallart-Fernandez, R., 2015, Operation of rural distribution grids with intermittent generation in connected and island mode using the open source EMS solver SCIP

Gode, D.K., Sunder, S., 1993, Allocative Efficiency of Markets with Zero-Intelligence Traders: Market as a Partial Substitute for Individual Rationality, The Journal of Political Economy, Vol. 101, No. 1., pp. 119-137.

Harbo, S.; Biegel, B., "Contracting flexibility services," in Innovative Smart Grid Technologies Europe (ISGT EUROPE), 2013 4th IEEE/PES , vol., no., pp.1-5, 6-9 Oct. 2013

Hess, D.J., 2009, Localist Movements in a Global Economy, The MIT Press

Heussen, K., Bondy, D.E.M., Junjie Hu, Gehrke, O., Hansen, L.H., A clearinghouse concept for distribution-level flexibility services, in Innovative Smart Grid Technologies Europe (ISGT EUROPE), 2013 4th IEEE/PES , vol., no., pp.1-5, 6-9 Oct. 2013

Howe, J., Crowdsourcing: Why the Power of the Crowd is Driving the Future of Business, Three Rivers Press, 2009

Ilic, D.; Da Silva, P.G.; Karnouskos, S.; Griesemer, M., "An energy market for trading electricity in smart grid neighbourhoods," in Digital Ecosystems Technologies (DEST), 2012 6th IEEE International Conference on , vol., no., pp.1-6, 18-20 June 2012

Ilieva, I., Gabriel, S.A., 2014, Electricity retailers' behavior in a highly competitive Nordic electricity market, Journal of Energy Markets, 7 (2014).

Ilieva, I., Gabriel, S.A., 2015, The impact of end-user market integration and smart grid on electricity retailers in the Nordic region (In review, Energy Strategy Reviews). Part of PhD thesis: Ilieva, I., 2015, "Economic perspectives of market integration and demand flexibility within a smart grid dominated power sector", Norwegian University of Life Sciences

Imran, K., Kockar, I., A technical comparison of wholesale electricity markets in North America and Europe, Electric Power Systems Research, Volume 108, March 2014, Pages 59-67

Kahrobaee, S., Rajabzadeh, R. A., Soh, L.-K., Asgarpoor, S., 2013, A Multiagent Modeling and Investigation of Smart Homes With Power Generation, Storage and Trading Features, IEEE Transactions on Smart Grid, Vol. 4, No. 2, June 2013

Kahrobaee, S., Rajabzadeh, R. A., Soh, L.-K., Asgarpoor, S., 2014, Multiagent study of smart grid customers with neighborhood electricity trading, Electric Power Systems Research, Volume 111, Pages 123–132

Kantamneni, A.,Brown, L.E., Parker, G., Weaver, W.W., Survey of multi-agent systems for microgrid control, Engineering Applications of Artificial Intelligence, Volume 45, October 2015, Pages 192-203

Karavas,C.-S., Kyriakarakos, G., Arvanitis,K.G., Papadakis,G., A multi-agent decentralized energy management system based on distributed intelligence for the design and control of autonomous polygeneration microgrids, Energy Conversion and Management, Volume 103, October 2015, Pages 166-179

Kok, K., 2009, Short-term economics of Virtual Power Plants, conference paper, CIRED 20th, International Conference on Electricity Distribution, Prague, 8-11 June 2009

Krovvidi, S., 2010, Competitive Microgrid Electricity Market Design, M.Sc. Thesis, Faculty of the Virginia Polytechnic Institute and State University

KU Leuven Energy Institute, 2015, EI Fact sheet: Current electricity market design in Europe

Kuo, Y.-F., Wu, C.-M., Deng, W.-J., The relationships among service equality, perceived value, customer satisfaction, and post-purchase intention in mobile value-added-service, Computers in Human Behavior, Volume 25, Issue 4, July 2009, p.887-896

LakeCountryPower, What is an electric coopertaive? Available at: http://www.lakecountrypower.coop/viewpage.php?pagename=whatisanelectriccooperative, Accessed 11.09.2015

Lane, W., Pak, W., Prakel, M., Rocha, C., Faber, I., Farr, J.V., Costing Consumer Preferences for a Micro Energy Market, Center for Nation Reconstruction and Capacity development, US Military Academy, West Point, New York, July 2013.

Loock, M., Helms, M., 2014, Value Creation Through Timing, Working Paper, Institute for Economy and the Environment, University of St. Gallen

Magnago, F. H., Alemany, J. & Lin, J., 2015, Impact of demand response resources on unit commitment and dispatch in a day-ahead electricity market. International Journal of Electrical Power & Energy Systems, 68 (0): 142-149.

Maktepour, S., On stock trading using a PI controller in an idealized market: The robust positive expectation property, 52nd IEEE Conference on Decision and Control. December 2013, Florence.

Metering and smart energy International, 2014, Bremdal, B.A., The Impact of Prosumers in a Smart Grid based Energy Market

National Energy Foundations, Ace and Local United, 2014, Community-led photovoltaic initiatives, Support and information for community groups and social enterprises setting up community-led photovoltaic projects

Norwegian Water Resource and Energy Directorate (NVE), Forslag om endring av kontrollforskriften og avregningsforskriften vedrørende plusskundeordning, 2/2014, Høringsdokument

NVE 2015, Tilleggshøring – måling og avregning av plusskunder. NVE July 2015, www.nve.no

Olje- og energidepartementet, 2014, Et bedre organisert strømnett, Rapport

Ravald, A., Grönroos, C., The Value Concept and Relationship, European Journal of marketing, Jan 1996

REScoop 20-20-20, 2015, The energy transition to energy democracy. Power to the People.

Final results oriented report of the REScoop 20-20-20 Intelligent Energy Europe project

REScoop.eu, The energy transition to energy democracy, available at: http://rescoop.eu/, Accessed 14.09.2015

Roos, A., Ottesen, S.Ø., Bolkesjø, T.F., Modeling Consumer Flexibility of an Aggregator Participating in the Wholesale Power Market and the Regulation Capacity Market, Energy Procedia, Volume 58, 2014, Pages 79-86

Roselund, C., Bernhardt, J., Lessons Learned Along Europe's Road to Renewables. IEEE Spectrum, May 2015

Saba, D., Laallam, F.Z., Hadidi, A.E., Berbaoui, B., Contribution to the Management of Energy in the Systems Multi Renewable Sources with Energy by the Application of the Multi Agents Systems "MAS", Energy Procedia, Volume 74, August 2015, Pages 616-623

Seiler, R. M., 2002, Selling Patriotism/Selling Beer: The case of the "I AM CANADIAN!" Commercial, The American Review of Canadian Studies, Spring 2002, p 45- 66

