COST – BENEFIT ANALYSIS OF LOAD CONTROL AGGREGATION SERVICE USING HOME AUTOMATION

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INTRODUCTION

Discussion about Demand Response (DR) has been active for several years in many countries. Studies include issues like estimating possible amount of loads in different EU countries [ToMo10]. In Finland issues like potential for income from DR is presented for example in [Gul10].

One of the aspects is that a service aggregator becomes responsible for the functionality of DR. This aggregator can be either an existing company broadening its offering or totally new company emerging in the market.

In general, making a decision to enter to the new markets or to expand existing offering, is based on several strategic considerations and e.g. sensitivity analyses. Analyzing service aggregation business requires studies that consider both costs and benefits. Additionally, business has other dimensions that need to be studied. In this paper a business model for service aggregator providing DR is presented.

RESEARCH METHODS

This study is carried out as part of the Smart Grids and Energy Markets (SGEM) research program in Finland. The background of this study is a cost model that was created based on [TrKu07]. The current model was created for an organization providing Demand Response functionality using Home Energy Management Systems (HEMS) devices. In the second stage cost model was used to calculate potential income for such a service aggregator. For this real market data from spot, balance and regulating power markets were used. The results for this cost-benefit analysis are presented in the research report [TrRe11].

For this study previous work is broadened to create a more detailed description of a service aggregator. This was done by applying business model theory. Theoretical background is established on business model theory literature review. Empirical information was gathered as a group work in several separate team works with following participants:

1. Home Energy Management Systems (HEMS) manufacturer
2. Service provider company
3. Distribution System Operator (DSO)
4. Tampere University of Technology (TUT) (Department of Electrical Energy Engineering and Department of Industrial Management)

The result is a general business model framework for a service provider offering Demand Response using HEMS. Further research needs have been identified and are presented in the discussion section. In addition, many factors of uncertainty are related in the discussion that has an impact on final business model description how this functionality should be carried out.

CONCEPT OF BUSINESS MODEL

A business model concept has created a lot of discussions in business research. A common conceptual base is still lacking. However, some parts of the definitions seem converging towards common understanding, leading to larger consolidation among scientists. [AmZo10].

In [Ost04] a single reference model is proposed based on the similarities of a wide range of business model conceptualizations. With this business model design template, a business model can be described. It includes four main categories and nine building blocks. These building blocks can be placed on a single framework that helps to process the model. Nine building blocks and the business model canvas are presented in Figure 1.

