Design of Energy-Management Services – Supporting the Role of the Prosumer in the Energy Market

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Abstract. This paper describes the PhD project on service design in the energy market. More and more households invest in home energy generation facilities like solar panels. The generated energy can be used for their own energy demand, but delivery to the central energy network or other consumers is also possible. Households become producers, thus creating a new role in the energy value network. Energy-producing consumers (*prosumers*) need to be supported in order to become a serious actor. This research focuses on the development of an approach for designing energy-management services to support the role of prosumers. The result will be a suite of guidelines, tools and methods that can be used in the service design process.

Keywords: service design process, service design methodology, service development.

1 Introduction

The energy business is in a state of change. The energy market is one of the last industries that transforms from analogue to digital. Environmental, political, and technological developments ask for a radical change: the energy infrastructure has to be transformed into an active network, with intelligent components and advanced communication facilities. This change will give rise to the development of new business concepts and the coming into existence of new services.

The inclusion of renewable energy sources and decentral energy generation are important issues. Households generate their own energy with their home installation (e.g. solar power, µCHP, heat pump), becoming both consumer and producer, thus playing a new role in the energy market place. This role is still rather limited, but in time this role will evolve into a more grown-up energy player in the energy value network. How this role will evolve and how energy-producing consumers (so called *prosumers*) can be supported by services, is the subject of the research described in this article.

2. Decentral Generation and the Role of the Prosumer

Decentral generation and inclusion of renewables will become more and more important in the future energy market, as it will contribute to the sustainability of the energy market place. Decentral generation, and consumption close to the source of generation, can contribute to more efficient energy usage. Households are stimulated by government to invest in sustainable energy by providing subsidies on installing generation facilities and on guaranteeing feed back tariffs on "home-generated energy", thus providing security on return on investments. Surplus of generated energy is delivered to the traditional energy supplier, and payment is settled by letting the meter run backwards. This makes that the consumer is both on the demand and the supply side. Today the role of the energy-producing consumer in the energy value network is new and rather limited in scale and importance. Large-scale deployment of prosumers is foreseen, but still many barriers have to be broken down. How can the energy-producing consumer play a role in the energy value network, where large companies play a dominant role?

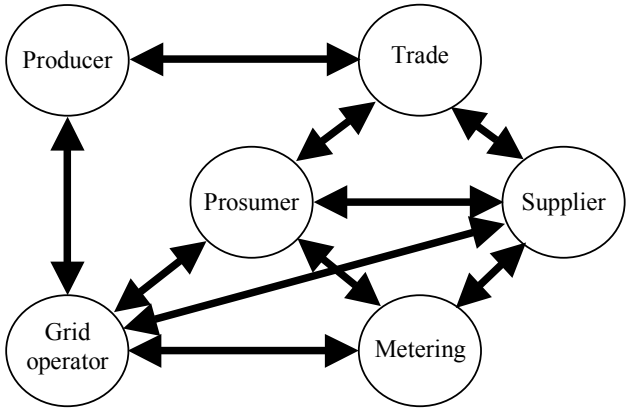

Fig 1: The prosumer, operating in a complex value network

The prosumer needs to be supported to play a role in the energy market. He is one of the actors in a complex value network, as is shown in figure 1. He wants to be in control of his own energy and he wants to decide whether or not he wants to deliver, to whom and when, and at what price. Intelligent energy-management services are needed that support him in his role of prosumer. These services need to be designed and developed. There are many uncertainties in this service design process with respect to demand and value, fast technology developments (e.g. smart energy grids, smart metering [22]), as well as regulatory aspects. The services have to be developed in a complex environment of continuous changing services and market circumstances, with multiple stake holders involved. The challenge is to develop services in these complex value networks that create value for both the prosumer and the other actors

involved. The objective of this research is to develop and validate an approach for designing energy-management services to support the role of the prosumer.

3 Service Design Theory

Extensive research has been conducted on product design and product development. With the emergence of internet in the 1990's, services became more and more important, and also academics defined research into the area of service design and service development. This section describes some important work in the field of service design processes and service design methodologies, which will be used as a reference point for this PhD study.

Technological developments, afforded by ICT, as well as globalization, put pressure on companies to compete on new service offerings [3]. Offering new services is beneficial because: (1) it enhances the profitability of existing offerings, (2) it attracts new customers, (3) it improves the loyalty of existing customers, and (4) it opens markets of new opportunities.

