Beyond energy efficiency: A 'prosumer market' as an integrated platform for consumer engagement with the energy system

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Abstract

Future renewable, smart-grid and highly efficient low-carbon energy systems present many challenges to existing energy security policies and will thus require a paradigm shift in the way these policies are planned and structured. In particular, demand side management will necessarily play a greater role in future low carbon energy systems and this will see consumers providing various ancillary services to the grid including: demand reduction, demand response, energy storage and micro-generation. Essentially, consumers will become prosumers: consumers that provide various services to the system. This is in marked contrast to existing energy policies which are supply-biased and dominated by techno-economic considerations, and thus fail to effectively engage and integrate consumers into the system.

This paper explores this challenge from a consumer and socio-techno-economic perspective and focuses on the 'prosumer market' as an innovative balancing mechanism that can match supply and demand. It is envisaged as a platform, which enables users to engage with market-based energy prosumption strategies and incentivizes demand reduction. A prosumer market goes beyond targeting efficiency gains. It allows energy users the flexibility to choose which energy services they want to provide and thus diminishes risks for users. The increased flexibility opens opportunities for involving local communities, Energy Service Companies (ESCOs), and individuals in generating off-grid energy and off-grid energy services, which in turn grants households and communities greater freedom to select how and when to 'prosume'. A prosumer market, thus, acts as an enabling platform for creating and developing new and innovative markets and niches that are needed to prevent further technological lock-ins; this will be particularly necessary during the energy system transition period.

The paper outlines the 'prosumer market' concept. It situates it in the current policy landscape, discusses optional designs and structures, associated advantages and disadvantages, and highlights directions for further investigation.

Introduction

> The difficulty lies not so much in developing new ideas as in escaping from old ones.
>
> (Keynes 1935)

Decarbonizing the electricity generation and electrifying the energy system (e.g. heating and transport) is a likely path to low carbon economy and society (International Energy Agency 2014). A large share of renewable generation from intermittent energy sources in the low carbon electricity system implies changes to the traditional power system, which was designed for highly controllable supply to match a largely uncontrolled demand. In future systems, however, the supply side will become less predictable and less flexible while demand side will become more flexible (e.g., through the use of smart meters and "smart" appliances), yet more complex to predict and manage (e.g., new demand) (Hoggett, Eyre et al. 2013). Hence, more than currently, the functioning and security of the energy system in the future – i.e. its ability to provide adequate, reliable and affordable energy without harming the environment – will rely on greater engagement of consumers in the system, on capabilities to reduce overall demand and on effectively manage demand side. In addition, the consumer contribution to the low carbon electricity system will include a larger share of on-site micro-generation. Essentially, in future electricity systems energy efficiency as a mean to reduce overall demand would not be sufficient to balance the grid and the role of the consumers is likely to change from merely consumption to prosumption. Consumers will become prosumers i.e. consumers that also provide various ancillary services to the electricity system, including micro-generation, demand reduction, demand response, and energy storage.

Currently, however, consumer engagement in the energy system is low (in particular small and medium-sized consumers). That is because, thus far, demand side patterns of consumption have not presented major problems to suppliers and have not challenged the security of supply or the supply-focused and techno-economic biased electricity governance structure. As a result the opportunities and platforms offered to consumers to engage and participate in the system are still limited in scope, discrete for each service, uncommon and far from harnessing the benefits of demand-side integration. But with the introduction of smart grid technologies, new opportunities for demand-side integration emerge and challenge both supply-demand dichotomy and the balance of power between them.

In this paper I apply demand-side and service-provision perspectives to examine consumer engagement in the electricity system and highlight the 'prosumer market' as an integrated engagement platform for all prosumption services. The paper begins with a brief review of existing engagement policies and platforms that aim to deliver prosumption services: demand reduction, load shifting from peak hours to off-peak, increased storage capacity and micro-generation. It then reviews the literature on prosumer markets and highlights the barriers they face and the opportunities they offer as an integrated and action enabling engagement platform. The paper concludes by identifying further areas and issues to explore in order for a prosumer market to become a valid option.

