# Energy Product Service Systems as core element of energy transition in the household sector: The Greenplay project

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## Abstract

This paper focuses on Business Model innovation practices within the specific field of energy transition in the household sector. In recent years the value chain between the stakeholders involved in this field has been modified due to recent technological changes, which poses a threat for current companies and an opportunity for insiders. This research work has been carried out within the Greenplay project, which is an EU funded Horizon H2020 project. This project aims to develop new business models that reduce energy consumption in the household sector and can be successfully implemented. In this paper, we present a framework based on intersection of two group of categories. The first one is issued from energy transition presented by consumer behaviour, energy efficiency and renewable energy and the second is abstracted from Product-Service System (PSS). The methodology is based on defining the characteristics of a Product Service System in general followed by Smart PSS (integrated smart product and e-service) qualities and the current ESCo (Energy Service Company) business model characteristics. Finally based on aforementioned analysis on energy transition and Product-Service System, we discuss a set of Servicizing energy business models for energy transition in household sector. The main objective is to shed light on the ability of designing new business models (BMs), in household sector, as a result of integrating PSS with the emerging trends for sustainable energy. In this study, a systematic literature review is conducted related to energy business models. Furthermore, the proposed framework is a crossing classification based on criteria concerning PSS and various energy production and consumption BM. Finally the characteristics of an innovative business model for energy transition in household sector can be transposed to other sectors, mainly those who deal with Product Service System. In the second phase of the Greenplay project the authors will apply the proposed framework to the use cases identified in the project: households that are able to fine-tune their energy use thanks to smart meters that provide free access to data in real-time. The goal is to get feedback from researchers that have already implement innovative Business Models in this or other sector, as well as to discuss with researchers and practitioners that have analysed firms that have successfully innovated their business models. This feedback will allow us to adjust the framework before the experiment with the companies of the Greenplay project.

**Keywords:** Product-Service System, Energy, Business models, Households, Energy transition

## 1. Introduction

In the midst of the critical changes such as climate change, unstable oil prices, energy security and the rapid changes in energy technologies (Awerbuch, 2006; Kilian, 2006; Manabe and Wetherald, 1980; Popp et al., 2011) a more sustainable use of energy through renewable energy and energy efficiency is expected to play a crucial role. The business model of centralised energy production utility is questionable nowadays. Recently the “utilities spiral death” (Costello and Hemphill, 2014; Felder and Athawale, 2014) which is the reduction of utility revenues due to the decreasing of consumer numbers, was addressed since the market

share of utilities has shrunk, while new insiders have appeared in the energy market mainly due to the rise of the distributed generation (DG) (Costello and Hemphill, 2014; Felder and Athawale, 2014). Recent studies indicate that electric utilities in the U.S consider that issues like energy storage, energy efficiency, utility-side renewable, response demand and distributed solar installations are key elements to be considered by utilities in order to keep the current electricity market share (Norbert, 2015; Utility Dive, 2015). In this context, the role of the consumers might be a key element for the future electricity system transition as the participation of the customer in the production (Engelken et al., 2016), the load management (Laicane et al., 2015) and energy efficiency (Caird et al., 2008) is increasing each year (Morris and Pehnt, 2012; Utility DIVE, n.d.).

New value propositions for the energy sector might be based on providing new services in this context. Indeed, Product Service Systems (PSS) have been discussed as sustainable alternatives of selling a product as it offers the possibility of decoupling consumption from the used product (Heiskanen and Jalas, 2003). Servicizing, which is about selling functionality instead of product, starts to emerge in the markets (Plepys et al., 2015) despite that, little academic work has handled the servicizing process of utilities business model (Hannon et al., 2013; Helms, 2016). Furthermore, integrating product and service, in order to create and deliver new value, usually causes less environmental impact (Baines et al., 2007).Providing energy as a service towards sustainability has been addressed in industrial, commercial and public sector as the "economies of scale" is more prominent (Irrek et al., 2013). Yet, few academic works have investigated energy services in the household sector.