Shandurkova, I., Bremdal, B., Bacher, R., 2012, The IMPROSUME project - WP3, A Prosumer Oriented Energy Market, Developments and future outlooks for, Smart Grid oriented energy markets, A state-of-the-art perspective, Revised for final release: 25.03.2012

Schubert, E., Zhou, S., Grasso, T., Niu, G, 2002, A Primer on Wholesale Market Design, Market Oversight Division White Paper, Public Utility Commission of Texas, USA

Sørdalen, O.J., Eltek, Smarte strømomformere med batterier – teknologi for smarte nett, Smartgridkonferansen 2015, Trondheim, Norway, 15-16 September 2015

The iPower project, Development of a DSO-market on flexibility services, WP 3.8, 18.03.2013

Toffler, A., 1990, Powershift : knowledge, wealth, and violence in the 21st century

Universitat Politècnica de Catalunya, 2015, D3.2, Functional IDPR prototype, Smart Rural Grid project

Uthus, B.O., TrønderEnergi Nett, Fra målbilde 2020 til nettutvikling 2030, Smartgridkonferansen 2015, Trondheim, Norway, 15-16 September 2015

van der Schoor, T., Scholtens, B., Power to the people: Local community initiatives and the transition to sustainable energy, Renewable and Sustainable Energy Reviews, Volume 43, March 2015, Pages 666-675

Vorilov, R., Art Auction Prices: Home Biases, Familiarity and Patriotism, Umeå University, Faculty of Social Sciences, Business Administration, www.diva-portal, March 2015, Accessed August 2015

Vytelingum et al., 2010, Trading Agents for the Smart Electricity Grid, Proc. of 9th Int. Conf. on Autonomous Agents and Multiagent Systems (AAMAS 2010), van der Hoek, Kaminka, Lespérance, Luck and Sen (eds.), May, 10–14, 2010, Toronto, Canada, pp. 894-904

Warren, C., McFadyen, M., 2014, Does community owernship affect public attitudes to wind energy? A case study from south-west Scotland. Land Use Policy, 27, Elsevier

Young, R., 2007, Europe's External Energy Policy: Between Geopolitics and the Market, CEPS Working Document No. 278, November 2007

Zhang, C., Ding, Y., Østergaard, J., Binder, H. W., Nordentoft, N. C., Hansen, L. H., Brath, P., Cajar, P. D., 2013, A Flex-market Design for flexibility Services through DERs, 4th IEEE PES Innovative Smart Grid Technologies Europe, October 6-9 2013, Copenhagen

9 Appendix

9.1 Introduction

To facilitate concurrent work in other work packages a set of ***pending*** business and use cases have been developed in Task 6.1. A selection of these is presented here. They may all be subjected to future revisions in subsequent tasks as work in WP6 progress together with emerging technological and business specifications in originating in WP2, WP3 and WP4 make progress. Further work is required in T6.2 and T6.3 to provide a firm use-case framework for the market side of the EMPOWER system.

9.2 Business cases

9.2.1 Business aspect 1: Recruitment of participants

BC 1: Data harvest & conceptualization

Abstract: Required to build community and understand needs and offer customized benefits to the participants. Also important to understand what local service providers can do and encourage local energy and service prosumer engagement. Generate provisions for sound energy economics and efficiency, including optimal utilization of generation assets. Prepare community for compliance with economic & environmental sustainability.

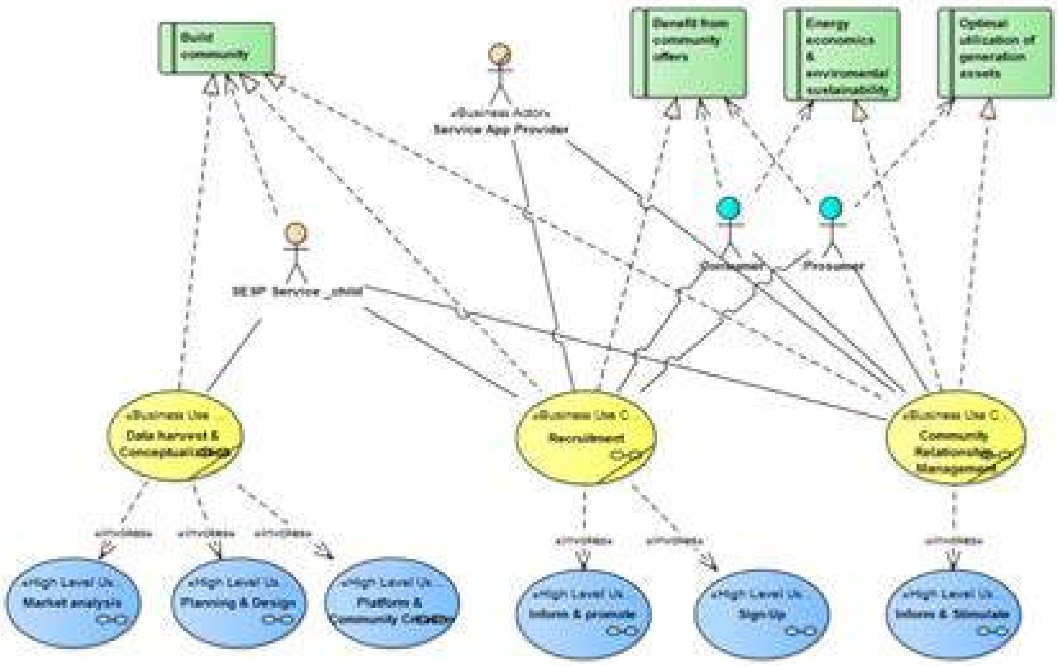
- UC-1: Market analysis
- UC-2: Planning & Design
- UC-3: Platform & Community Creation

BC 2: Recruitment

- UC-1: Inform & Promote
- UC-2: Sign-Up

BC 3: Community Relationship management

- UC-1: Inform and Stimulate



9.2.2 Business aspect 2: Credit assignment & Reporting

Abstract: To create and maintain lasting incentives for continued participation and to establish awareness for sound engagement. Split collective rewards according to order of merit. Provide simple, but sound and intriguing information about periodic performance and merits. Both individual and collective results will be shared.