Offering new services is a competitive issue. Menor [3] recognizes the need to consider both the newness of the service offering (what service is offered?) and the service concept (how the service is offered?). He defines a new service as an offering not previously available to a firm's customers, resulting from the addition of a service offering, or changes in the service concept that allow for the service offering to be made available. The distinctions of what constitutes a new service are meaningful, both to strategic planners determining the appropriate mix of services in the portfolio they offer, and in terms of understanding how the customer—or the marketplace—perceives the new service.

For developing new services the service development process is a critical factor for success or failure. Therefore it is crucial to adopt a good service design process. Many studies have been conducted into service design and service development processes [4, 5, 6]. Johne et al. [14] provide an extensive review of literature on New Service Development (NSD). Johnson et al. [15] give an evaluation of the NSD process from the perspective of integrating service design and service innovation. De Jong et al. [17] classify literature on organising NSD into two evolutionary stages: managing key activities in the NSD process, and creating a climate for continuous innovation.

Important work in service process design is performed by G. Lynn Shostack. In [13] he presents the service blueprinting methodology, a graphical technique for documenting processes that displays process functions above and below the line of visibility to the customer. The graphical display of the processes provides insight into potential failure points in the service offering. Furthermore, each activity in the process is assigned with a cost and time parameter, so that the total cost and profitability of the total process can be derived.

A service design process is multi-dimensional: requirements from the various stake holders in the value network, each with their own discipline, should be considered. Normann and Ramirez [18] state that product and service innovation constantly needs

to be mapped onto customer requirements and customer satisfaction. They call it a *co-production of value:* innovation needs to be performed in partnership with customers and its suppliers in a flexible and mutual dependent way. Ramaswamy [9] states that a *total design approach* is needed. This implicates that both technical-engineering functions, as well as customer-focused requirements, must be taken into account. Focus should be kept on the customer throughout the design process, in order to satisfy, excite, or delight customers' expectations. Meyer Goldstein et al. [1] argue that *the service concept* plays an important role in service design and development. The service concept defines the *how* and *what* of service design, and helps mediate between customer's needs and an organization's strategic intent.

Total design, according to Pugh [19], is a multidisciplinary iterative process that takes an idea or market need forward into a successful product or service. Five principles need to be followed: (1) involve the customer in all stages, (2) derive specifications from the customer, (3) derive technical aspects from the customer's specifications, (4) the design team should be multifunctional from relevant organizations, and (5) test in the market place, not in the lab.

One of the total design approaches is Quality Function Deployment (QFD). QFD is a systematic, matrix-based visual approach for designing quality products and services [9].

Keen & Sol [21] state that effective support for service development is expressed using a combination of three U's: *usefulness* of the tools and methods i.e. the value they add to the decision processes; *usability* of the tools i.e. the mesh between people, process and technology; and *usage* i.e. their flexibility, adaptability, and suitability to the organizational, social, and political context. The development of services requires an environment that places equal emphasis on all three U's.

4 Research Approach

In this section the research approach will be described, as well as the strategy and the instruments being used in the various phases of the research.

4.1 Research Questions and Objective

Section 2 describes the changing energy playing field and the new role of the prosumer in the energy value network. The prosumer needs to be supported by value-added services in order to enable him to play a full-fledged role in this network. A design approach can help to develop these energy-management services in a multi-disciplinary context. In this approach the end-user value (i.e. value for the prosumer) is the starting point.

The main research question is:

> How can actors in the energy value network design energy-management services that support the role of the prosumer?

This raises a number of other questions that are dealt with in this research:

1. How does the value network, where the prosumer acts in, look like?
2. What are the requirements of the stake holders involved, with respect to energy-management service design?
3. What are possible services that can support the prosumer?
4. What are the methods currently used for service design? What are advantages and disadvantages?
5. What are the critical elements when designing energy-management services, and what are the possible solutions?

The prosumer acts in a complex value network with multiple actors. Designing services in this context means that a multi-disciplinary approach is necessary in order to satisfy the stake holders involved.

This leads to the following research objective:

> To develop and validate an approach for designing energy-management services for prosumers, which can be used to support actors in the energy value network to develop these services.

The approach can be described as a suite of do's' and don'ts', of guidelines, and a coherent set of tools and methods, which can be used in the service design process. The *scientific* contribution of this research will be the development of a design approach for services that support prosumers in the fast changing energy world. The approach can be used to solve problems in the real world of service design. Businesses in the value network are provided with a validated and tested design approach.

4.2 Research Strategy

The role of the prosumer in the energy value network is new. Developing services in this complex, fast developing environment is not straight-forward. A first step is to achieve an understanding of the playing field and the incentives and barriers that play a role. Only then a strategy can be developed to tackle the perceived problems and to develop an approach for designing services for the players in the value network.