The objectives of this paper is an attempt to link product-service system with energy consumption in household sector by identifying the potential business models (BMs) that could be used to reduce household consumption. The paper is structured as follows. Section 2 reviews the main characteristics of the new transformation in the energy sector. Besides, this section introduces the PSS concept. Section 3 introduces a framework based on a PSS classification and three energy transition criteria: consumer's behaviour, efficiency and renewable energy. This framework is used to classify the review of the literature about the energy transition. Section 4 introduces the case study of the Greenplay European project and poses the scope and the research questions of the PhD work of the main author. Finally section 5 draws the conclusions.

## 2. Methods:

Our approach to define new business models in the given context is summarized as follows:

- Determine the emerging business models in three energy transition areas which are inspired by French initiative for energy transition Négawatt ("The négaWatt energy scenario," n.d.).
- Presenting Product-Service System and defining its three categories.
- Allocating and mapping the different energy business models into two axes' framework. The first one is the energy transition areas and the second is the PSS categories.

## 3. The energy transition and PSS concept:

### 3.1 Characteristics of the energy transition:

The traditional electricity value chains are represented by production, distribution, and consumption subdivisions. This paper analyses the different perspectives of Servicizing energy's BM along this value chain in the PSS framework by analysing the articles that tackled energy business models.

Recently, the rapid changes in technologies related to energy efficiency, energy storage and renewable technologies have tackled the "business as usual" practice of traditional electricity utilities (Norbert, 2015). With the new paradigm proposed by the "Smart Grid", the producer of renewable energy has become the consumer itself, or a supplier for local consumers. The

active role of the consumer makes the energy issue become more dynamic, evolving from a one direction flow to a two directions flow between utilities and consumers. For utilities, mitigating the risk behind energy demand reduction requires changing its traditional BM (Utility Dive, 2015). For the new entrants, servicizing may hold the market opportunity that enables them to put a feet in the market.

Different approaches are emerging that facilitate energy transition. Top down forces like regulations have put pressure on the utilities and have facilitated the emergence of Energy Service Companies ESCos (Hannon et al., 2015). In other cases, utilities have found a new market opportunity. This is the case for example of the two major energy utilities in Hawaii who were driven to innovate and overcome landlord and tenant split incentive to implement energy efficiency and renewable programs for households (Johnson et al., 2012). Bottom up approaches have also been considered as a key actors in the energy transition; as an example the number of energy cooperatives in Germany have raised from 136 utilities in 2008 to 888 in 2013 (Morris and Pehnt, 2012*)*. Since the industrial revolution, five transformational technologies have deeply reformed the energy sector: water-powered machine, steam power, electrification, combustion engine and computerization (Hargroves and Smith, 2005). The new energy transition is considered by some authors as the sixth innovation wave platform (Nair and Paulose, 2014).

Some academic papers have discussed that servicizing energy BM towards cleaner and more efficient usage of energy, could structure the new BM for current utilities and new entrants (Hannon et al., 2013; Helms, 2016; Norbert, 2015; Richter, 2013, 2012; Shomali and Pinkse, 2016). Servicizing energy's BMs has different approaches, (1) it can refer to providing technological devices and associated services for energy efficiency or for micro generation. In this case there is a reduction of energy consumption or the generation of renewable energy. Or (2) can refer to the Demand Side Management (DSM) towards the optimization of the energy use. In this case, beyond the technological aspects, a consumer behaviour modification is explored. The result can be a reduction of the energy consumption or the modification of this consumption: in some cases the consumed energy amount can be constant but the time window of the consuming period may vary.

### 3.1 Product Service Systems

The Product-Service System (PSS) concept emerged in 1999 (Goedkoop, Van Halen, Te Riele, & Rommens, 1999). Mont et al. define PSS as "a system of product, services, supporting networks and infrastructure that is designed to be competitive, satisfy customer needs and have a lower environmental impact than traditional business models" (Mont, 2002).

In general PSS has been classified in three major categories (Tukker and Tischner, 2006a):

- Product-oriented: the provider selling the product with additional services.
- Use-oriented: the provider keep the ownership of the product and sell the availability or use.
- Result-oriented: the provider guarantee specific result to satisfy consumer need.