BC 1: Periodic Assessment

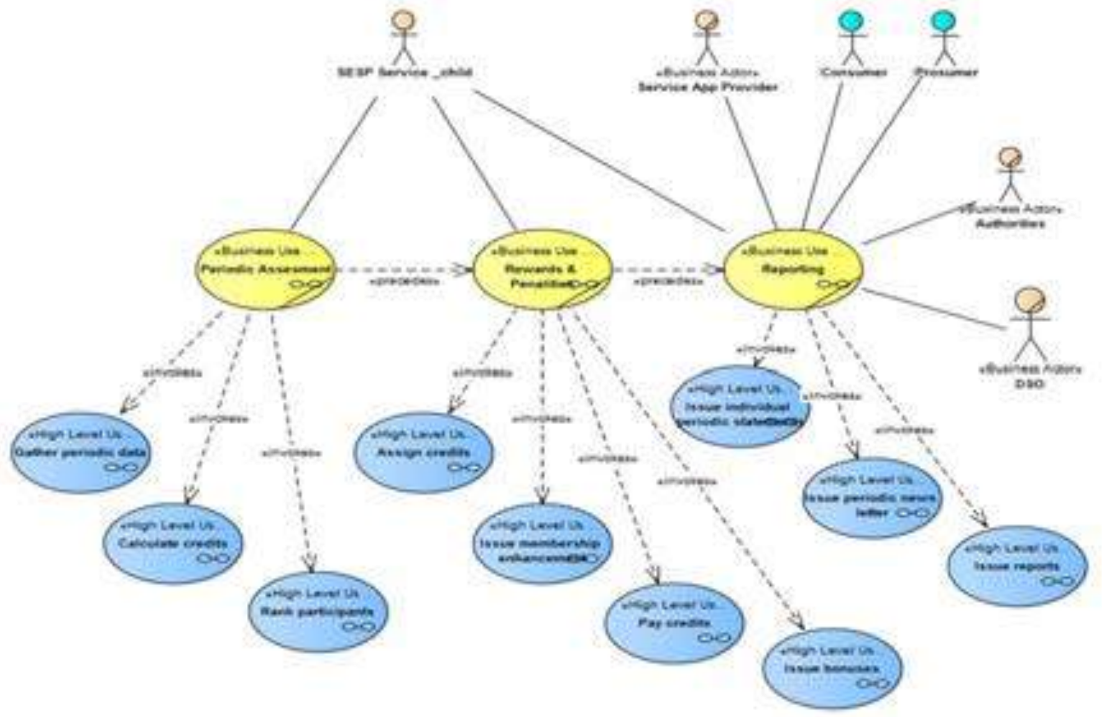
- UC-1: Gather periodic data
- UC-2: Calculate credits
- UC-3: Rank participants

BC-2: Rewards & Penalties

- UC-1: Assign credits
- UC-2: Issue membership enhancements
- UC-3: Pay credits
- UC-4: Issue bonuses

BC-3: Reporting

- UC-1: Issue individual periodic statements
- UC-2: Issue periodic newsletter
- UC-3: Issue reports



9.2.3 Business aspect 3: Services & Service App Market

Abstract: Create an arena for trading services. Promote engagement and support prosumers, producers and consumers with relevant services. Assure that services and service apps offered are quality assured and provide benefits for the participants. Act as broker for services like finance, securities, maintenance and repair and others that can boost and optimize generation, while improving demand side energy efficiency and flexibility. Provide sound advice and assure as stable as possible generation as possible.

BC 1: Service App Creation

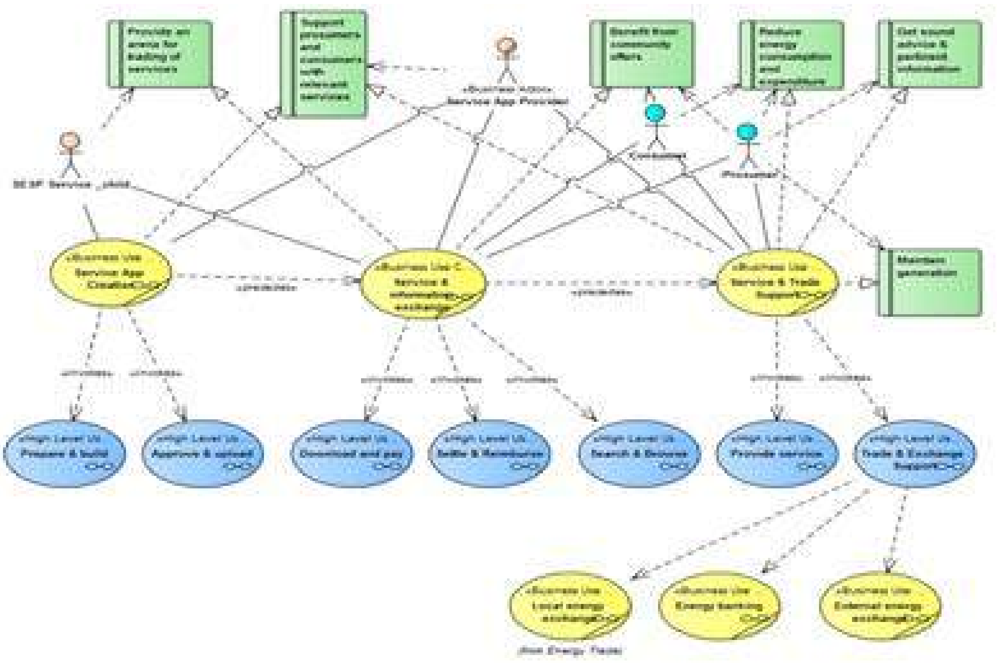
- UC-1: Prepare & Build
- UC-2: Approve & Upload

BC-2: Service & Information exchange

- UC-1: Search & Browse
- UC-2: Download and pay
- UC-3: Settle & Reimburse

BC-3: Service & Trade Support

- UC-1: Provide Service
- UC-2: Trade & Exchange Support
  - Linked to BCs “Local Energy Exchange”, “Energy Banking” “External Energy Exchange”



9.2.4 Business aspect 4: Flexibility Sale Management

Abstract: Help to maintain local balance and support the local DSO to manage congestion. Mitigate peak loads on routine and instant signals. Use the same mechanisms involved here to support traders and aggregators to meet obligations. Respond to prices for the benefit of the community members. Manage a storage facility to support individual and collective flexibility and to assure local balance.