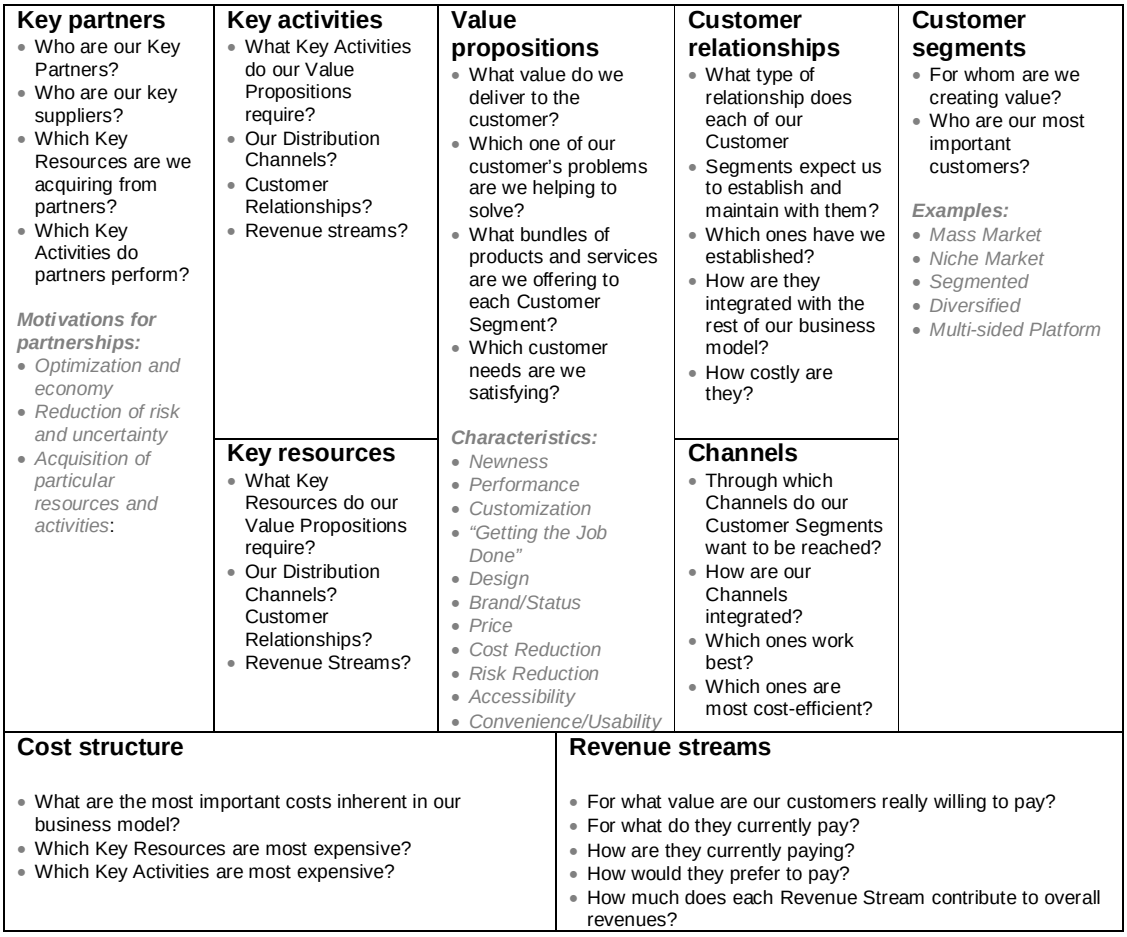

Figure 1. Business model canvas [Bus12].

DEMAND RESPONSE BY INDEPENDENT SERVICE PROVIDER

In this paper, service provider is studied as an independent company responsible of creating DR services. This is done by implementing Home Energy Management System (HEMS) for selected electricity end users. Service provider has a responsibility of having a near real time load availability and pricing system. In Figure 2, different functionalities/organizations are presented with separate elements. In some cases, these may be also under same company for example service provider may have installation or telecommunication functionalities.