In general, the PSS goes beyond the physical product and provides a solution to a function or to the final need of the consumer. It combines the physical product with intangible services (Heiskanen and Jalas, 2003). Thus the value behind PSS is providing functionality which allows the provider to have the necessary freedom and a wide spectrum of variation of PSS in a single value that makes the PSS more flexible and capable to tackle the possible changes in the market, consumer's trends and stakeholders' expectations. Flexibility is essential for implementing successful PSS that brings out higher revenue (Rese and Gesing, 2013). PSS can bring together sustainability and competitiveness (Baines et al., 2007; Tukker and Tischner, 2006b). integrating service with product has the potential to decouple the materials from consumption that assigns to the motion from material product to immaterial service which, in its turn, will push companies to reduce cost through increasing energy efficiency and reducing the used material (Heiskanen and Jalas, 2003; Peruzzini and Germani, 2013).

The contextual factors (existing organization, institutions and networks that share practices, rules and interests) that control the value chain hinder obtaining the desired changes, so that a broader system approach is required rather than business-consumer approach (Tukker & Tischner 2006). (Ceschin, 2013) stressed that there is a need for companies to Focus on the contextual conditions that may facilitate or hamper the societal embeding of the PSS. Furthermore, the value in PSS is more related to the components in the context which includes not just the delivered product but also the ad-on service and the associated activities with consumers rather than the components themselves (Wallin et al., 2013).

In general the relationship between the consumer and suppler in the traditional selling process, is terminated after selling the product, while in PSS it is extended with major focus on usage phase to guarantee the desired results. Thus, more trust is required when dealing with PSS, indeed, a clear understanding of consumer expectations, his/her capability to deal with new technologies and division of responsibilities should be addressed (Di Francisco Kurak et al., 2013).

## 4. PSS in the energy sector

### 4.1 Criteria for energy PSS classification:

The major reason behind changing the energy production and consumption patterns is the need for more sustainable and cleaner source of energy. Many academic papers have focused on renewables, energy efficiency and distributed energy. In the same line, PSS has been considered a way of delivering value with less environmental impact by decoupling material and energy from consumption.

Conflict of interest between current regulatory policies which push towards reduce end-user consumption and the current BM of utility which profits from the amount of sold energy (Sousa et al., 2013). So that decoupling utility revenue from energy consumption would encourage utilities to participate more in energy efficiency, renewable energy technologies and demand side management. This split of utility revenue from consumption could be done by delivering more services than product.

Energy transition characterised by three aspects: changing the consumer behaviour, integrating new technologies for energy efficiency and developing renewable energies. (“The négaWatt energy scenario,” n.d.).

Changing consumers’ behaviour can be fostered by two different perspectives. On one hand the reduction of the energy consumption can be stimulated by modifying the way the consumers performs the actions to obtain a function. On the other hand, the consumer might be induced to modify the periods of energy consumption, for example from day time to night period in order to balance the electrical load management.

Changing the rooted patterns of energy consumption can occur through different incentives. It can be voluntary behaviour change through information and knowledge, or could be obtained by changing the contextual factors (e.g. energy prices) (Abrahamse et al., 2005). (Laicane et al., 2015) have showed a significant amount of peak reduction that has been obtained by altering consumers behaviour through useful information and feedback about their consumption obtained by smart meters.

Energy efficiency has contributed effectively to reduce CO2 emissions by 10.2 billion tonnes of CO2 since 1990 (International Energy Agency, 2015). It strengthens the energy security and aids in flattening the consumption load curve. It is a way of managing and limiting energy growth consumption (IEA, n.d.). Integrating new technologies for energy efficiency means delivering the same services by less energy or more services by using the same energy. Common examples include replacing incandescent bulb by LEDs that uses less energy and produces the same amount of light.

Finally, renewable energy has been considered a more sustainable source of energy that enables energy security due to its diversity. Its increasing share is expected to change the energy sector structure (Boston Consulting Group, 2010). A new trend for energy utility is expected to be developed which could be decentralized and small-size (Alanne and Saari, 2006). The role of energy utilities and how they could exploit RE technologies is not yet clear (Richter, 2012).