The nature of the research area and the problem definition represent a typically ill-structured problem [20]. According to Sol [20], ill-structured problems are vague and *do not* fulfil the following requirements:

- the set of alternative courses of action or solutions is finite and limited
- the solutions are consistently derived from a model of the problem situation that shows a good correspondence with reality
- the effectiveness or the efficiency of the courses of action can be numerically evaluated

The inductive-hypothetic cycle can be used for this kind of research [20]. The main advantages of the inductive-hypothetic strategy are that it:

- emphasizes the specification and testing of premises in an inductive way

- opens up possibilities for an interdisciplinary approach
- enables the generation of various alternatives for the solution of the problem
- permits feedback and learning

These benefits make the inductive-hypothetic strategy very useful for new and emerging research fields such as service design in the energy market.

The inductive-hypothetic research strategy consists of four model types, which are linked by five activities, as is illustrated in figure 2 below.

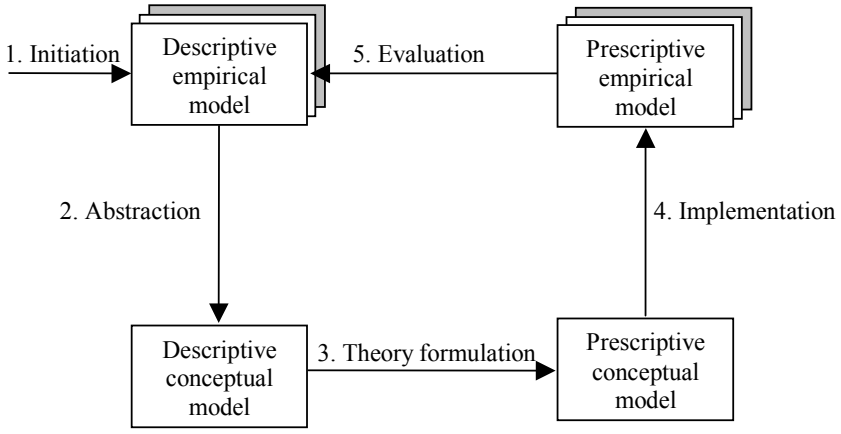

Fig. 2: Inductive-hypothetic research strategy

1. Initiation: based on an analysis of the specific field of study (i.e. service design for prosumers) one or more descriptive empirical models are constructed, each describing a perceived situation. Analysing these perceived situations should provide a better understanding of the research area. The empirical model can be based on both practice and theory.
2. Abstraction: the essential aspects are abstracted into a descriptive conceptual model (the "as is" model). This model describes the problems in the perceived situation at a generic level, and gives indications of possible solutions.
3. Theory formulation: the solutions are combined into a general theory (a prescriptive conceptual model) for solving the problems found.
4. Implementation: to test the theory the model is implemented in one or more prescriptive empirical situations (the "to be" model, or an experimental model). This implies that the approach developed is applied in practice.
5. Evaluation: the effectiveness of the proposed theory is evaluated by comparing the prescriptive empirical model and the prescriptive conceptual model. This may result in additional requirements for improving the prescriptive conceptual model and an iteration of the cycle.

4.3 Research Instruments

Various research instruments are being applied in the different phases of the research. The research instruments provide the means with which data is collected on the subject of study and subsequently analysed.

Initiation phase
In the initiation phase *literature* is studied on service design methodologies. Stake holders in the energy value network will be *interviewed* to get a better understanding of the current situation and their requirements with respect to services and service design (*requirement engineering*). Pilots and experimental projects with implementation of prosumer models will be studied and analysed (*case studies*). Business modelling [2, 7] will be used to reflect the value network and the interactions.

Abstraction and theory formulation phase
In these phases *literature review*, *focus groups*, *surveys* and *case studies* will be used to discuss and develop preliminary ideas on the conceptual model and possible solutions to the perceived problems. *Experts* will be consulted to validate the developed conceptual model.

Implementation phase
The researcher participates in the Flexines project, a cooperation between GasUnie, RijksUniversiteit Groningen, ECN, TNO, Esha and the Hanze Hogeschool. Within the project an Energy Management System for households will be designed, developed and tested. Flexines will function as a test bed for the developed approach for service design (*action research*). *Observations*, *questionnaires* and *interviews* will be used to get feedback on the design approach and the results.

Evaluation phase
The results of the implementation will be evaluated with the Flexines project members and other experts. Feedback will be collected by presenting the results at various meetings.

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