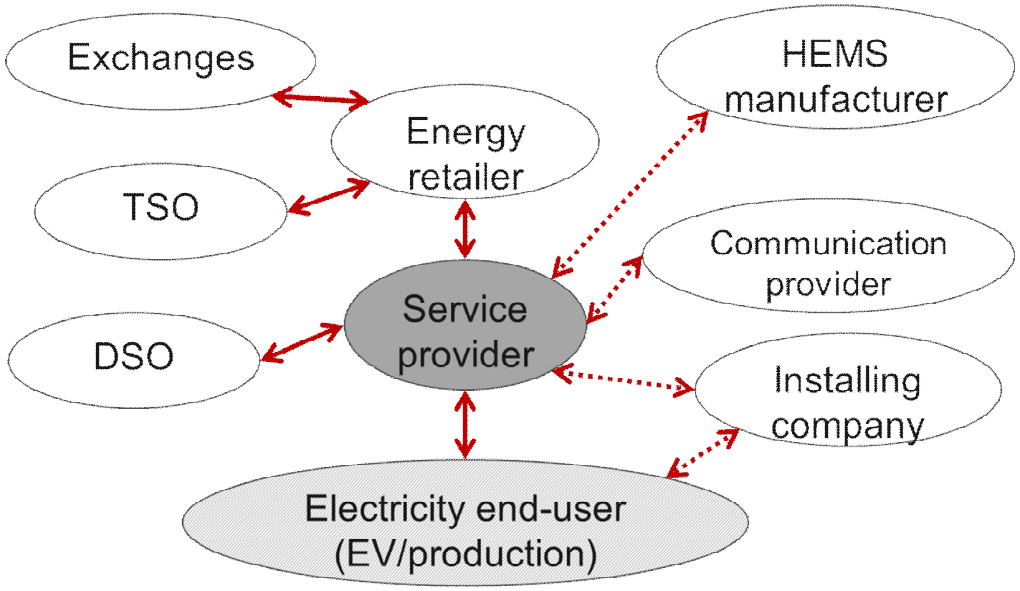

Figure 2. Value network of Demand Response (DR) carried out by independent service provider.

In Figure 2, arrows indicate the relationships of different parties in DR service. Solid lines indicate control of load and dotted lines indicate product or service to enable functionality of load controlling. As part of the research project also an Excel-based model to calculate money flows was created [TrRe11].

The business model described in this paper is created to service provider in center of Figure 2. It is the key player in making the DR services available to potential users. More detailed information of each nine business model blocks are being presented in Tables 1-9.

Key activities

In Key activities, DR service Provider's main business activities are described. Activities are related to creating value, delivering it to the customers and maintaining customer relationship. Key activities are described in Table 1.

Table 1. Key activities

Activity	***Description***
Load acquisition	*Contracting controllable load from a single consumer*
Building control to load	*Building load control technology to a single consumer*
ICT integration	*Integrations to different actors like Enery retailer, DSO*
Pricing load resources	*Calculating costs and profit margins (load usability, pricing/compensating end user and offering to DSO)*
Price information sharing to load providing consumers	*Consumer receives information of electricity prices and can use this as a signal to self-controlling of loads*
Bidding load resources	*Offering loads to energy retailers and DSO´s*
Managing loads (on/off each load) according to contracts	*Carry out load controls according to sales.*
Calculating load resources	*According to usage*
Consumer compensation	*Pay of using the loads to the consumers*
Operating and managing delivery chain	*Making sure all phases of the delivery work as planned*
Managing partner network	*Taking care of the partner network*
Developing concept	*How to make load control more efficient to all involved*
Selling and delivering HEMS devices	*Direct sales and web store*
Warehousing HEMS devices	*Order and warehousing HEMS devices*
Maintenance to HEMS devices	*Updates, repairs etc.*

Key Resources

Key Resources for delivering key action in Table 1 can be of various types [Bus12], for instance:

- Physical
- Intellectual (brand patents, copyrights, data)
- Human
- Financial

Table 2. Key resources

Resource	***Description***
Business know-how: Contracts, purchasing	*Know how related to the concept*
Central system for load control management (interfaces or client systems)	*Centralized system for managing all loads according to realization of trades of total loads*
Load bidding system	*pricing and offering loads to various actors*
Consumer information system	*Consumer specific information*
Technical support for partners and consumers	*Taking care of possible problems (resources depend if consumers are involved)*
HEMS device purchasing and delivery to customers	*Pricing, orders and deliveries*
Device installations (purchase)	*Must be defined what customer does self?*
Financing of the HEMS devices	
IT integrations and purchase/develop	

Partner network

In Figure 2 the different partners for DR service provider are presented. In some cases different functionalities may be under same company. The main motivations for partnerships can be [Bus12]:

- Optimization and economy
- Reduction of risk and uncertainty
- Acquisition of particular resources and activities

Telecommunication partner is needed for reduction the risk and cost of building separate communication only for this purpose. Most likely, a public mobile network would be used for majority of HEMS devices communication. Installing electricity loads under HEMS control is done with authorized installing personnel. Financial partner may be needed to provide finance for HEMS devices and necessary accessories and acquisitions of IT systems.