Prosumption services and consumer engagement

DEMAND REDUCTION SERVICES VIA ENERGY EFFICIENCY

Energy efficiency has long been considered the preferred way to approach consumers and reduce demand. Policies to promote efficiency are common during and after energy crisis (Geller, Harrington et al. 2006). International Energy Agency (IEA) calculations shows that a watt reduced is not only cheaper but also cleaner than a watt produced and therefore refers to energy efficiency as 'the first fuel' (International Energy Agency 2014a). Others demonstrate that efficiency gains are good for the economy and the environment and argue that instead of building new power plants to meet the increasing electricity demand or invest in carbon capture and storage (CCS) facilities to mitigate climate change, we should invest in energy efficiency and 'build' distributed 'negawatt[1] power plants' (Cary and Benton 2012; Molina 2014).

1. 'Negawatt' is a term coined by Amory Lovins (1990) to describe saved watts (negative watts).

Energy efficiency improvements allow cost efficient and cost effective provision of the same (or better) energy services to consumers, with almost no need to change behavior and a relatively low level of consumer engagement. Energy efficiency policies are also politically 'safe', as they do not challenge existing governance structures or behavior patterns and do not call for any constraints on consumption. Indeed, many energy efficiency improvements are considered 'low hanging fruits': easy and cheap to achieve. While traditionally considered highly cost effective from economic perspective, Allcott and Greenstone (2012) argue that the size of profitable and unexploited investment opportunities in efficiency is actually much smaller than those suggested by many engineering-accounting studies. Others suggest that the huge demand reductions that could be delivered via efficiency improvements across various sectors have not been met thus far and are unlikely to be achieved in the current policy path (e.g. Cary and Benton 2012), and with existing consumer engagement platforms and incentive structures (e.g., 'green deal' in the UK: Rosenow and Eyre 2012).

In addition, efficiency gains may be smaller than expected due to the 'rebound effect': improved energy efficiency of consumers' electric appliances or infrastructures (e.g., homes) reduces the cost of the energy services and frees up resources that may be spent on greater use of that appliance (direct effect) or on other electricity consuming good and services (indirect effect). Indeed, often, there is a gap between engineering assessments of potential energy savings and actual measured savings after the energy-efficient technology or measure is adopted. Results from a detailed econometric analysis of historical energy efficiency rebound magnitudes in the US economy strongly suggest that energy consumption forecasts that ignore rebound effects will systematically and significantly understate energy consumption (Saunders 2013). It is hard and complex to measure the rebound effect of improved efficient or predict its size for many reasons, one of which is the difficulty in understanding and modeling consumer behavior (Azevedo 2014).

DEMAND REDUCTION SERVICES VIA FEEDBACK, SMART METER AND IN-HOME DISPLAY

Feedback to consumers to advise them on their electricity consumption is currently the most common consumer engagement platform. Feedback can be given at shorter or longer intervals, in various mediums, with several comparisons to others, and with different engagement messages. The feedback has the potential to narrow the direct and indirect rebound effect and encourage behavior change. Allcott (2011) evaluated the effectiveness of a series of programs in the US in which energy report letters were sent to residential consumers by utility, comparing their electricity use to that of their neighbors. Allcott found that the average program reduces energy consumption by 2 % and concluded that well-designed non-price intervention can substantially and cost effectively engage consumers and change their behavior, and be equivalent in its effect to a short-run electricity price increase of 11–20 %.

Compared to periodic report letters, in-home energy display (monitors) connected to the smart meter provide more frequent and accurate information on consumption and in some cases also provide information on cheaper/more expensive 'time of use' tariffs. Well informed consumers are presumed to have greater control over their energy use and apply rational economic behavior, leading them to save money and energy. Studies estimate that smart energy information display could realistically lead to electricity savings of about 3–5 % in the residential sector (McKerracher and Torriti 2013). The UK, for example, sees monitors as essential for delivering demand reductions and aims for all homes and small businesses to have smart meters by 2020 (installed by suppliers).

It is important to note that currently, in the vast majority of programs, consumers that save energy or consume electricity during off-peak hours save money and may receive positive encouragement from their supplier, but they do not gain any revenue for the services they provide to the grid.