BC 1: Contract negotiation

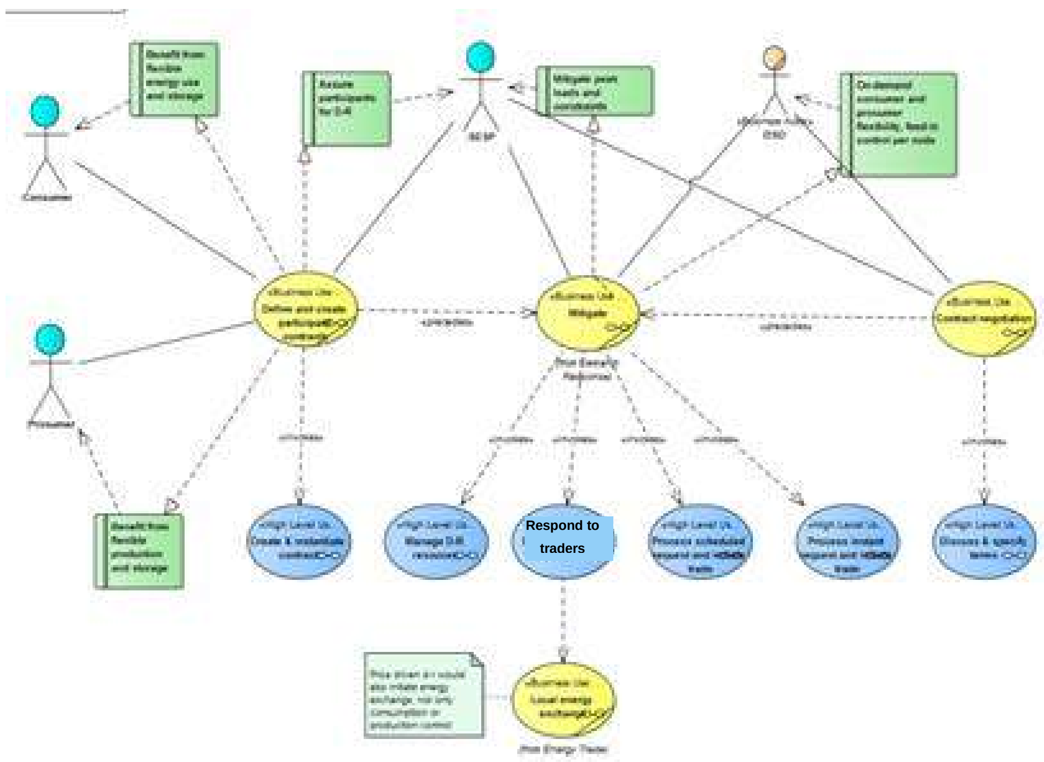
- UC-1: Discuss & specify terms

BC-2: Define & create participant contracts

- UC-1: Create & instantiate contract

BC-3: Mitigate

- UC-1: Manage D-R resources
- UC-2: Respond to energy sale & purchase mitigation needs
- UC-3: Process scheduled DSO request and initiate trade
- UC-3: Process instant DSO request and initiate trade



9.2.5 Business aspect 5: Energy exchange

Abstract: Create a local trading arena and trading rules. Support sale of self-generated energy surplus internally as well as externally. Establish provisions that will help to cover local energy needs from local, renewable energy sources. Cater for at least one central energy vault for energy to increase trading options for participants.

BC 1: Local energy exchange

- UC-1:Establish contract
- UC-2: Predict & Optimize
- UC-3: Trade Energy
    - Linked to BCs “Service & trade support”, “Energy Banking” ,“External Energy Exchange” & “Mitigate”

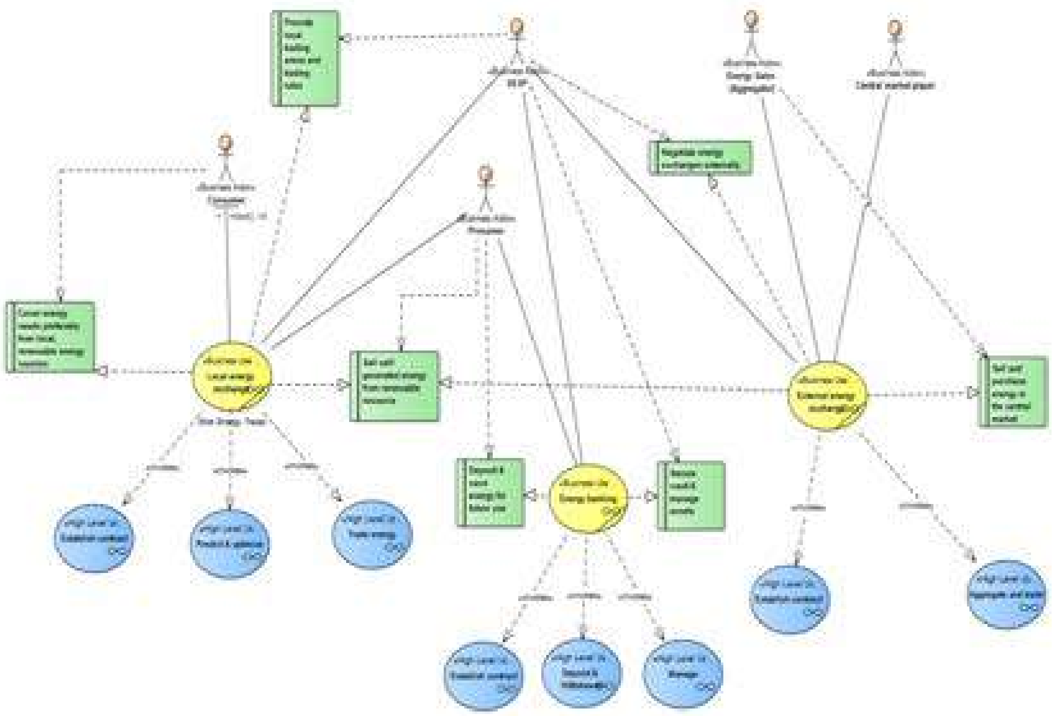
BC-2: Energy Banking

- UC-1: Establish contract
- UC-2: Deposit & Withdrawal
    - Linked to BCs “Service & trade support”, “Local energy exchange”, “External Energy Exchange” & “Mitigate”
- UC-3 Manage

BC-3: External energy exchange

- UC-1: Establish contract

- UC-2: Aggregate & trade
  - Linked to BCs “Service & trade support”, “Local energy exchange” ,“Energy banking” & “Mitigate”
- UC-3: Aggregate & sell
  - Linked to BCs “Service & trade support”, “Local energy exchange” ,“Energy banking” & “Mitigate”



9.3 A selection of use case descriptions

A selection of tentative use cases x have been included here. They are likely to be subjected to revisions in Task 6.2 and also in conclusion of Task 2.1, but are meant to promote the general idea of the market operations for the benefit of the technical developments in EMPOWER.

9.3.1 UC-4.3.1-4: Instantiate DSO contract

Abstract:

Provisions are made so that devices in the household that will be controlled are installed, tested and approved. Personal software agent for monitoring and controlling devices have been created, tested and approved.

Each agent can be specified according to two main states: Home & Away.

For each main state specification a schemata for each controlled device is defined according to users' specifications and DSO Contract.

Devices are specified according to two types of control: On/Off, thermostat controlled. Others might be possible.