In the next section, new product-service systems in the energy sector will be described and classified following two criteria. On one hand the category of PSS regarding the servicitation level (product-oriented, use-oriented or result-oriented). On the other hand associating the PSS to a consumer behaviour modification, to a technology for energy efficiency or to a renewable energy.

### 4.2 A review of new Product-Service Systems for the energy transition

In this section, we classify the business models that aim to change consumer behaviour, and then we indicate the PSS category in these BMs. Many strategies can lead to change the consumer behaviour: "antecedent strategies" (e.g. commitment, target setting, information), "consequence strategies" (e.g. feedback, incentives and rewards) (Abrahamse et al., 2005). However, we will focus on models that can be included into the PSS framework the results are proposed in the Table 1 hereafter.

**Table 1**. The intersection between energy transition criteria and PSS categories

| **Energy transition criteria** | **PSS Classification** | | |
|---|---|---|---|
| | **Product-oriented** | **Use-oriented** | **Result-oriented** |
| Changing consumer Behaviour | (Valencia et al., 2015), (Laicane et al., 2015), (Behrangrad, 2015), (Bell et al., 2011) | (Behrangrad, 2015) | (Knol and De Vries, 2011) |
| Efficiency | (Bell et al., 2011), (Kobus et al., 2015), (Bertoldi and Rezessy, 2008) | (Sorrell, 2005), (Bertoldi et al., 2006) | (Sorrell, 2005), (Bertoldi et al., 2006), (Apajalahti et al., 2015) |
| Renewable energy | (Richter, 2012), (Gsodam et al., 2015) | (Richter, 2012), (Gsodam et al., 2015), (Liu et al., 2014) | (Kroposki et al., 2008), (Schoettl and Lehmann-Ortega, 2011) |

Previous works (Laicane et al., 2015) indicates that smart meters provide useful information about appliance's consumption in households, and can lead to significant changes in load consumption, thus the load peak could be avoided. In the line with smart meters, the integration of smart product with e-service has been introduced as Smart Product-service System. An example about Smart PSS for energy efficiency is Wattcher (www.wattcher.nl) which is a sensor measures and displays energy consumption and enables consumers, through a web portal, to communicate and compare energy consumption (Valencia et al., 2015). We can describe these business models as Product-oriented PSS as these meters should be

supported by other services like data process and supplemental services like comparing consumption with others as mentioned before.

Gamification is powerful way to educate people and influence the energy consumption. EnerCities is serious game that has some preliminary results that led to increase user awareness and more positive attitude towards some every-day energy related behaviours. Gamification for energy transition can be classified as result-oriented PSS as the game is more than the tangible product and the intangible information (Knol and De Vries, 2011).

On-bill financing is an innovative financing method that allows consumers to overcome up-front payment of implementing energy efficiency measures by providing the necessary loan and dividing it to small monthly payments that are cut from the amount of monthly bill savings. On-bill financing can lead to win-win situation and permits the energy companies to diffuse efficiency measures and renewable energy technologies (Johnson et al., 2012). this solution is a financial product served by utility which is coupled with energy efficiency services that lead to energy efficient improvements (Bell et al., 2011). Thus it could be classified as product-oriented PSS. Similarly White Certificate has been considered as a market mechanism for stimulating energy efficiency actions, it confirms that an specific amount of energy savings have been achieved by market actor as a results of energy efficiency improvement measures (Bertoldi and Rezessy, 2008). White certificates are tradable in the market, so that it is considered as a cost recovery mechanism. An positive relationship between providing energy services and white certificate in France has been noticed and tested (Duplessis et al., 2012). Thus White Certificate can be classified: a financial service for the user who can acquire a new energy efficient equipment.