In addition to overall demand reduction via efficiency gains and behavior change, other essential and important ingredients of the evolving low carbon and highly renewable electricity system are demand response, distributed energy storage and distributed generation. Rahimi and Ipakchi (2010) refer to these elements as distributed energy resources and call them 'virtual power plants' (VPP). Harnessing these resources requires consumer engagement that moves beyond efficiency.

LOAD MANAGEMENT SERVICES VIA DEMAND RESPONSE AND SMART APPLIANCES

Future smart grids will include extensive information and communication infrastructures. The introduction of smart meters within the smart grid opens new opportunities for consumer engagement via demand response (DR) programs, which are consumer-centered programs aiming to improve system efficiency and to acheive the best economic /operational / technical fit between supply and demand by influencing demand side. DR programs are considered cost effective and zero carbon balancing resouces for wind and solar generation. DR programs include activities designed to encourage consumers to change their electricity usage patterns, including 'time-of-use' and levels of electricity consumption, by means such as on-time accurate information provision, dynamic rates or pricing, remote control of devices, and others. DR resources are important elements for the reliable and economic operation of the transmission system and the wholesale market (Rahimi and Ipakchi 2010; Cappers, Mills et al. 2012). While DR programs often overlap with energy monitors and feedback programs mentioned above, the main difference relates to the predictability of consumption, the level of anticipated consumer engagement, and the poteintial of remotely control consumption.

Significant percentage of daily electricity consumption in the developed world arises from the usage of appliances that envisaged as becoming "smart" (e.g., water heater, air conditioners, cloth dryers, dish washers). "Smart" means that the energy demands are elastic and could tolerate delay (compared to other appliances that need to be powered at the same time they provide the service). From a consumer perspective, as long as the service provided by the smart appliance can be met within certain time limits, their welfare is not reduced and they should be satisfied. Smart appliances connected to the smart grid may include an option to be remotely controlled, therefore, theoretically, such appliances could be utilized by the grid manager to reduce or increase demand when needed (Yuanxiong, Miao et al. 2012). Technology is key in DR programs and many trials around the world have tested the feasibility of DR technology. Yet, consumer engagement is what likely can make such programs successful. Ownership of smart appliances as well as consent and willingness to allow a third party (or the energy utility) to intervene in daily household procedures would depend not only upon providing an appropriate and acceptable economic incentive (such as real-time pricing or subsidies) but also on privacy and health concerns, trust in the utility, and the social acceptability/desirability of the technology.

Currently demand response programs in the EU are limited with only 6 countries (Belgium, Great Britain, Finland, France, Ireland and Switzerland) reaching a level where demand response is a commercially viable product (Smart Energy Demand Coalition 2014). In the majority of the EU member states DR is either illegal or impossible due to regulations (Smart Energy Demand Coalition 2014).

Cappaers, Mills et al (2012) argue that future DR programs will require more frequent interactions of shorter duration, in other words – greater level of consumer engagement than the current demand response programs. Cappaers, Mills et al. (2012) also highlight the role of mass market customers as significant actors in demand response programs and conclude that market rules and regulatory policies need to change to expand the role of demand response. Mass market customers might be an aggregation of smaller customers.

LOAD MANAGEMENT SERVICES VIA ENERGY STORAGE

Energy storage technologies are another essential component to integrate renewable energies into the electricity system. Energy storage can smooth out the mismatch between electricity provision and consumption due to random power demand or uncertain energy supply. High penetration rates of the plug-in electric vehicle would open up the opportunity of using electric vehicle batteries for temporary electricity storage (Sandalow 2009; Heymans, Walker et al. 2014). A study that explored the feasibility and cost saving from repurposing the electric vehicle battery unit for peak-shifting found that residential energy storage could support the reduction of demand during typical peak use periods (Heymans, Walker et al. 2014).

Thermal energy storage (TES), too, has demonstrated capabilities to shift electrical loads from high-peak to off-peak hours (Arteconi, Hewitt et al. 2012). As Such TES could potentially become a powerful instrument in demand-side management programs. In particular, TES systems could help manage the mismatch between supply and demand in buildings where heat pumps and air conditioning deliver hot water, heating and cooling (e.g., the Belgium based project FLEXIPAC[2]).

Wide implementation and utilization of both technologies – electric vehicles and TES – requires not only changes to infrastructure and economic incentives but also, similarly to the case of "smart" appliances, consumers' willingness to share private property with the electricity network.

