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Alteration in Business Models of Electricity Distribution Companies – A Case of Smart Metering

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Abstract

Smart metering is currently implemented in many countries. The change from traditional metering is significant and impacts many of the Distribution system operator´s (DSO's) activities. This dissertation aims to provide a structured model for analysing the impacts of Smart metering on a DSO´s business.

Research was conducted by gathering a theoretical framework for understanding how the business operates. The concept of business model has been presented. It is used as a framework of metering business. Detailed studies on specific parts of the business model have been carried out. These concentrate on finding a theoretical background of what Smart metering can provide. Cost analyses were conducted to better understand resources required by Smart metering. Problems related to ICT resources have also been studied based on the DSO´s experiences. Partner network was studied based on DSO´s experiences related to service purchasing and finally experiences in working with IT services provided to the DSOs has been presented.

This dissertation presents a development trend that has taken place regarding Smart metering in implementation and operation. Results are presented in a business model framework to provide a more structured view on issues related to Smart metering. Also non-technical issues should be analysed to fully understand the extent of the changes taking place when implementing Smart metering. The information presented can be utilized when significant change factors to the DSO´s business models can be recognized.

Preface

This work started in 2003. It has been done in the Department of Electrical Energy Engineering in Tampere University of Technology (TUT). During the years, several public funding organisations and other associations have been taken part of the research: the Finnish Funding Agency for Technology and Innovations (Tekes), Finnish Acadamy, ST-pooli and Finnish Energy Industries (Energiateollisuus ry),. As co-operative research organisations have been Technical Research Centre of Finland (VTT) and Lappeenranta University of Technology (LUT). Companies related to this research include Aidon Oy, MX Electrix Oy, Fortum Oyj, Helen Sähköverkko Oy, Jyväskylän Energia Oy, Koillis-Satakunnan Sähkö Oy, Netcontrol Oy, Oulun Energia Oy, PowerQ Oy, Tampereen Sähköverkko Oy and VAMP Oy. To these organisations I wish to express my gratitude.

The supervisor for this dissertation has been Professor Pertti Järventausta in TUT. He is to thank for guiding this dissertation to the end. Language inspection of this dissertation has been carried out by Sirpa Järvensivu from which I am grateful.

I would also like to thank my colleagues Janne Toivonen and Anssi Seppälä. Janne has provided support and expertise on technical issues and also supporting my work by helping me with daily tasks at PowerQ Oy. Anssi as my partner in PowerQ has offered many discussions related to electricity distribution business.

My biggest gratitude I address to my wife Mirva. She has encouraged me to push forward even in times when work has been somewhat overwhelming. Our daughter Tara was born at final stages of this work. She has given me other things to do and think and pushed me towards finishing this work so that we would have more time together. Mirva´s parents Tarja and Jorma have helped me immensely by allowing me to spend time at their summer cottage and relax. Thank you!

Tampere, April 2013

Petri Trygg

Table of content

Publications

This dissertation consists of the following publications:

[P1] Trygg, P., Toivonen, J., Järventausta, P., "Changes in business models of electricity distribution", International Energy Journal, Volume 8, issue 4, 2007, p 243-248. Published by RERIC. ISSN1513-718X.

[P2] Trygg, P, Antila, S., Kivikko, K., Lampo, V-P., Järventausta, P., "Implementing ASP to serve energy supply industry", Proceedings of electricity supply industry in Transition – Issues and Prospects for Asia conference, 14-16 January 2004, Bangkok Thailand.

[P3] Toivonen, J., Trygg, P., Mäkinen, A., Järventausta, P., "A survey of information systems in Finnish electricity distribution companies", Proceedings of the Nordic distribution and asset management conference (NORDAC 2006), 21-22 August, 2006, Stockholm, Sweden.

[P4] Trygg, P., Aminoff, A., Tahvanainen, K., Viljainen, S., Lappeteläinen, I., Järventausta, P., "Questionnaire survey of services and outsourcing in Finnish distribution companies", Journal of Energy and Power Engineering, Volume 6, issue 5, 2012, p. 792-798. Published by David publishing company. ISSN1934-8975.

[P5] Trygg, P., Kulmala, H., I., Antola, J., Järventausta, P. , "Cost structure of energy measurements – a case study", Proceedings of the 18th International Conference on Electricity Distribution (Cired 2005) conference, 6-9 June 2005, Turin, Italy.

[P6] Trygg, P., Kulmala, H. I., Järventausta, P., "Comparison of life-cycle costs of energy metering processes", Proceedings of the 19th International Conference on Electricity Distribution (Cired 2007). 21-24 May 2007, Wien, Austria.

[P7] Trygg, P., Makinen, A., Verho, P. Järventausta, P., "Providing additional value for AMR with integration to operational systems", Proceedings of the Nordic Electricity Distribution and Asset Management Conference (NORDAC 2008), 8-9 September, 2008, Bergen, Norway.

[P8] Hyvärinen, M., Pettissalo, S., Trygg, P., Malmberg, K., Holmlund, J., Kumpulainen, L., "A comprehensive secondary substation monitoring system", Proceedings of the 20th International Conference on Electricity Distribution (Cired 2009) conference. 8-11 June, 2009, Prague, Czech Republic.

[P9] Trygg, P., Repo, S., Järventausta, P., Seppänen, M., "Cost – benefit analysis of load control aggregation service using home automation", Proceedings of the 10th Nordic Conference on Electricity Distribution System Management and Development (NORDAC 2012). 10-11 September, 2012, Espoo, Finland.

