



ENTREPRENEURSHIP AND SUSTAINABILITY ISSUES

ISSN 2345-0282 (online) <http://jssidoi.org/jesi/>

BUSINESS MODEL STRATEGIES: FLEXIBILITY TRADE IN LOW VOLTAGE DISTRIBUTION NETWORKS¹

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Received 29 September 2016; accepted 16 November 2016

Abstract. Empowered by information and communication technologies (ICT) analytics and smart technologies, the energy model landscape is changing with flexibility at the core of a new energy market design. In particular, multi-sided platforms (MSPs) has gained prominent attention as a business model that creates value by enabling direct interactions between several distinct groups of actors who need each other in order to deliver products to their customers. However, as MSPs are less familiar within the energy market, there has been little investigation in modelling this emerging and dynamic ecosystem. Utilising the business modelling methodology of value network analysis and the key informant technique, value flows were modelled within the context of a MSP to understand the creation, delivery and capture of value in a network of interdependent relationship, its networked position and the stakeholder interactions required for delivery of local flexibility. Supported by this analysis, this paper focuses on the LV area of the smart grid, and presents the Local Flexibility Market (LFM) as a Multi-Sided Platform. In comparison to the traditional utility model, the complexity of this recharacterization of the industry ecosystem is significant. While it presents new opportunities for incumbent energy providers to collaborate and develop new products, the proposed LFM market design will also dramatically reshape the value model of the industry.

Keywords: Smartgrid; Low Voltage Grid; Flexibility Management; Local Flexibility Market; Local Flexibility Aggregator; Prosumer; Local Energy Community; Multi-Sided Business Models

Reference to this paper should be made as follows: Lynch, P., Power, J., Hickey, R., Messervey, T. 2017. Business model strategies: Flexibility trade in emerging low voltage distribution networks, *Entrepreneurship and Sustainability Issues*, 380-391. [http://dx.doi.org/10.9770/jesi.2017.4.3S\(12\)](http://dx.doi.org/10.9770/jesi.2017.4.3S(12))

¹ This research was supported by the project Mas²tering (www.mas2tering.com), which has received funding from the European Union's FP7 research and innovation programme under the grant agreement No 619682.

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JEL Classifications L10, Q10, P41

Additional disciplines : Software Engineering, Sociology

1. Introduction

Developing infrastructures, technologies and supporting business models to unlock energy market flexibility is currently one of the core questions discussed in various key energy policy circles in Europe (European Commission 2015 a; b; EC Europa 2015). In an environment of increased deregulation, competition and collaboration, achieving a demand-responsive smart-grid depends not only on the intersection between ICT and energy infrastructure but equally on sustainable business models and stakeholder collaboration (Mourshed, et al., 2015). The technologies, methods and aspects surrounding the smart grid are disruptive innovations that present both challenges and opportunities to utility business models and the actors involved (Lynch et al., 2016a; b; Ala-Juusela et al., 2014). For the power industry, business as normal will likely not be possible and those maintaining traditional practices will likely fall to competitive pressures. Driven by both technology developments and policy targets, Europe's energy system is and will continue to undergo significant transformations, with flexibility as a cornerstone of emerging energy market design. *"We are transitioning away from a power system in which controllable power stations follow electricity demand, to an overall efficient power system where flexible producers, flexible consumers and storage systems respond to increasing intermittent supply of wind and solar power"* (BNE, 2015: 1). Within this vein of transformation, increasing focus is being placed at exploring the local level markets. Decentralised energy (DE) is energy generated at or near the point of use and involves offers buildings (including both domestic and residential) doubling up as power stations via their usage of generating technologies such as solar panels, wind turbines or cogeneration units. The growing interest in local energy communities is further fuelled by the increasing adoption of both distributed energy resources (DERs), and residential Internet of Things (IoT) devices.