GENERATION SERVICES VIA MICRO-GENERATION

Micro-generation by consumers potentially increases the supply of low carbon electricity. In addition, micro-generation in distributed small and medium-scale systems saves transmission and distribution lost as well as costs (Pepermans, Driesen

2. http://www.flexipac.ulg.ac.be/

et al. 2005). Encouraging consumers to install various micro-generation technologies is usually done with attractive Feed in Tariffs (FiTs) which are replaced with other mechanisms once the technology becomes cheaper (e.g., Net metering). The FiT has promoted the development of this sector, but overall consumer uptake remains low, with the main barrier being capital costs (Balcombe, Rigby et al. 2013). However, research shows that motivation barriers for micro-generation installation go beyond cost and vary between segments of population and age (Balcombe, Rigby et al. 2013).

INNOVATIVE DEMAND SIDE TOOLS FOR DEMAND REDUCTION SERVICES

Innovative instruments are proposed to overcome barriers to consumer engagement in both demand reduction and demand response. Energy efficiency Feed in Tariff (EE FiT) have been proposed as a tool to promote energy efficiency (Bertoldi and Rezessy 2007; Benton 2011; Cary and Benton 2012; Xia and Thomas 2013). Essentially, EE FiT provides a revenue stream for projects that can demonstrate measured electricity savings on a per kWh basis, while support levels are determined the same way as they are for renewables and CCS, or could be determined, for example, by auction (Cary and Benton 2012). Comparison between three mechanisms to deliver demand reduction in the UK electricity market, namely a capacity market, supplier obligation and EE FiT highlights the advantages of the latter and suggests that EE FiT would deliver the greatest energy saving (Cary and Benton 2012). Eyre (2013) proposes an energy saving FiT (ES FiT) which provides direct and transparent incentives to energy users to save energy via efficiency but also via behavior change.

It is claimed that both EE FiT and ES FiT can be introduced as part of market reforms that can help unlock new sources of finance that either supplier obligation or a capacity mechanism cannot. Both instruments require further conceptual development and more thought on design and enforcement issues.

Prosumers markets: an integrated approach for prosumption

Market-based instruments are policy instruments that apply economic rationale and economic tools, such as markets, price, subsidies, taxes and others to incentivise desirable behaviour. Common market-based instruments offered to consumers include various energy efficiency incentives for demand reduction services, FiTs for micro-generation services and to a lesser extent, 'time of use' tariffs for load-shifting services. The use of a market place, where buyers and sellers are bidding for goods and services is applied most commonly for electricity on the supply side (e.g., 'capacity market', EU Emission Trading Scheme).

The idea of a market for services offered by consumers is not new. Twenty-five years ago, Lovins (1990) suggested an innovative way to approach demand side resources and foster efficiency gains through the creation of negawatt markets, which would treat saved electricity as a commodity (just like copper, wheat, and pork bellies). Negawatts – which are 'saved watts' – "would be subject to competitive bidding, arbitrage, and secondary markets. Some entrepreneurial utilities even want to become 'negawatt brokers' and create spot, future, and options markets in saved electricity" (Lovins 1990:22). Lovins argued that such markets provide 'win-win' solutions as they could be highly profitable, generate growth and tackle environmental problems, such as pollution, climate change, acid rain and urban smog. Eyre (Eyre 2013) points out that, currently, common market based instruments for energy efficiency (e.g. taxes and cap and trade) are provided to energy suppliers. These tools, he argues, are better for generating revenues for supply side than for engaging consumers and changing demand side behavior.

The concept of a prosumer marketplace was introduced more recently and presents innovative integrated approach for consumers and the various services they can provide to the new evolving distributed and highly renewable electricity system (e.g., Marqués, Serrano et al. 2010; Karnouskos, Serrano et al. 2011; Linnenberg, Wior et al. 2011; Rosen and Madlener 2014). With the development of the smart grid and new projects such as the iDEaS, and Flexipac that aim to explore issues associated with the decentralised control, operation and management of future generation electricity networks, a prosumer market seems to be more feasible.