Example:

Device 1: Water Boiler, kW, On/Off unit

Home: Always On/Always on between hours Away: Always on between hours

Device 2: Air Conditioner, kW, Thermostat controlled

Home: Preferred temp 22C Max: 24C Min: 20C Alarm level low: 17C Alarm level high: 26C

Away: Preferred temp 26C Max: 30C Min: 24C Alarm level low: 17C Alarm level high: 26C

Actors:

SESP Contract, SESP control, Service Unit, D-R Group Member

Preconditions:

New member is registered as Consumer or Prosumer. Preferences and specifications are duly noted and archived.

Software agents for managing D-R activation have been tested and approved and ready to be used.

Post conditions:

D-R Member agent created and activated. Aggregated flexibility per hour is updated. D-R Member has access to personal page with accounts and legal control adjustments per device controlled.

Steps:

1. SESP Contract creates a Device & Install Order and passes it to Service Unit. SESP Control is activated on the same order.
2. Service Unit undertakes installations according to order and performs preliminary test for communication, temperature monitoring, thermostat management, light control etc.
3. SESP Control instantiates D-R Member agent according to contract and user specifications.

4. SESP Control tests agent according to test plan once preliminary service test is approved.
5. SESP Control issues username, password to D-R Member with link to interface that allows monitoring of state, and simple adjustments of temperature levels as well as AWAY/HOME specifications. This also gives access to the user's personal account that allows him or her to monitor monetary status, performance credits, reputation, news, comparative performance etc.
6. SESP Control updates status for D-R-Member in CRM system with ACTIVE and adds max flexibility capacity for the different hours for the user in the control database.
7. SESP control updates aggregated flexibility per hour for scheduled as well as non-scheduled activations.

Note: The same preparations are required also as part of an aggregator initiated contract

9.3.2 UC-4.3.1-5: Manage D-R Resources

Abstract:

Every half hour to every second hour the following needs to be done. Inventory control in terms of: Households Away/Home, connected devices, max kW controlled, storage levels, peak and hourly production and estimated kWh/h flexibility must be carried out continuously in order to determine latent flexibility at all times. This also includes temperature control where this is relevant. Max temperature levels and minimum temperature levels must be observed closely to avoid critical max or min. Critical minimum temperature could be frost related. Critical max temperature could be related to fouling of food and beverages in coolers etc. Inventory management is especially important 1-2 hours prior to scheduled cut-off periods. Spot prices and prices in the balancing market are also monitored. The assessments made determine how well the SESP can meet the DSO requirements and respond to prices. It also determines how much reserve power and flexibility the SESP needs to procure to maintain sufficient buffers.

This use-case does not include regular customer support.

Actors:

D-R Member Agents (DRMA), SESP Control, Storage Monitoring and Control, (SMC), Smart Meters (SM), Central Power Exchange (CPE), SESP Market

Preconditions:

D-R Member agents created and activated. Devices installed, tested and approved.

Post conditions:

A D-R strategy for the next hour is produced; a support & service order is issued,

Assumptions:

A separate use-case for regular customer support (support desk) must be developed.

Steps:

1. SESP Control requests operational status from its portfolio of DRMAs. It detects failures or potential failures and issues non-conformance statement and passes this to Service Unit.
2. SESP Control requests capacity status from its portfolio of DRMAs. The following calculations/estimates are produced for the next hour and the five following hours:
    a. Max available kW
    b. Max available kWh/h based on current consumption and learned household consumption profile
    c. Max peak production kW
    d. Average production in kWh
    e. Storage levels measured in Ah and kWh
    f. Outdoor temperature levels
    g. Indoor temperature levels in each zone monitored by an installed device
    h. Cloud forecast
3. SESP Control defines a D-R strategy for the next hour and issues DRMA credits for availability or non-availability which is passed on to SESP Market

9.3.3 UC-4.3.1-6: Process scheduled request – fixed price regime

Abstract:

Based on the established strategy which is compatible with the current inventory, execution of the activation order from the DSO takes place. Price for activation is fixed. As this type of activation are pre-scheduled SESP control polls for time. According to contract and state of the zone controlled by an agent ramp-up or step-down might be required. An example of this is shown in the diagram below. Here the temperature level (red line) is very low and frost is imminent if cut-off is performed. By increasing the indoor temperature before cut-off a thermal buffer is created. This option is used only if the participant household has agreed to such a strategy up front. Similarly step-downs are performed by boosting cooling where high temperatures might cause a problem during cut-off. A D-R strategy specifies which devices and how these are going to be controlled. The actual control is left to the agent. This is important as observed temperature levels etc. will not be uniform. Each house will have its own specific settings. In the contract with the D-R member the availability of devices will be specified (see example below). This suggests that some devices might be readily available. Others might not. The latter group still represents a contingency which means that they can be activated beyond specified hours, but then compensation will be higher. Eventually a reduction in power is monitored and each member's contribution is duly noted. The DSO and the member's will be invoiced or credited accordingly.

Actors:

SESP Control, DSO, SESP Contract, D-R Member Agents (DRMA), Timer

Preconditions:

A D-R strategy for the next hour is produced; Contract with DSO has been established

Post conditions:

A power reduction is monitored and experienced. Each D-R member's contribution is noted and rewards/penalties are recorded. A report on the activation is sent to the DSO. A basis for invoicing is created.

Assumptions:

Sufficient storage capacity to buffer, mitigate and negotiate is important.

Steps:

1. SESP Control D-R scripts checks schedule and polls Timer for time.
2. If scheduled cut-off time is due in 1-2 hours SESP Control activates DRMAs according to D-R strategy.
3. DRMAs check the devices that it controls. Those thermostat controlled units operating in zones with critical temperatures are pre-activated. Those operating close to critical minimum temperature undergo a temperature ramp-up (see diagram above) until temperature in zone reaches a pre-defined temperature level. Those operating close to critical maximum temperature undergo a step-down where temperature is lowered to a reference value.
4. SESP Control D-R scripts checks schedule and polls Timer for time.
5. If scheduled cut-off time is due (latency taken into account) SESP Control activates DRMAs according to D-R strategy.

6. DRMAs send a signal to devices controlled and cut-off is activated. DRMAs report activation start time to SESP Control. The activity can be monitored on consumer user interfaces (i.e. smart phone app)
7. SESP Control updates GUIs and logs accordingly. Nominal, aggregated power reduction is recorded. Average reduction in power per hour (kWh/h) is monitored and recorded continuously. (Reduction should also be monitored at sub-station level). DSO can monitor activation through proprietary user interface.
8. If anticipated reduction is less than expected SESP Control compensates by unleashing power from local storage while negotiating added flexibility from restricted devices (less elastic units) according to D-R strategy. Step 5 to 8 is repeated.
9. DRMA monitors thermostat controlled devices. If temperature is below or above critical limits cut-off for the device is aborted and action reported to SESP Control.
10. SESP compensates for loss of flexibility it releases more battery storage and negotiates less flexible resources (for a higher pre-defined price)
11. SESP Control D-R scripts checks schedule and polls Timer for time.
12. If scheduled cut-off time is due to terminate SESP Control sends termination signal to DRMAs that reactivates devices and reports back o SESP Control which records this.
13. SESP Control passes the log to SESP Contract that analyzes it and compares performance of each D- R Member with the contract specifications of each. Credits and penalties are awarded accordingly to each member's account.
14. SESP Contract creates a report for the DSO and the basis for an invoice statement for the activation is created.