These advancements are paving the way for paradigm shifts in the energy generation/distribution system. Indeed, moving from a unidirectional electricity grid system that delivers energy from centralized power plants to customers through transmission and distribution lines represents a disruptive shift (Wainsteina & Bumpus, 2016). Such transformations in energy systems, necessitates the need for exploring the role of innovative business models and adapting, and in some cases creating new stakeholder roles, to realise the opportunities available associated with flexibility in local market contexts from the context of Prosumers ("pro" in prosumer comes from production) and aggregators (Steinheimer and Ulrich, 2012; Rathnayaka, et al., 2011). In comparison to the traditional utility model, the complexity of this recharacterization of the industry ecosystem and business model is significant. To date, energy market actors have primarily focused on technology advancement within the smart grid which is within their comfort zone, however, this recharacterization will also require a call to action to engage in business model transformation which is new to most (Valocchi et al., 2010)

In this fashion, the main contribution of this paper is that from an ecosystem perspective, the business modelling methodology of value network analysis (VNA) was utilised (Peppard and Rylander, 2006) to develop a multi-sided business model (MSP) for a local flexibility aggregator to facilitate flexibility management between Suppliers, Wholesale Market Aggregators (WMAs), Distribution System Operators (DSOs), Consumers and Prosumers in the Low Voltage area of the grid. This paper argues that empowered by ICT, analytics and smart technologies, the emergence of the Prosumer as an active participant in the energy value chain will herald the era of multi-sided platforms (MSPs) which fundamentally changes the energy model landscape with flexibility at the core of a new energy market design. The rest of the paper is structured as follows. In the next section we discuss the business model shift to MSPs. Section 3 defines the Local Flexibility Market (LFM) and the actor's roles.

Next we present our initial findings around the conceptualising the LFM as a MSP. Finally, Section 5 states the concluding remarks and discusses some directions for future works.

2. Business Model Shift

The traditional power grid was designed only to carry energy from few central generation points to the final users. Today however, the power grid is facing a series of new demands (Mourshed, et al., 2015). Following the adoption by EU countries of the Directives for the reduction of CO₂ emissions, the last 10-15 years have seen the increasing penetration of Renewable Energy Resources (RES) on the grid. Typically located at the Medium Voltage (MV) and Low Voltage (LV) levels, these intermittent and fluctuating distributed energy resources (DERs) require management to maintain grid stability and balance. The grid also continues to electrify. More users have higher demand profiles. Especially in urban areas, increasing grid capacity and avoiding grid congestion is a challenge. This will continue to worsen with the welcome increased penetration of electric vehicles although as storage systems their batteries can also provide solutions (Dupont et al., 2012). More and more, there is the need to manage and plan grid operations at the low voltage level where Consumers, Prosumers, Suppliers, WMA and DSOs will need to act and collaborate in new ways (BNE, 2015).

Converging evidence indicates that there is a real opportunity to resolve or mitigate some of the current challenges through the harnessing information and communication technologies (ICT), analytics, control strategies and smart devices for automating changes in how and when consumers consume, generate or store electricity (European Commission, 2015a). When Consumers or Prosumers agree to change their planned consumption profile, this is called flexibility and the consequent shifting of loads can provide one tool to manage network capacity, congestion, and to achieve balance at local levels. If homes can individually and collectively level their demand load profile, then the generation, distribution and storage of electricity at the LV level (and indirectly at higher voltages) can be optimized (Lennard et al., 2015). Indeed, the increasing rate of intelligent domestic devices provides a real impetus for a smarter distribution network by creating a novel market energy model to maximise the advantages of DERs through smarter coordination of a prosumer community and DERs to provide more flexibility at the LV level. Smart consumers and prosumers are defined as those that use demand response to shift their flexible loads. Prosumer communities imply a collective force that would theoretically influence, and be influenced by the local energy market (Lynch et al., 2016a). Local flexibility is at the cornerstone of this new emerging energy market design (Rathnayaka, et al., 2011).

Bringing this opportunity to a reality, the formation of prosumer communities implies that they should have an intermediary to help manage DG (Distributed Generation) and DS (Distributed Storage) with regards to the injection of unused capacity to the LV-grid. A new role of a flexibility manager (Hagui, 2015) or aggregator (Valocchi et al., 2010; 2012) is foreseen in the energy value chain to act as an intermediary and facilitating agent between prosumers and traditional market players. The role being developed is one that combines the main aspects of flexibility management (Rochet, 2003) and aggregation (Ondrus, 2015) labeled the Local Flexibility Aggregator (LFA). The LFA represents a community of prosumers who through their own smart technologies will also become an integral part of the value chain as providers of flexibility. DSOs will be able to buy flexibility from LFAs to locally deal with congestions and increase grid performances and reliability (Lynch et al., 2016a).