Conceptually, prosumer markets are different from demand response programs because in the prosumer market the demand side not only passively reacts to price signals, but also actively offers services that the supply side has to bid for. Compared to existing supply-side markets a prosumer marketplace would be more complex because it is envisaged as a multi-agent system which includes not only different type of services, but also a wider variety of participants groups that fulfill different and changing roles and a large number of participants for each prosumption service.

Hvelplund (2006) suggests that a decentralized market that mirrors the nature of energy production and consumption should replace current centralized markets that mirror centralized production. In such decentralized markets consumers and producers could more easily trade directly with each other. Rosen and Madlener (2014), too argue that local markets are a necessary institution for managing highly distributed renewable generation. The literature on prosumer markets adopts the local geographical arena as the departing point

Studies on prosumer markets examine how markets could best manage virtual power plants (VPP) resources in the context of a microgrid which is either independent or connected to a larger grid. The main difference between the two is that independent microgrids cannot benefit from the same varieties of balancing mechanisms of larger grids and need to balance their own generation and consumption using VPP resources. In open microgrids, which can interchange as much electricity with a higher level grid, VPP resources could be utilized for generating revenues, as they can facilitate greater generation for export purposes only (Rosen and Madlener 2014). Each type of market presents opportunities to new actors and business models.

Today, in the internal electricity market, consumers are divided into balance groups: collection of metering points (representing consumers and producers) used to calculate the balance between supply and demand. Renewable energy resources are part of these balance groups but as it is harder to control renewable generation, balancing is more difficult and expensive. Most prosumers studies thus far examined the energy balance management problem from techno-economic point of view. In these studies the two most common ways to consider prosumers are as individual prosumer and/or prosumer-group. In this context, the NOBEL project (a Neighborhood Oriented

Brokerage ELectricity and monitoring system) aims to help network operators improve last mile energy distribution efficiency (Marqués, Serrano et al. 2010). The ultimate objective of NOBEL is to achieve higher energy efficiency and optimize its usage. Accordingly it suggests an energy brokerage system where individual energy prosumers can communicate their energy needs directly to both large-scale and small-scale energy producers, thereby making energy use more efficient. In this project two profiles of prosumers are considered: (a) a standard prosumer represented via a Brokerage Agent. This Agent should be able to dynamically monitor the amount of energy that he has produced, and the amount that is not yet consumed. This energy could be traded and made available to other users, thus improving the overall efficiency of the system. (b) A senior prosumer that requires additional internal processes to not only dynamically monitor but also control the energy produced or consumed in a largely distributed local area (senior prosumers could be for example sport centers, industrial parks, and shopping centers).

Linnenberg, Wior et al. (2011) apply market-based multi-agent-system approach for the control of decentralized power and grid. They argue that the evolving decentralized grid which includes small power plants calls for decentralized decision models, which allow for the coordination of large numbers of elements. The high number of small actors may better facilitate and tolerate failure in a single module of the system. Linnenberg, Wior et al. (2011) suggest that a marketplace with a high number of self-interested autonomous agents would be the best platform to achieve results that satisfy all agents. Accordingly, they tested a system that allows each generator and consumer to negotiate and trade its' surplus or missing energy in a virtual 'spot' marketplace. Test runs of their model (which does not include energy storage services), they argue, demonstrate the huge potential of this control strategy.

In their model Linnenberg, Wior et al. (2011) identify eight different agent types (detailed below) that can be classified into three different groups: (a) Agents that are indispensable for the trading process and are needed to impose the negotiated results onto the connected machinery; (b) Agents that take corrective measures when frequency deviation occurs; and (c) Auxiliary agents for organizational tasks (Linnenberg, Wior et al. 2011:2).

Group (a) includes the following agents: (1) Prosumers, which include every electric device that could serve as energy sink or sources and that is connected to the (2) home gateway, which pools all prosumers in one house and tries to balance their energy offers and needs. Home gateways can act as a buyer or seller in the (3) marketplace, which is the local central contact point for all local home gateways and the place where based on price, offers and requests are matched. In this marketplace, energy can be traded with multiple partners. (4) Ambassadors are place in between two marketplaces: low and high. An ambassador can buy and sell unsatisfied offers and requests in the local marketplace. Marketplaces should ideally be linked to the structure of the grid, and prefer proximate selling and buying. Likewise, low and high marketplaces should correspond to low- and high-voltage part of the grid.