Variations:

Actors can also be local producers, prosumers with surplus to sell, aggregators or retailers or the SESP itself. This type of use case will respond to triggers agreed.

Using control devices that disconnect the community from the grid will use the same type of signals.

9.3.4 UC-4.3.1-7: Process scheduled request – auction

Abstract:

Similar to use case 6 above. However, a Dutch auction takes place to settle the price. This reduces the importance of the device schedule as shown above. This also requires a flexible pricing regime with the DSO. Price determines how many devices will be engaged. The D-R agents handle this. What determines each agent’s engagement and potential contribution that the SESP Control does not already know from the contract created with the D-R Member? The answer to this question is the current state in the buildings, households and zones that the agent controls. The general market price might also influence this (see UC-10 too). Critical temperatures and use of devices might make it harder to unleash power. The expression “negotiation” applied for contingencies in UC-6 can possibly be the same as an auction as described here. Steps that are not similar to the description for UC-6 are highlighted in red. Bids and pricing will reflect the current state of the household. If the household is busy reduction in consumption might require very high prices to take place.

Actors:

SESP Control, DSO, SESP Contract, D-R Member Agents (DRMA), Timer

Preconditions:

A D-R strategy for the next hour has been produced; Contract with DSO has been established

Post conditions:

A power reduction is monitored and experienced. Each D-R member’s contribution is noted and rewards/penalties are recorded. A report on the activation is sent to the DSO. A basis for invoicing is created.

Assumptions:

Sufficient storage capacity to buffer, mitigate and negotiate is important.

Steps:

1. SESP Control D-R scripts checks schedule and polls Timer for time.
2. If scheduled cut-off time is due in 1-2 hours SESP Control activates DRMAs according to D-R strategy and evaluates battery levels that it controls. A power reduction demand is calculated.
3. SESP Control invites bids from DRMAs. DRMAs nominate devices and potential kWh and kWh/h for a given price. SESP Control assesses bids and volume.
4. Bids are ranked according to price and volume. High volumes with low prices are ranked highest. When 130% of the scheduled reduction is achieved auction is closed. The extra 30% constituting a contingency in addition to storage

capacity controlled by the SESP. The 30% might never be used (this should help to reduce aspects of gaming too).

5. SESP Control issues an activation order to the DRMAs for the scheduled reduction.
6. DRMAs check the devices that it controls. Those thermostat controlled units operating in zones with critical temperatures are pre-activated. Those operating close to critical minimum temperature undergo a temperature ramp-up (see diagram above) until temperature in zone reaches a pre-defined temperature level. Those operating close to critical maximum temperature undergo a step-down where temperature is lowered to a reference value.
7. SESP Control D-R scripts checks schedule and polls Timer for time.
8. If scheduled cut-off time is due (latency taken into account) SESP Control activates DRMAs according to auction settlement.
9. DRMAs send a signal to devices controlled and cut-off is activated. DRMAs report activation start time to SESP Control. The activity can be monitored on consumer user interfaces (i.e. smart phone app)
10. SESP Control updates GUIs and logs accordingly. Nominal, aggregated power reduction is recorded. Average reduction in power per hour (kWh/h) is monitored and recorded continuously. (Reduction should also be monitored at sub-station level). DSO can monitor activation through proprietary user interface.
11. If anticipated reduction is less than expected SESP Control does one of two things depending on cost evaluations (or a combination of both)
    a. Unleashes stored energy in repository that it controls
    b. Sends signal to the DRMAs constituting the contingency part of the auction
12. DRMA monitors thermostat controlled devices. If temperature is below or above critical limits cut-off for the device is aborted and action reported to SESP Control.
13. SESP compensates for loss of flexibility by repeating step 11 above.
14. SESP Control D-R scripts checks schedule and polls Timer for time.
15. If scheduled cut-off time is due to terminate SESP Control sends termination signal to DRMAs that reactivates devices and reports back o SESP Control which records this.
16. SESP Control passes the log to SESP Contract that analyzes it and compares performance of each D- R Member with the contract specifications of each. Credits and penalties are awarded accordingly to each member’s account.

17. SESP Contract creates a report for the DSO and the basis for an invoice statement for the activation is created.

Variations:

Actors can also be local producers, prosumers with surplus to sell, aggregators or retailers or the SESP itself. This type of use case will respond to triggers agreed upon.

Using control devices that disconnect the community from the grid will use the same type of signals.

9.3.5 UC-4.3.1 -8: Process instant request – fixed price regime

Abstract:

Use-Case is similar to UC-4.3.1-6. However, responsiveness is critical. This assumedly requires a high storage capacity to buffer the first 30-90 minutes of the cut-off.

Actors:

SESP Control, DSO, SESP Contract, D-R Member Agents (DRMA), Timer

Preconditions:

A D-R strategy for the next hour is produced; Contract with DSO has been established

Post conditions:

A power reduction is monitored and experienced. Each D-R member's contribution is noted and rewards/penalties are recorded. A report on the activation is sent to the DSO. A basis for invoicing is created.

Assumptions:

High storage capacity is required to buffer, mitigate and negotiate is important.

Steps:

1. DSO issues activation signal. SESP Control responds by unleashing stored energy to instantly alleviate central import to the neighborhood.
2. SESP Control activates DRMAs according to D-R strategy.
3. DRMAs send a signal to devices controlled and cut-off is activated. DRMAs report activation start time to SESP Control. The activity can be monitored on consumer user interfaces (i.e. smart phone app)
4. SESP Control updates GUIs and logs accordingly. Nominal, aggregated power reduction is recorded. Average reduction in power per hour (kWh/h) is monitored and recorded continuously. (Reduction should also be monitored at

sub-station level). DSO can monitor activation through proprietary user interface.