In comparison to the traditional utility model (see Richter, 2012), the complexity of this recharacterization of the industry ecosystem is significant. While it presents new opportunities for incumbent energy providers to collaborate and develop new products and services, it will also dramatically reshape the value model of the industry as a whole and the value propositions required by the market (Wainsteina & Bumpus, 2016). As energy, information and revenue flows can happen in various combinations, the nature of value has changed as there are far more types of reciprocal value and combinations of actor exchanges to deliver value. Moreover, as new types

of reciprocal value will be generated, new value added businesses and services and new participants to the ecosystem that traditionally would not have been directly involved in the industry will emerge (Mourshed, et al., 2015). Consequently, the value capture opportunities available to the ecosystem participants will continuously increase, as will the complexity of the business models to capture and exploit that business value opportunity such as “platform-based business models” that services interdependent customer segments in an ecosystem concept (Hagiu, 2014). In particular, multi-sided platform (MSP) has gained prominent attention (Ondrus, 2015) as a business model that creates value by enabling direct interactions between several distinct groups of actors who need each other in order to deliver goods or services to their customers (Rochet, 2003). The real challenge of understanding such an emerging and dynamic complex business platform is to map out the flexibility business model opportunities that will take advantage of the new network-enabled capabilities that will allow companies to reap as much of the ecosystems’ new value (Rochet, 2003; EURELECTRIC, 2011). However, there has been very little investigation in modelling this dynamic ecosystem beyond viewing business model value creation from the perspective of an individual actor which is not very effective when trying to ignite network based business models. It is the network of collaborative relationships that provides the key to understanding and realizing the business model opportunities within the ecosystem concept associated with flexibility in local market context (Steinheimer and Ulrich T, 2012; Rathnayaka, et al., 2011).

3. Conceptualising the Local Flexibility Market as a Multi-Sided Business Platform (LFM)

On an individual level, flexibility is “*the modification of generation injection and/or consumption patterns in reaction to an external signal (price signal or activation) in order to provide a service within the energy system*” (EURELECTRIC, 2014: 5). The parameters used to characterize flexibility in electricity include: the amount of power modulation, the duration, the rate of charge, the response time, and the location. Emerging in EU are technologies that allow for a two-way exchange between consumers and their energy supplier. Prosumers can be highly active in balancing the supply and demand of electricity as entrepreneurs, by storing electricity through electric car batteries or other storage facilities and providing electricity generated from renewable energy sources (RES), such as solar panels, or micro CHPs. Flexibility can be derived from various types of Active Demand and Supply (ADS) from small commercial and residential Prosumers, representing all the energy-consuming or -producing appliances that have the ability to shift, increase, or decrease their energy consumption or production (programmability, automation, etc.). Smart consumers and smart prosumers are providers of flexibility. In a smart grid context each end user will use flexibility provided by his own smart technologies to reduce the costs associated with the energy bill of his house. According to Lynch et al. (2016a) the specific set of smart technologies end users will use flexibility to self-consume, move loads when cost of electricity is lower or for more complex management strategies. In most cases the reduction of the energy bill will be the first driver for consumers to become prosumers. However, besides using it in the house, prosumers can decide to offer their flexibility as a product to other actors.

Customers of flexibility acquired from residential and commercial sources include other Prosumers in the local community, the DSO that distributes energy to that local community and actors in the upstream value chain which may include other DSOs, aggregators of aggregators, balance responsible parties or TSOs. In simplified terms and as illustrated in Figure 1, depicted in the right proportion of the dotted line, the classical energy system market model involves the reliable and universal sale of energy at reasonable prices by utilities to consumers. Information flows (billing information from utilities to consumers) and revenue flows (from consumers to utilities) are unidirectional and the consumer plays a passive role (Lynch et al., 2016a). This ‘one-sided’ market model is called the “Utility” business model and has been largely unchanged over the last century.