Group (b) includes the following agents: (5) GridNode collects data from different sensor on the grid and send the information to the (6) Oracle, which gather information from the GridNodes and the local Marketplace, and advises the balancing agent on corrective measures. (7) Balancing Agent aims to stabilize the grid. Based on the Oracle's advice the balancing agent will buy from or sell to the local home gateways.

Group (c) includes one agent: (8) Bookkeeper these are the agents who receive all the transaction results from the marketplace and analyses them.

Karnouskos (2011) examines prosumer markets in the context of smart cities and neighborhoods and suggests that prosumer markets and smart grids may help to manage energy better and reduce its ecological footprint. Today, he argues, energy management in the 'smart environment' is done mostly at standalone mode, e.g., a smart building or smart home trying to optimize behavior internally to optimize energy use while the distribution system operator (DSO) is trying to predict and manage the energy on the smart city neighborhood. Currently, these efforts are disconnected from each other and do not cooperate. In future smart cities, neighborhoods will be more autonomous and thus able to manage more efficiently and dynamically their energy resources, taking into account local resources (e.g., smart buildings and homes), stakeholder needs as well as prosumption services. Smart infrastructures will facilitate dynamic interaction between various stakeholders which, supposedly, leads to optimal resource usage.

Karnouskos (2011) puts forward two trading pre-requirements: monitoring and control (management). To allow these, prosuming devices need to be coupled (to some level) with the market. He suggests three optional prosumers device interactions with the market: (1) prosuming devices which are directly and independently connected to the marketplace, (2) prosuming devices that are integrated to an energy management system, which able to manage difference devices according to the user goal, (3) group of users in community or organization that are large enough to be considered as Prosumer Virtual Power Plants (PVPP). The last option, which he sees as the most promising one, is contrary to common VPPs in which coordination of distributed generation is managed. Here, both distributed production and generation are managed towards community-wide goals set by the prosumers themselves. PVPPs should be able to monitor and manage prosumer infrastructure, therefore a layer that interacts with prosuming devices (option 1) and prosuming devices management system (option 2) is essential. The rise of such PVPPs communities that interact needs to be further explored (Karnouskos 2011).

Corn, Cerne et al. (2014) introduce a system based on markets rules, which activates willing-to-participate users of the distribution part of the electricity system. Users can offer to adapt their electricity consumption or production in return of financial benefits or incentives. The system can reject or accept offers on the basis of market principles (driven by the optimization method). Corn, Cerne et al. (2014) used market control algorithms to test such system operation and found that it improved the integration of renewable energy and enabled prosumers to profit from the services they offered.

Crosby (2014) applies the sharing economy thinking mode on prosumers market and suggests an 'Airbnb' model for the electricity grid. With few details to explain how it will actually work, this model proposes a peer-to-peer platform to empower electricity producers and consumers to directly sell and buy electricity. Crosby gives the example of the Netherland-based company Vandebron (https://vandebron.nl) that launched a platform to enable individuals to buy electricity directly from the local farmer with excess renewable electricity generation. While currently this model is limited to generation and consumption only, theoretically it could be extended to other prosumption services.

One of the greatest challenges to a prosumer market is in managing them. Recently, the concept of a Prosumer Community Group (PCG) has emerged as promising and effective ways to manage prosumers (Rathnayaka, Vidyasagar et al. 2012; Rathnayaka, Potdar et al. 2014; Rathnayaka, Potdar et al. 2014a; Rathnayaka, Potdar et al. 2015). According to Rathnayaka, Potdar et al. (2014a) one key challenge in developing sustainable PCGs is to assess the contribution made by individual prosumers of a PCG, and find a subset of the most influential prosumers whose behavior would facilitate the long-term sustainability of the PCG. The goal-oriented PCG groups together prosumers that have relatively similar energy behaviors and that are located in the same geographical area to allow energy sharing among the local members. Each PCG is associated with a prequalification criteria defined by the group, and a new prosumer that wishes to obtain membership needs to comply with them. The relations between members in the group are signed in a contract. The prosumers of a PCG can sell their unused energy to prosumers of same PCG, as defined in the contract, or auction off their collective surplus energy to the external energy buying customers (e.g., utility grid). The prosumers receive a standard tariff for the amount of shared energy and could be given bonuses if they exceed the expectations in their initial contract. Rathnayaka, Potdar et al. (2014a) propose an innovative methodology to assess and rank prosumers, in order to build an influential membership base. In their study Rathnayaka, Potdar et al. (2014a) have assessed and ranked the long-term and short-term energy behaviors of prosumers based on multiple evaluation criteria, where the higher ranked prosumers are considered more influential in enhancing the long-term sustenance of the PCG.