Demand Side Management (DSM) has been introduced as a way of flatten the load curve of consumption, Two main services have become the major elements of the DSM (Behrangrad, 2015) Energy efficiency and Demand response (DS). The former is a model for incentivize customer to change their consumption pattern in order to reduce the electricity consumption. The former is a model for incentivize customer to change their consumption pattern in order to reduce the peak of the consumption in the load curve. “Business model involving load” includes both price incentives and consumption awareness that consumer needs in order to reduce the electricity cost of the load. This BM offers infrastructure to the consumer to receive price information at a suitable time and format. In other words it is about selling infrastructure, visualization devices and software (Behrangrad, 2015). This BM could be product-oriented PSS, when selling the infrastructure with the supporting software services or could be use-oriented PSS when the infrastructure is rented.

Energy Service Company (ESCo) is defined as “*a company that offers energy services which should include implementing energy efficiency projects (and other sustainable energy projects)”* (Bertodli et al., 2014). (Sorrel, 2005) has introduced two concepts “useful energy” and “final energy service” based on the analysis of ESCos activities. The idea behind “Useful energy” is to implement more efficient form of energy generation like Combined Heat and Power (CHP) so that the output is hot water, coolant or heat. The consumer will be charged by the unit of useful energy. That will make lower cost for consumer and enable ESCo from profiting from energy savings. The useful energy is a use-oriented PSS as it is obtained by primary conversion tool (e.g. CHP) (Sorrell, 2005).

Final energy service is about guaranteeing a specific results like room temperature or degree of lighting by conversion, control and distribution of the necessary technologies. That can be categorized as result-oriented PSS as the stream of services (lighting, heating) is obtained by secondary conversion tool (e.g. radiator or fluorescent) and can be consumed directly by the consumer (Sorrell, 2005).

(Bertoldi et al., 2006) presents Mini-ESCos as a business model that can propose energy efficiency measures to households as alternative for ESCo. Mini-ESCo could be the small

facilities that used to provide maintenances and breakdown repair for households. Many reasons are behind this proposal, the lack of awareness of ESCo business, the cost comparing with savings (Pätäri et al., 2016). In addition, there is a the lack of trust towards large energy utilities (Holt and Wiser, 2007; Richter, 2012) and scepticism about the real motivation for utility to engage in households energy efficiency (Apajalahti et al., 2015). Households can shift their energy consumption to period when there is abundant of electricity that generated by solar panels by using smart appliances that can schedule their working hours to fit with weather and the sunny days (Kobus et al., 2015). This business model depends on efficient technologies and supporting services such energy management system and energy prices changes and it can be use-oriented PSS or product-oriented depending on the ownership.

Finally, some papers have tackled the energy transition and analyse the business model where the value can be shifted from selling energy as commodity to selling services. (Apajalahti et al., 2015) suggests that " energy service-based business solution" such as light and heat can be an alternative model that grasps the efficiency benefits.

Among of the three different renewable energy BMs; lowest price, best technology and customer intimacy, the Investors prefer to select "customer intimacy" business model which is a service-dominated and service-centralised BM rather than an upstream production-dominated BM (Loock, 2012). The services attached to customer-side renewables may range from simple consulting services to a full services package including financing, ownership, operation and maintenance of the assets (Gsodam et al., 2015; Richter, 2012). Between purchasing and leasing of solar photovoltaic cell micro-generation, the leasing has become more popular option as the supporting service like regularly scheduled maintenances are often handled by the lessor. In addition, this kind of BM avoiding the up-front cost (Liu et al., 2014). "1st Generation PV business models" are more attractive BMs that overcome the market barriers and reach broader markets. The model is driven by third party rather than utility and own the PV systems, thus it reduces hassle and complexity for the consumer (Kroposki et al., 2008). While the ownership is linked to third party who controls the whole system, This BM is rather results-oriented PSS. Another result-oriented BM "Turnkey project provider" which is a more pure service BM. Consumer doesn't own the PV and doesn't want to be bothered by selecting and installing the PV. They just want reliable sources of energy, competitive prices and assurance of rapid-response service and supporting maintenance (Schoettl and Lehmann-Ortega, 2011).