The unbundling of energy markets and emergence of renewable energy technologies have begun to change the energy market model landscape (Dupont et al., 2012). The realization of the smart grid and emergence of a flexibility market will change it even more (Valocchi et al., 2010). This is depicted in the left portion of the dotted

lines in Figure 1 which shows our conceptualization of a Local Flexibility Market model (LFM) where a LFA is between the consumer/prosumer and the upstream energy system actors (Lynch et al., 2016a). In comparison to the classical utility model, the complexity of the ecosystem is significant. Moving from a passive recipient of energy, within our conceptualisation of the LFM, the Prosumer will now become an empowered and integral value chain participant offering flexibility (IEA-RETD, 2014). In a smart grid context each end user will use flexibility provided by his own smart technologies to reduce the costs associated with the energy bill of his house. According to the specific set of smart technologies end users will use flexibility to self-consume, move loads when cost of electricity is lower or for more complex management strategies (Rathnayaka, et al., 2011). In most cases the reduction of the energy bill will be the first driver for consumers to become prosumers. However, besides using it in the house, prosumers can decide to offer their flexibility as a product to other actors. In this sense, prosumers belonging to the community will be able to trade flexibility with each other in order to minimize the individual costs associated to their energy bill. One end user will not only rely on the flexibility provided by its own smart technologies, but will also be able to buy the flexibility provided by the other end users of the same community and globally reduce its bill. In addition, it will be possible to use flexibility in an aggregated - but still local - form to cope with local congestion problems (EURELECTRIC, 2011).

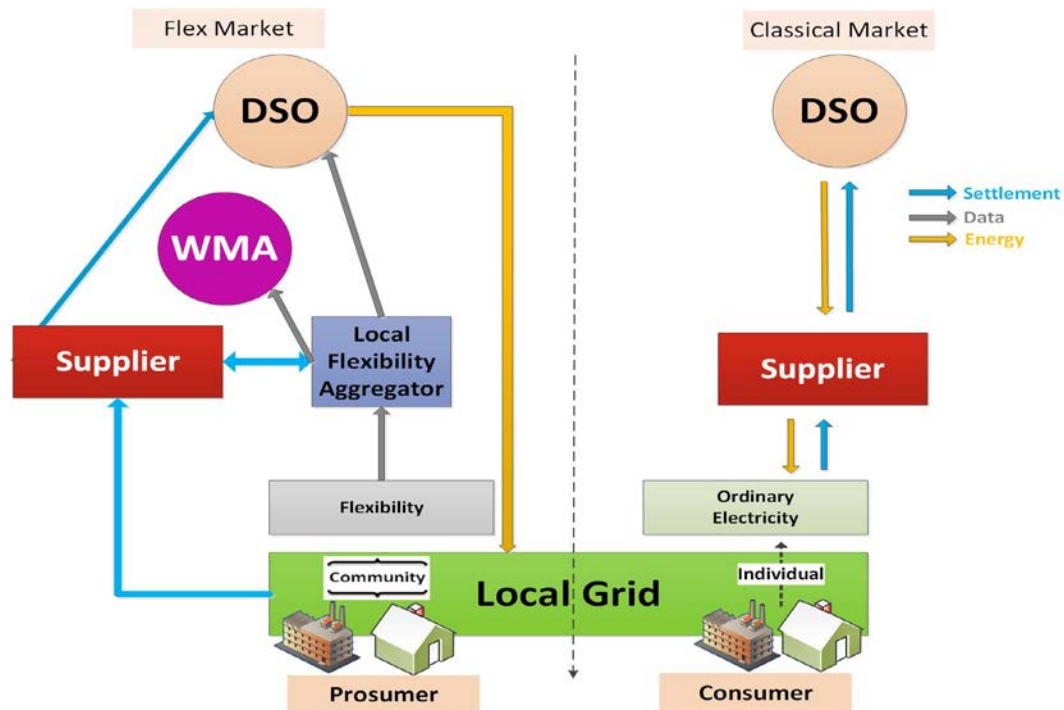


Figure 1. The Structure of the Local Flexible Market (LFM)

The LFA is responsible for acquiring flexibility from Prosumers, aggregating it into a portfolio, creating services that draw on the accumulated flexibility, and offering these flexibility services to the other market participants such as the WMA, DSO and other LFAs. Local flexibility is at the cornerstone of this new energy market design and is the added value of the proposed Local Flexible Market. The argument being proposed is that the centralised management of flexibility by the WMA is not always effective for congestion and capacity management and that local optimization of flexibility provided by the LFA ensures that flexibility is first used for in-home optimization; second traded at local level and; third aggregated for wholesale markets. For the DSO that provides

services to a LEC, it is possible to use flexibility in an aggregated - but still local – form to cope with local congestion problems and capacity requirements. The DSO benefits from the local flexibility market in two ways. First, a more efficient and reliable distribution of electricity is possible because better balancing and predictability is attained at the local level. Second, investments to increase the capacity of the network can either be delayed or potentially avoided.