NEW ACTORS, NEW OPPORTUNITIES, NEW BUSINESS MODELS

Individual prosumers and prosumer groups present new type of stakeholders in the electricity market that may be driven by different motivations and perform new sets of behaviors than current stakeholders. As prosumer markets are envisaged to be primarily local (neighborhoods, communities) new opportunities and incentives for local organizations emerge. Geelen, Reinders et al. (2013) propose new design directions to encourage end-users to become prosumers, including enabling community-based facilitation and initiatives to stimulate local management of supply and demand. Theoretically, communities or local authorities could pool their prosumption resources to generate a revenue stream for the community benefit. Such business models for community benefit exist for renewable generation, where the FiT not only covers capital investment but is also directed to funding community goals. But while the high upfront costs of renewable generation technologies pose obstacles for installation in many communities, and with the continuous changes in the FiT model, prosumption services might present a new and cheaper way for communities to generate revenue.

Selling prosumption services could potentially encourage the development of social and technological innovations that substitute traditional and grid-supplied energy services. Likewise, opportunities are presented for the emergence of new arrangements that pull together local private and/or shared resources for the benefit of individuals or communities.

Energy services companies (ESCOs), too, may benefit from the new prosumer market. Timmerman (2014), for example, suggests a new innovative energy management service concept in order to assist prosumers: an Energy Services Shopping Mall. The Energy Services Shopping Mall offers various 'off-the-shelf' facilities for stakeholders in the prosumer value network, including services, tools and standard components that will help design, develop, exploit and use collection of energy management services. Mainstream products for prosumers include for example smart appliances, in-home displays, PV panels and products and services for energy savings. More specialist offers in this 'shopping mall' include consulting and energy advice, special offers for community projects, financial and legal counseling, as well as installation and maintenance services for complex projects and providers. Timmerman (2014) sees the main 'shoppers' as individual prosumers, prosumer communities, utilities and energy service providers.

UNCONSUMED ENERGY AS A SELLABLE COMMODITY

In most DR programs, consumers that provide prosumption services to the grid save money. Bidding and paying consumers (out of pocket) for demand side services provided to the energy system challenges the traditional relationship between consumer and supplier. In particular, the idea that consumers should be paid money for power they did not spend is somewhat problematic. Some municipality-owned utilities and cooperatives in the US, for example, have criticized the concept of negawatt power, arguing that it allows consumers to "treat electricity as a property right rather than a service [… giving them] legal entitlement to power [they] don't consume" (Landers 2001). So while it is relatively easy to meter and pay for micro-generation or energy storage services, and somewhat more complicated to pay for shift in 'time of use', the above critique highlights a fundamental problem inherent to energy saving services and more specifically to the energy saving market concept – how should we consider, measure and 'count' saved energy (see also Eyre 2013).

Chao (2010) argues that allowing consumers to sell energy that they do not own creates double payment benefits. That is because the consumer benefits from both the demand reduction payment and retail bill savings. Consequently, an excessive incentive is created for consumers to under-consume, even in times when abundant low-cost supplies are available to meet high-value demands. According to Chao (2010), in most cases consumers have the right to procure any amount of energy at a fixed and agreed on price. Consumers do not own the amount of energy until it is paid for and thus do not have the tradable property right to a specific amount of energy. If this problem is not appropriately addressed, he adds, "demand-response programs could become counterproductive and ultimately undermine the development of efficient price responsive demand. In other words, the cure may become worse than the disease" (Chao 2010:8).

A related problem is how to set the baseline demand and estimate the electricity that would have been consumed by a customer in the absence of a prosumption option. Put differently: what should be the measure that captures what the customer did not do, but would have done, had there not been a prosumption option (Smart Energy Demand Coalition 2014).