5. When sufficient reduction is experienced SESP Control reduces/adjusts storage activation accordingly.
6. DRMA monitors thermostat controlled devices. If temperature is below or above critical limits cut-off for the device is aborted and action reported to SESP Control.
7. SESP compensates for loss of flexibility it releases more battery storage and negotiates less flexible resources (for a higher pre-defined price)
8. DSO sends off-trigger signal to SESP Control that passes this on to the DRMA that reactivates devices and reports back to SESP Control which records this.
9. SESP Control passes the log to SESP Contract that analyzes it and compares performance of each D- R Member with the contract specifications of each. Credits and penalties are awarded accordingly to each member's account.
10. SESP Contract creates a report for the DSO and the basis for an invoice statement for the activation is created.

Variations:

Actors can also be local producers, prosumers with surplus to sell, aggregators or retailers or the SESP itself. This type of use case will respond to triggers agreed upon.

Using control devices that disconnect the community from the grid will use the same type of signals.

9.3.6 UC-4.3.1 -9: Process instant request – auction

Abstract:

Use-Case is similar to UC-4.3.1 -6 and UC-4.3.1 --8. Responsiveness is critical. This assumedly requires a high storage capacity to buffer the first 30-90 minutes of the cut-off.

Actors:

SESP Control, DSO, SESP Contract, D-R Member Agents (DRMA), Timer

Preconditions:

A D-R strategy for the next hour is produced; Contract with DSO has been established

Post conditions:

A power reduction is monitored and experienced. Each D-R member's contribution is noted and rewards/penalties are recorded. A report on the activation is sent to the DSO. A basis for invoicing is created.

Assumptions:

High storage capacity is required to buffer, mitigate and negotiate is important.

Steps:

1. DSO issues activation signal. SESP Control responds by unleashing stored energy to instantly alleviate central import to the neighborhood.
2. SESP Control activates DRMAs according to D-R strategy and evaluates battery levels that it controls. A power reduction demand is calculated.
3. SESP Control invites bids from DRMAs. DRMAs nominate devices and potential kWh and kWh/h for a given price. SESP Control assesses bids and volume.
4. Bids are ranked according to price and volume. High volumes with low prices are ranked highest. When 130% of the scheduled reduction is achieved auction is closed. The extra 30% constituting a contingency in addition to storage capacity controlled by the SESP. The 30% might never be used (this should help to reduce aspects of gaming too).
5. SESP Control issues an activation order to the DRMAs for the scheduled reduction according to auction settlement.
6. DRMAs that are part of the settlement send a signal to devices controlled and cut-off is activated. DRMAs report activation start time to SESP Control. The activity can be monitored on consumer user interfaces (i.e. smart phone app)
7. SESP Control updates GUIs and logs accordingly. Nominal, aggregated power reduction is recorded. Average reduction in power per hour (kWh/h) is monitored and recorded continuously. (Reduction should also be monitored at sub-station level). DSO can monitor activation through proprietary user interface.
8. When sufficient reduction is experienced SESP Control reduces/adjusts storage activation accordingly.
9. If anticipated reduction is less than expected SESP Control does one of two things depending on cost evaluations (or a combination of both)
    a. Unleashes more stored energy in repository that it controls
    b. Sends signal to the DRMAs constituting the contingency part of the auction

10. DRMA monitors thermostat controlled devices. If temperature is below or above critical limits cut-off for the device is aborted and action reported to SESP Control.
11. SESP compensates for loss of flexibility by repeating step 11 above.
12. DSO sends off-trigger signal to SESP Control that passes this on to the DRMA that reactivates devices and reports back to SESP Control which records this.
13. If scheduled cut-off time is due to terminate SESP Control sends termination signal to DRMAs that reactivates devices and reports back o SESP Control which records this.
14. SESP Control passes the log to SESP Contract that analyzes it and compares performance of each D- R Member with the contract specifications of each. Credits and penalties are awarded accordingly to each member's account.
15. SESP Contract creates a report for the DSO and the basis for an invoice statement for the activation is created.

Variations:

Actors can also be local producers, prosumers with surplus to sell, aggregators or retailers or the SESP itself. This type of use case will respond to triggers agreed upon

Using control devices that disconnect the community from the grid will use the same type of signals.

9.3.7 UC-3.3.2-1: Process scheduled request for service – fixed price regime

Abstract:

Very similar to UC-4.3.1-6 above. The idea is to purchase a service or service app for a fixed price determined by the SESP

Actors:

SESP Control, Service provider (internal and external) , SESP Contract, service apps/ Agents (SMA), Timer

Preconditions:

Information about the service or service app is available. For services a fixed scheduled program has been established for the procurer.

Post conditions:

Service has been executed and enumeration is due.

Assumptions:

Service has been quality assured and integrated with the SESP Control.

Steps:

1 SESP Control checks service schedule and polls Timer for time.
2 If scheduled offline service is due in 1-2 hours SESP Control activates service provider .If scheduled online service is due then it will trigger itself by polling the Timer.
3 Progress of service is monitored by the SESP and a GUI presenting this can be provided to the recipient.
4 If service has been conducted successfully the service app/agent signals this to SESP that enumerates accordingly
5 If service is not conducted successfully the service provider and the customer is notified.
6 SESP Control passes the log to SESP Contract that analyzes it and compares performance of each D- R Member with the contract specifications of each. Credits and penalties are awarded accordingly to each member's account.
7 SESP Contract creates a report for the parties involved and the basis for an invoice statement for the activation is created.

Variations:

Actors can also be local producers, prosumers with surplus to sell, aggregators or retailers or the SESP itself. This type of use case will respond to triggers agreed

9.3.8 UC-3.3.2-2: Process scheduled request for service – auction

Abstract:

Very similar to UC-4.3.1-7 and UC-3.3.2-1 above. The idea is to negotiate a service or service app for a fixed price determined by the SESP.

Actors:

SESP Control, Service provider (internal and external), SESP Contract, service apps/ Agents (SMA), Timer

Preconditions:

Information about the service or service app is available. Two or more sellers can provide the same type of service

Post conditions:

Service has been executed and enumeration is due.

Assumptions:

This is assumed relevant for financial services, securities as well as diagnosis, repair/healing, boosting.

Steps:

1 SESP Control checks service schedule and polls Timer for time.
2 If scheduled offline service is due in 1-2 hours SESP Control activates service provider .If scheduled online service is due then it will trigger itself by polling the Timer.
3 SESP Control invites bids from SMAs. SMAs nominate services.
4 Bids are ranked according to price, outcome (typically measured in kW and kWh). High volumes with low prices are ranked highest. When 100% of the scheduled reduction is achieved auction is closed.
5 SESP Control issues an activation order to the SMAs for the scheduled reduction.
6 SMAs check the devices/assets of the recipient(s) and perform services.
7 Progress of service is monitored by the SESP and a GUI presenting this can be provided to the recipient.
8 If service has been conducted successfully the service app/agent signals this to SESP that enumerates accordingly
9 If service is not conducted successfully the service provider and the customer is notified.
10 SESP Control passes the log to SESP Contract that analyzes it and compares performance of each D- R Member with the contract specifications of each. Credits and penalties are awarded accordingly to each member’s account.
11 SESP Contract creates a report for the parties involved and the basis for an invoice statement for the activation is created.