The problem with the evolution to the LFM proposed is that it is a grid of the future and the structure of the market place is uncertain. It will see the integration of the current market-based energy system and its players with new services and roles. These are required to unleash the added value provided by local flexibility, as described above. Table I presents a description of the actor roles and objectives in the LFM. There are additional actors in the ecosystem not depicted. These include telecom data services, security services and ancillary service providers. Key aspects when designing solutions for enabling flexibility management in the distribution network is that different actors and stakeholders will have different individual objectives that the system should optimize in order to guarantee their participation and interest to the proposed flexibility programs (Table 1).

TABLE 1. ACTOR ROLES & OBJECTIVES

Grid Actor	Roles in Classical Energy Market	Role in LFM	Objectives
Prosumer	The Prosumer is seen as a passive recipient and consumer of energy.	End users that provide flexibility. They may act through smart technologies or by changes in behavior. With renewables, they may generate to sell, self-consume or store electricity.	Save money and lower their electricity bills. Respect of comfort preferences and desired electricity use. Be more eco-friendly.
Local Energy Community	Aggregate the buying power of individual customers for energy savings. Focus on the integration of renewables.	Consumers and Prosumers that join together under a LEC to act in a coordinated way with respect to consumption, generation and storage. Financial and non financial benefits are possible. Potential to be a cooperative entity.	Save money and lower their electricity bills leveraging a community approach. Respect of comfort preferences and desired electricity use. Access to the Flexibility Market. Be part of an eco-friendly community.
Local Flexibility Aggregator	Does not exist	Central role in the MSP. Acts as an intermediary between the Prosumer/LEC and the flexibility market. Aggregates flexibility provided by Prosumer and LEC and sells it to the market players that require it.	Maximize the value of local flexibility for its portfolio, taking into account customer needs, economic optimization and grid capacity. Maximize profit. Build a client portfolio and position for cross selling opportunities between actors.
Wholesale Market Aggregator	Manage large amounts of load in a highly dispersed area in order to meet the requirements of producers, suppliers, BRPs and in line with the balancing requirements established by the TSO and the DSOs .	Will engage local agents such as LFAs to perform the customer acquisition role and local optimisation of flexibility to sell (Internal) as a product offering to the WMA who performs the wholesale market role.	Maximize the value of wholesale market flexibility for its portfolio, taking into account customer needs, economic optimization and grid capacity.
Supplier	The role of the Supplier is to source, supply, and invoice energy to its customers. The Supplier acts as the single contract point for access to the		Maximize its benefit when sourcing, supplying and invoicing energy to its

	electricity market.		customers.
DSO	Distributes electricity at MV and LV levels and ensures quality of supply while maintaining grid stability.	Acts as a purchaser of flexibility from LFA for congestion management and voltage control.	Use LV flexibility as a tool to reduce grid congestion, further ensure the security of supply and improve network capacity planning.

4. Conceptualising the Local Flexibility Market as a Multi-Sided Business Platform (LFM)

Many platforms are single-sided platforms, with a seller at one end and a buyer at the other and, often, intermediaries (distributors) between them that transfer the product from buyer to seller without changing it substantively. The electric power network has historically operated as a single-sided platform. However, within the LFM model presented, the LFA clearly holds the central position and provides the link between the supply of Prosumers flexibility on one side and demand for flexibility by the market players on the other side. From a business and market modelling perspective this type of market design is referred to as a two-sided or multi-sided business market (Hagiu, 2014). In essence, LFM should be viewed from a Multi-Sided Platforms (MSPs) perspective because it brings together different sets of actors who might otherwise not get the chance to engage with each other. Flows of interactions can travel from one side of the market model to the other and in a multi-directional fashion

Lynch et al., (2016c) presents a conceptualisation of the Local Flexibility Market as a Multi-Sided Platform (LFM) (see Figure 2). Table II presents a synthesised explanation of the interactions between the various stakeholders across a number of interaction flows.