Research agenda for prosumer markets

Operational and techno-economic optimizations of the smart grid and prosumer markets are very complex and require advanced information and communication technologies plus high penetration of automation technologies at the consumer side. The prime objective of most smart grid projects is to examine technical and economic feasibilities. In many such economist- (but mostly) engineer-led projects users are reduced to a set of parameters that emulate their rational actions and this, in turn, is fed into the model. Yet, market design that ignores or diminishes behaviors and motivations of real users might fail to deliver its purpose. As the smart grid evolves and with growing penetration rates of smart meters, smart appliances, 'smart homes', as well as heat pumps and electric vehicles, new opportunities for demand side integration are presented, calling for a paradigm shift in the way policy instruments are designed and how users are accounted for. This paradigm shift should be accompanied with, and supported by a new and broader interdisciplinary research agenda that explores socio-techno-economic aspects such as the impact and implications of the smart grid and the new options it offers on behavior, society and governance (example for such research could be seen in Geelen, Reinders et al. 2013; Gaye and Wallenborn 2014).

Below I identify set of socio-techno-economic research areas and directions that could contribute to the further development of prosumer markets:

1. Regulatory issues – What would be the compatibility of prosumer markets with the existing and proposed policy landscape of energy and climate mitigation? And with local, regional and EU wide energy market framework? How, and against which benchmark negawatts (or unconsumed energy) should be measured, counted and accounted?
2. Design issues – Who are the most suitable target consumers to participate in the market? What would be the type and length of contracts and commitment? What would be the price setting mechanisms? What other supporting policies should be put in place (e.g., privacy, market transformation, climate, etc.)?
3. Prosumer behavior –What would motivate/discourage prosumers from participating in the market? Can participation happen with low level of engagement and with high level of automation only?
4. Implementation and enforcement issues – What should be the most appropriate and effective level of governance (national, regional, utility)? What mechanisms should be set for verification, supervision and enforcement?
5. Economic consideration and analysis – How various incentives would impact the market? How varying levels of participation impact the effectiveness of the market? Would the amount of power or energy that could be effectively reduced by an individual consumer or the value of ancillary services provided by consumer or consumers group would compensate the added costs incurred with devices and overall accrued complexity?
6. Business opportunities – What sort of innovation and business opportunities would be presented for various stakeholders (including, for example, energy utilities, energy providers, ESCOs, local communities, small and medium enterprises, public organizations and institutions such as schools, universities)?
7. Distributive impact – Is a prosumer market progressive? Who would be the most likely stakeholders to 'win' and 'lose' in a prosumer market?
8. Environmental impact – What impact would prosumer market have on emissions and on other environmental indicators?
9. *Public view* – What are the public perceptions and attitudes towards a prosumer market and participation in such market?

Summary and conclusion

Increasing the level of consumer engagement in low carbon electricity systems entails a paradigm shift in the way consumers are encouraged by regulators, suppliers and utilities to engage in the system and requires the adoption of socio-techno-economic approaches to engagement. Transforming consumers into active prosumers may maximize the economic, operational and environmental benefits from services such as micro-generation, demand reduction, demand response and energy storage. Various variables and policies would influence the attractiveness and likelihood of consumers becoming prosumers. These include, for example, the introduction pace of new communication technologies (e.g. smart meters), and the interface between the technology and users (e.g., energy display, smart appliances); rates of technology adoption (e.g., storage) and implementation of cost efficient energy saving measures (e.g., efficient appliances, building insulation); as well as willingness to change behavior (e.g., changing time-of-use) and public support in new policies (e.g. willingness to accept and participate in the energy system).

Prosumer markets act as a platform that transforms users from being passive consumers to active participants in the power sector by being paid for services in the same way producers are paid. From a demand side perspective, the market will allow prosumers the flexibility to choose which energy services they want to reduce, which they want to resume and which prosumption services they want to offer. This voluntary behavioral choice clearly diminishes the risks associated with engaging with prosumption. The increased flexibility opens opportunities for involving local communities, Energy Service Companies (ESCOs), and individuals in generating off-grid energy and off-grid energy services, which in turn grants households greater freedom to select how and when to "generate" prosumption services.

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