Also utility may move from selling a commodity to providing energy services (Helms, 2016; Richter, 2013) and change their business model (Loock, 2012). Changing utility BM is confronted with many obstacles such as managing intangible assets like services, the lack of demand and willingness to pay for innovative services and the difficulty associated with simultaneously managing utility and service business (Helms, 2016). The "conflicting institutional demands" are sending confusing signals to utilities and consumer similarly (Apajalahti et al., 2015). Moreover, there is the lack of understanding of the importance of changing the business model in order to successfully exploit the new technologies "cognitive barriers to business model innovation". Also the inability to allocate resources to new technologies or developing new BM for these technologies (Richter, 2013).

## 5. Discussion

This research work is developed in the framework of a European Union's Horizon 2020 project called GreenPlay. This project seeks to reduce by 30% the electricity consumption in the household sector and will be validated through a large scale experiment based on 200 households situated in France and Spain.

The Greenplay system is composed by sensors, a smart monitoring platform and a game. The sensors installed at the user's home measure global electricity, heating, water heating and temperature. The sensors are linked to GreenPlay system. The core of this system is a

pervasive game i.e. eco-gestures in real life and thus electricity consumption reduction allows to earn points and evolve in the game.
The system allows to monitor real behaviour and possible long-term changes in the context of the participation of the customer in the load management (Apajalahti et al., 2015) and energy efficiency (Helms, 2016).

The use of game principles or "gamification" is an efficient tool to deal with behavioural modifications (Nieuwdrop, 2007), (Germaud, 2013).

(ABI AKLE et al., 2016) have identified nine projects working on pervasive and persuasive gaming for energy conservation.

The main research objective of the Greenplay project is to study the potential of combining game elements and instructional advices for modifying energy consumption. The combination of these two elements within a serious games offers some possibilities to encourage the immersion in context, the empowerment and the learning appetence of users.

Through this approach, the system identifies the use of energy and users' behavior in the private sphere. This information can be used to identify decision variable for product design processes (building, home appliances, etc.), as well as an input for the development of innovative business models that rely the product and services associated to the building ecosystem.

Greenplay is a User-centred project. Consumer is more literate than before and there is emerging tendency to surpass price issue in order to consume green energy. The digital technology offers momentary channels of two side interactions which enable personalize energy experience and determine the specific needs of consumers, and gathering feedback and suggestion from consumers. Furthermore, automation of appliances and integrating energy with different household's products and services would encourage consumer to engage and go further to become prosumer selling and buying energy.

All the consumer characteristics that mentioned above are confronted with the traditional business model of energy utilities which is still confined to the one way flow of power and information, dependency on economies of scale as cost structure, weak and broken relationship with consumers and reliance on fossil fuel as unlimited and inexpensive source of power.

Between the two ends, consumer expectations and utilities perspectives, the paper puts spotlight on PSS as a new business model that can match the two ends for more sustainable energy value chain. Thus, some supporting emerging concepts based on PSS framework are presented which support this hypothesis.

Channing consumer behaviour can be reached through PSS by offering real time devices (meters, sensors, etc.) coupled with supporting services (communication, sharing, advices etc.) that help consumer to change their aptitudes, become more active and reduce their energy consumption.

In the same line, these infrastructure and services can be used for avoiding the peak load of household electricity, by use-oriented or product-oriented PSS business models depending on the ownership.
This paper could be considered as the cornerstone of the PhD launched within the Greenplay project which aims to define energy business models that respond to the changes in the energy value chain. It poses questions related to the degree of sercivizing, interested stakeholders, user expectations, capability of utilities to take major role, possibility of new players as facilitators. In addition, it tackles the role of incentives factors and barriers such as dynamic prices and hampering factors like regulations and lack of trust of utilities. It addresses the issues related to up-front cost and the role of citizens and cooperatives.

## 6. Conclusions

We notice that there are emerging trends to servicizing energy utility's BM and to design BM for new entrants of energy markets. So that, we discussed the ability of PSS to embrace the upcoming changes in the energy system. Furthermore, based on academic review we point out to few BMs that underpin our proposal and map them according to their PSS categories (product-oriented, use-oriented and result-oriented) and their energy transition type (consumer behavior, efficiency and renewable energy). The new technological advancement, the literate consumer and tendency towards green energy, would bring out new form of product and services that need new PSS business model.

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