Table 3. Partner network

Partner	***Description***
HEMS manufacturer	*Company manufacturing HA/HEMS devices and key components*
Electricity/Energy retailer	*First HEMS sales contact*
Telecommunication provider	*Providing sufficient communication for HA/HEMS device (SIM card or similar)*
Financial partner	*Loan / financial arrangement for purchasing the HA/HEMS devices*
Technical partners (ICT)	*Providing IT and other technology*
Installing partner	*Taking care of electrical installations*

Value proposition

Value propositions for different customers are the core element in business model. Typical values created are [Bus12]:

- Newness
- Performance
- Customization
- "Getting the Job Done"
- Design
- Brand/Status
- Price
- Cost Reduction
- Risk Reduction
- Accessibility
- Convenience/Usability

Enabling cost reduction is one of the most typical value propositions. This most likely should be addressed to each customer segments. In some cases for DR service performance – in terms of avoiding outages – is valuable to Distribution System Operator (DSO). For consumer value proposition can be based on more than just DR. Making the offering suitable for example for Electrical Vehicle (EV) loading optimization and easy selling / optimizing of micro generation (solar and wind power) can add the value of the concept. Also possibility to

reduce the final electricity bill and receiving compensation from DR can attract consumers to participate.

Table 4. Value proposition

Products/Services	***Description***
DSO: Controllable loads for enhancing network management (faults, capacity, feeding arrangements)	*Distribution system operator DSO can use DR for alternative for capacity building in some cases. In fault situations loads could be restored /maintained with criticality information.*
Energy retailer: Balance settlement correction, Regulating power market, Frequency control market	*With more dynamic acting of production, storing and consumption of electricity energy retailer can correct balance errors with actively using DR service.*
Consumer: Possibility to sell green energy to markets, compensation of allowing loads to be controlled, lower price of energy.	*Green energy: Functionality needed to support and maximize this. Compensation from ER, and DSO (collected and paid by service provider). Additionally consumer could be offered low cost power for example for EV loading. Aim of this would be to improve production and consumption balance.*

Customer segments

Customer segments for DR service can be discussed based on Figure 2. Energy retailer is seen as the main customer [Gul10]. They are most likely the one customer that can use DR the most. This means that they purchase most controls and for this can be categorized as the main customer. As discussed in [TrRe11] the profitability of DR requires as many controls as possible. In discussions with DSO´s they indicated that there are most likely cases that they could also use DR. For this purpose more accurate studies would still be needed. Finally the end customer is one possible customer depending of the value proposition for them. This is discussed more detailed in Table 4 above.

Table 5. Customer segments.

Customer segment	***Description***
Consumers and small business	*Loads available 3-8 kW for control, purchase HEMS equipment (and installation). Additionally services related to their own micro production and electrical vehicle loading.*
DSO	*DSO: Controllable loads for enhancing network management (faults, capacity, feeding arrangements)*
Energy retailer	*Energy retailer: Balance settlement correction, Regulating power market, Frequency control market*

Channels

Each customer segments must have specified channels for different phases. These can be defined with following questions in each phase:

1. Awareness
   How do we raise awareness about our company's products and services?
2. Evaluation
   How do we help customers evaluate our organization's Value Proposition?
3. Purchase
   How do we allow customers to purchase specific products and services?
4. Delivery
   How do we deliver a Value Proposition to customers?
5. After sales
   How do we provide post-purchase customer support?

Table 6. Channels

Channel	***Description***
Awareness as general marketing: B2B customers by service provider. Consumers by energy retailer	*Making the product and concept known. Exhibitions, commercials and targeted marketing material.*
Evaluation: continuation of awareness. Service provider and energy retailer have sales tours and phone campaigns. DSO contact customers directly when suitable and ask for HEMS.	*Campaigns together with other companies to target specific consumers.*
Purchase: service provider selling. Direct sales and web store available	*Customers seek for information and are offered web store for purchasing device. Additionally road tours may be used to sell some units.*
Delivery: postal delivery from warehouse	*Service provider or HEMS manufacturer has a warehouse where HEMS units are shipped to consumers.*
Support and maintenance: service provider as HEMS phone support center and return at warehouse. Installing partner for changes in loads connected.	*After sales and return channels.*