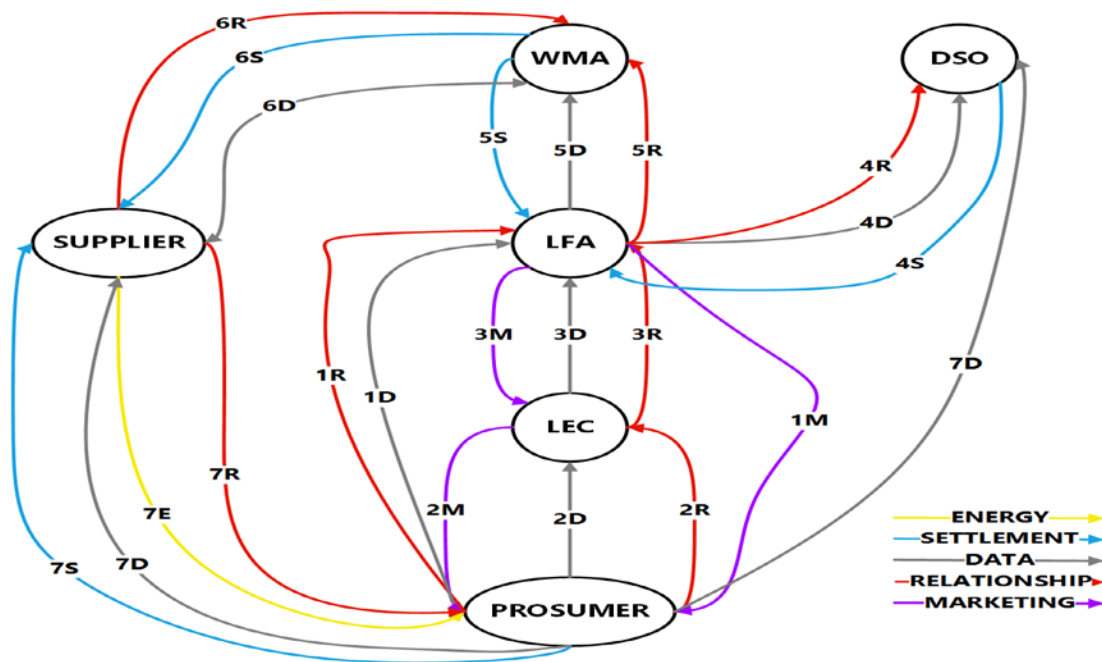


Figure 2. LFM and the LFA Relationships to other Energy Stakeholders

Table II. Actor Interaction Flow in LFM

Interacting Functions	Flow Type	Code	Flexibility Market Design
Prosumer – LFA	Relationship	1R	Prosumers are part of an LEC because they are associated to the same LFA by an individual contract. Prosumers have no knowledge of one another and are free to choose the LFA that they prefer
Prosumer - LFA	Data	1D	Prosumer provides flexibility to the LFA
LFA – Prosumer	Marketing	1M	Advertising flexibility services and education of market
Prosumer - LEC	Relationship	2R	Individuals sign up to a collective of local householders in order to manage the flexibility commodity (sale & settlement thereof).
Prosumer - LEC	Data	2D	Individual Prosumers pool their combined flexibility into a marketable commodity unit
LEC - Prosumer	Marketing	2M	Advertising flexibility services and education of market
LEC-LFA	Data	3D	The LFA buys the flexibility unit
LEC-LFA	Relationship	3R	The agreement governs the use of flexibility and settlement
LFA- LEC	Marketing	3m	Advertising flexibility services and education of market
LFA - DSO	Data	4D	The LFA provides the flexibility unit to the DSO.
LFA - DSO	Relationship	4R	Flexibility Service Contract. The agreement governs the use of flexibility and settlement.
DSO - LFA	Settlement	4S	Buying Flexibility for congestion management, voltage control and grid losses reduction.
LFA - WMA	Data	5D	The LFA provides an internal portfolio optimization for the WMA and occurs when the LFA receives a request from the WMA for the provision of flexibility in aggregated form (as per classical centralised management of flexibility).
LFA - WMA	Relationship	5R	Contract will be in place which governs the use of flexibility and settlement.
WMA - LFA	Settlement	5S	Buying Flexibility to optimise its function (portfolio optimisation).
WMA- Supplier	Data	6D	Information exchange in order to forecast future portfolio consumption.
Supplier - WMA	Relationship	6R	Energy imbalance service contract.
WMA- Supplier	Settlement	6S	WMA pays compensation to the Supplier based on market-based pricing of flexibility.
Supplier-Prosumer	Energy	7E	Supplier sells energy to Prosumer
Prosumer – Supplier	Settlement	7S	The Supplier agrees commercial conditions with its customers for the supply and procurement of energy.
Supplier – Prosumer	Relationship	7R	Contractual relationship
Prosumer – Supplier	Data	7D	Consumption Data. When flexibility contract is activated with the LFA, the Prosumer should inform the Supplier.
Prosumer-DSO	Data	8D	There is a data flow from the Prosumer to the DSO. Data is used to calculate distribution charges.