Variations:

Actors can also be local producers, prosumers with surplus to sell, aggregators or retailers or the SESP itself. This type of use case will respond to triggers agreed upon

Execution might not follow directly

9.3.9 UC-3.3.2 -3: Process instant request – fixed price regime

Abstract:

Use-Case is similar to UC-4.3.1-6 UC-3.3.2-1 above. However, responsiveness is critical.

Actors:

SESP Control, Service provider (internal and external), SESP Contract, service apps/ Agents (SMA), Timer

Preconditions:

Information about the service or service app is available. Two or more sellers can provide the same type of service

Post conditions:

Service has been executed and enumeration is due.

Assumptions:

High storage capacity might be required to buffer, mitigate and negotiate is important.

Steps:

1 SESP Control receives signal about the need for service

2 SESP Control activates service provider through direct signal .If scheduled online service is due then it will trigger itself by polling the Timer.

3 Progress of service is monitored by the SESP and a GUI presenting this can be provided to the recipient.

4 If service has been conducted successfully the service app/agent signals this to SESP that enumerates accordingly

5 If service is not conducted successfully the service provider and the customer is notified.

15. SESP Control passes the log to SESP Contract that analyzes it and compares performance of each D- R Member with the contract specifications of each. Credits and penalties are awarded accordingly to each member’s account.

16. SESP Contract creates a report for the parties involved and the basis for an invoice statement for the activation is created.

Variations:

Actors can also be local producers, prosumers with surplus to sell, aggregators or retailers or the SESP itself. This type of use case will respond to triggers agreed upon.

9.3.10 UC-3.3.3 -1: Process instant request – auction

Abstract:

Use-Case is similar to UC-4.3.1 -6, UC-3.3.2-2, UC-3.3.2-1 and UC-4.3.1 --8. Responsiveness is critical. This assumedly requires a high storage capacity to buffer the first 30-90 minutes of the cut-off. Related to energy sale and D-R mitigation.

Actors:

SESP Control, Service provider (internal and external), SESP Contract, service apps/ Agents (SMA), Timer

Preconditions:

Information about the service or service app is available. Two or more sellers can provide the same type of service

Post conditions:

Service has been executed and enumeration is due.

Assumptions:

High storage capacity is required to buffer, mitigate and negotiate is important.

Steps:

1 SESP Control checks Timer and initiate process when time is due.
2 SESP Control invites bids from SMAs. SMAs nominate services.
3 Bids are ranked according to price, outcome (typically measured in kW and kWh). High volumes with low prices are ranked highest. When 100% of the scheduled reduction is achieved auction is closed.
4 SESP Control issues an activation order to the SMAs for the scheduled reduction.
5 SMAs check the devices/assets of the recipient(s) and perform services.
6 Progress of service is monitored by the SESP and a GUI presenting this can be provided to the recipient.
7 If service has been conducted successfully the service app/agent signals this to SESP that enumerates accordingly
8 If service is not conducted successfully the service provider and the customer is notified.
9 SESP Control passes the log to SESP Contract that analyzes it and compares performance of each D- R Member with the contract specifications of each. Credits and penalties are awarded accordingly to each member's account.

10 SESP Contract creates a report for the parties involved and the basis for an invoice statement for the activation is created.

Variations:

Actors can also be local producers, prosumers with surplus to sell, aggregators or retailers or the SESP itself. This type of use case will respond to triggers agreed upon

---

9.3.11 UC-5.1.3-1: Process scheduled exchange of energy – fixed price regime

Abstract:

More substance related to this will be established in Task 6.2. This UC is meant as guide for technical specifications only, not a blueprint.

Actors:

SESP Control, Service provider (internal and external), SESP Contract, trade agents (TMA), Timer

Preconditions:

A periodic fixed price regime has been established whereby the SESP guarantees a price for the consumer and one for the suppliers at a given hour. The price does not need to be the same. The price for the prosumer might be lower than the one that suppliers have been promised. Fixed price agreements have been initiated in advance.

Post conditions:

Settlement is reached and pending mitigation to fulfill obligations might be triggered.

Assumptions:

The price for the consumer and the prosumers does not need to be the same. The price for the prosumer might be lower than the one that suppliers have been promised. Mismatch between available surplus and local demand can be catered for through use of the external market as well as mitigation involving storage or local demand. (See UC-4.x.x-x and UC-3.x.x.-x)

Steps:

1 SESP Control polls Timer for time.
2 Signal to post surplus volumes and demand requirements are made.

3 SESP assures balance. Excess is stored or sold centrally. Deficiency is covered by buying from the central market or mitigated by means of UC-4.x.x-x and UC-3.x.x.-x.
4 After settlement the SESP Control produces the activation to the appropriate devices that allows the correct energy flow.
5 SESP Control passes the settlement for credit and debit assignment.
6 SESP Contract creates a report for the parties involved and the basis for an invoice statement for the activation is created.

Variations:

Local producers, prosumers with surplus to sell, aggregators or retailers can trigger a trade like this.

9.3.12 UC-5.1.3-2: Process scheduled exchange of energy – auction

Abstract:

More substance related to this will be established in Task 6.2. This UC is meant as guide for technical specifications only, not a blueprint. No preferences for trade frequency have been defined.

Actors:

SESP Control, Service provider (internal and external), SESP Contract, trade agents (TMA), Timer

Preconditions:

There are multiple traders

Post conditions:

Settlement is reached and pending mitigation to fulfill obligations might be triggered.

Assumptions:

External aggregators and retailers may take part. Mitigation might be needed. (See also previously specified use case in the form UC-4.x.x-x and UC-3.x.x.-x)

Steps:

1 SESP Control polls Timer for time. If time is due it starts trading process.
2 Buyers and sellers are invited to place their bids and asks.
3 Bids and asks with price and volume for the designated period are displayed and should be possible to visualize for all a shared trading board supported by the SESP Market.

4 A spread is established. As soon as an ask or a bid is fulfilled it is taken off the board.

5 Bids and asks that are not met remain unmatched, possibly until trade has concluded.

6 SESP Control polls Timer for time. If time is due trading process is concluded.

7 After settlement the SESP Control produces the activation to the appropriate devices that allows the correct energy flow.

8 SESP Control passes the settlement for credit and debit assignment.

9 SESP Contract creates a report for the parties involved and the basis for an invoice statement for the activation is created.

Variations:

Local producers, prosumers with surplus to sell, aggregators or retailers can trigger a trade like this.