Customer relationship

After defining the customers and channels it is needed to define how the customers are managed. These actions can include for example following [Bu212]:

- Personal assistance
- Dedicated Personal Assistance
- Self-service
- Automated services
- Communities
- Co-creation

Table 7. Customer relationship

Handling of a Customer segment	***Description***
Consumers and small business: Automated services in marketing, self-service in ordering	*Marketing and Web store for majority. Targeted direct sales on road tours*
DSO: Personal assistance	*Customer contact team or person*
Energy reteiler: personal assistance	*Customer contact team or person*
After sales: Service provider own customer service and technical support	*Service provider needs to take care of the consumer customers as well as the retailers and DSO´s*

Cost structures

In [TrRe11] cost structure for DR service provider was created. Most defining costs that effected the cost of the DR service were:

- Price of the HEMS devices
- Life-cycle of the HEMS devices
- Price for the communication for HEMS devices
- Amount of controls sold

Cost structure was based on results from [TrKu07]. These cost categories are presented in Table 8.

Table 8. Cost structures

Cost	***Description***
Material costs: Material related to installing home automation to the end customer	*Material related to installing home automation to the end customer*
Direct labor: Ordering Installation work and % of fault repairing	*Installation work and % of fault repairing*
Indirect labor: Managing HEMS load control resources and installations (management of what is needed to integrate single customer to the system)	*Managing HEMS load control resources and installations (management of what is needed to integrate single customer to the system)*
Fixed labor: General management of company, marketing & sales, Customer service and related typical secondary supportive functions on any business	*General management of company, marketing & sales, Customer service and related typical secondary supportive functions on any business*
Capital costs: ICT, HEMS systems, Communications, Offices	*ICT, HEMS systems, Communications, Offices*

Revenue streams

Final stage of the nine blocks in business model is defining possible revenues. In results of [TrRe11] one of the key questions was that how are the revenues divided so that all parties involved have positive value compared to the costs. Modeling of this is done using Excel calculations and results indicate that with careful planning model can be profitable. However this does require that all possible parties are involved and usage of the DR service is maximized. Additionally customer´s compensation compared to the price it is paying of the device has significant impact of the total profitability of the DR service.

Table 9. Revenue streams

Revenue	***Description***
Energy retailer service fee	*Pays according to usage and/or capacity availability*
DSO service fee	*Pays according to usage and/or capacity availability*
Customer device fee	*Pays according to usage and/or capacity availability. Customer may purchase the device or it can be owned by the service provider or in some cases even DSO.*
Integration income from DSO, and ER	*Integration work when service is implemented*

DISCUSSION

The presented model is a general one including the idea that it can be used as the first version when starting with actual business model for a real company considering this type of business. Challenge in creating a complete and accurate business model is that quite many factors can vary in current partly regulated and partly open electricity business environment.

When creating the final business model at least following questions needs to be answered:

1. What is the value of this functionality to DSO?
    a. What are the use cases for DSO?
    b. How much capacity DSO needs?
    c. How often DSO could control the capacity?
2. Who is purchasing HEMS device and who has ownership of it?
3. What is the economical price of HEMS device?
4. If consumers offering loads are compensated how it is being done and what is the amount of compensation?
5. How much can Energy retailer earn by selling Demand Response?
6. Is there value proposition for Power producers?

[KiMa05] presented four distinct questions how to assess the created business model. These questions are in rank order so that each question has to receive positive answer; otherwise the whole model should be put under reconsideration. The questions are:

1. Does the business model include exceptional value for the customer?
2. Can most of our customer by easily with strategically set price?
3. Are we able to reach the set cost level to enable strategic price?
4. What are the hurdles in implementing the business model? Have you prepared to overcome those?

If each question has a positive response, the created business model may be commercially viable [KiMa05]. Furthermore, managers should consider the model scalability: is it possible to scale business with the same committed resources?

Finally, future studies should include making more accurate calculations in different electricity exchange models what is the earning potential for DR to different players. With more specific information business model could be described in more detailed level.

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