As a business modelling methodology, Value Network Analysis (VNA) facilitated the visualization, analysis and insight into the business exchange flows and network relationships within the MPS (Ondrus, 2015). Figure 2 clearly shows that the LFM involves a complex networked web of stakeholder interactions to create value. Indeed, the multi-directional flows of energy and data evidenced in the value flow map clearly shows a more sophisticated marketplace and provide us with a contextual understanding of how a networked economy or multi-sided business platform could potentially materialize (Lynch et al., 2016c). As the LFA is serving multiple customers and facilitating the interactions those customers have with each other, the market model clearly matches any definition of a multi-sided business model that is bring together two or more distinct but interdependent groups of customers (Rochet and Tirole, 2003).

In general, the LFM provides a mechanism for providers and buyers of products and services to interact and co-create value that could not be created individually. For Lynch et al. (2016a) this is what makes the business model for the LFA multi-sided and complex in that it will be required to create, deliver, and capture value to multiple actors in the market. No current actor in the traditional model has a multi-sided nature to their business model so this will require the development of significantly different business model for whoever takes on the role of LFA. Revenue models within the MSP will be quite complex as the different trades along the value chain in the LFM are answered for and settled (Hagiu, 2014). The revenue flow will not only consist of funds as owed power for flexibility, reduced penalties, and other new forms of value capture enter into the business models of the actors in the LFM. There will also be multiple types of buyers and/or sellers and, in fact, a single party can be both a buyer and a seller. While customers are becoming more demanding, they also have much more to offer in return to power providers and other participants than just payment for energy consumed. Some of these new elements of reciprocal value are primarily operational in nature; demand response, load profile flexibility, and distributed power and storage allow for optimization of system performance and asset utilization. Others, such as information on energy consumption patterns, other consumer demographic and behavioural information, and access to personal connections/networks for marketing purposes, are the foundation for new revenue sources for companies able to effectively leverage the increased information and existing infrastructures.

Conclusions

Local flexibility is at the core of the emerging energy market model landscape. Although embryonic, complex and challenging, this new market landscape holds new business and collaboration opportunities for all stakeholders and is the focus of our ongoing research endeavors. The emergence of prosumer communities changes the roles of the consumers in the local grid from having an individual passive relationship to an active participant in the value chain. Indeed, for the first time, end users will be empowered to participate directly in the electricity market and with greater choice. Consequently, businesses will have to become far more attuned to the needs of the prosumer, design new value propositions to maintain and attract their business and utilize the collaboration potential of their value chain network to provide a more responsive and interactive service model. In this paper, we proposed a LFM that involved local energy communities and where a local flexibility aggregator facilitates flexibility management between supplier, distribution system operators, and consumers/prosumers. While it presents new opportunities for incumbent energy providers to collaborate and develop new products, this recharacterization of the industry business platform brings with it additional constraints and challenges. There are obvious constraints to prosumer participation in that the amount of savings possible is going to have to be greater than the cost of investment to enable participation. Another constraint concerns privacy issues particularly in relation to data ownership. A particular challenge of MSPs is that a critical mass of prosumers will be required to create the network effect whereby all the other business actors around the LFA will come on board, which is often referred to the chicken and egg problem. Indeed, in order to ignite the LFM, the LFA will have to devote much attention to designing innovative business strategies to get on-board as many early adopters as possible in order to drive this network effect.

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Aknowledgements

This research was supported by the project Mas²tering (www.mas2tering.com), which has received funding from the European Union's FP7 research and innovation programme under the grant agreement No 619682.

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