Abbreviations and symbols

ABC	Activity based costing
AMI	Automated meter infrastructure
AMM	Automated meter management
AMR	Automated meter reading
ASP	Application service provisioning
BSP	Business service provisioning
Case study	Analysis of an individual unit/case
CIS	Customer information system
CMMI	Capability maturity model integration
DG	Distributed generation
DMS	Distribution management system
DSO	Distribution system operator
DER	Distributed energy resources
DR	Demand response
ET	Energiateollisuus ry – Finnish energy industries
HEMS	Home energy management System
EV	Electric vehicle
ICT	Information and communication technology
IT	Information technology
KPI	Key performance indicators
TSO	Transmission system operator
TUT	Tampere University of Technology
PLC	Power line carrier
SaaS	Software as a service
SLA	Service level agreement
SM	Smart metering
SME	Small and medium size enterprise
VPN	Virtual private network

1 Introduction

Technical development and innovations have created not only possibilities but also challenges to different businesses. This dissertation discusses technical change in electricity distribution business. Identity of the business can be described with highest concern on safety. Technology used must fill safety requirements that are higher than in many other businesses. Reliability requirement is increasingly important. Society is increasingly depending of electricity. After these requirements costs are considered. Finally the life-cycles of technologies are typically several decades. These factors define electricity distribution business. New technology and service innovations must meet these requirements. Electricity distribution is not considered the most advanced business and changes typically happen slowly compared to other businesses. During past few years transfer to Automated meter reading (AMR) has been an exception. In Finland, the first steps in AMR were already taken in the 1980´s. The first implementations to be introduced included remote controlling of meters in terms of tariff changes, load control and for example street lighting control.

Later, steps were taken to add more functionality to meters, e.g. to replace the manual meter reading especially from larger customers with monthly consumption reading for billing. Additionally different telecommunication methods were studied. Meter reading was being tested in small scale implementations in order to get experiences for large-scale roll-outs. As technology has developed, the name of the concept has also changed. Automated meter reading (AMR) was one of the first terms. Later terms like Automated meter management (AMM) and Automated metering infrastructure (AMI) have been introduced. In this dissertation the term Smart metering is used and will be used from this point forward. Publications also include other terms mentioned above.

Many stated that Smart metering is too expensive compared to the traditional meter reading and for this reason will never be implemented on a large scale. Opposite arguments were also discussed. For example in Finland, the Finnish Energy Industries (Energiateollisuus ry) indicated that they see Smart metering as being a long-term goal for them.

Kainuu Energy was one of the first companies to launched large-scale Smart metering installations in the mid-2000. In 2005, Vattenfall Verkko Oy electricity Distribution system operator also announced that it will implement Smart metering to all of its circa 376,000 customers in Finland. This was one of the points where Smart metering was taken seriously for the first time and after which many companies slowly started discussing about large scale implementations. Finnish Energy Industries also encouraged that DSO´s should implement large scale Smart metering concerning at least customers with fuse size 63 A and more. In 2009 the Finnish Government passed act 66/2009 concerning electricity markets [Työ09]. It states that at least 80 % of the customers of each DSO must have Smart metering implemented by December 31, 2013. This requirement for Smart metering also included that hourly consumption data is to be collected and the possibility of controlling customer load must be included in the meter. The remaining maximum 20 % can also be handled manually. This announcement caused an increase in the demand for metering systems and most of the DSO´s started to study Smart metering solutions.

Energy efficiency and energy saving have also been a big discussion in EU countries. Political pressure to react to the mitigation of climate change has resulted in laws that have requirements concerning the DSOs´ capabilities in metering their customers' energy usage and reporting it. This has resulted in many of the information systems also being replaced by the DSOs to meet requirements and recommendations.

This transition has been and still is a relatively large challenge to the DSOs. A lot of work has been done and is still needed to have the DSOs meeting all the requirements set to them. Energy metering is a core type of process which has been stable for a long time. Changing it causes many changes in business processes. In some DSOs the implementation of Smart metering has also caused higher workload and additional costs. The information systems and tasks and knowledge of employees may also have changed more than was expected before starting the implementations.

These types of changes also take place in other businesses. In economy sciences, the Business model is one of the possible theories of discussing change in business and different aspects of it. It is a structure to describe the way the business is operating. It can also be used as a target model in helping organizations to face the changes in business and see the goal to be reached more clearly. For company management operational strategy is an alternative theory.

To better understand the changes, this dissertation describes research done from the early stages of Smart metering to the current situation. A Business model has been selected for more detailed and structured analysis to understand and to model the changes.

1.1 Research questions and objectives

The main research question in this thesis is that can Business model theory be used to model and analyse the change of the electricity distribution business due to the Smart metering implementation. Additionally, this can be divided into more detailed secondary questions:

1. Can the Business model theoretical framework be implemented to Smart metering in electricity distribution business environment?
2. What types of analysis and information is needed?
3. What is the importance of information systems in changing the business environment of electricity distribution?
4. What is the role of service purchasing in electricity distribution business?

The overall aim of this work is to find answers to the research questions mentioned above. This large entity is narrowed down to Smart metering and power quality measurements specially studying the following aspects:

a. Theoretical framework that can be used to analyse business and its change.
b. DSO´s business processes in terms of in-house and service purchasing.
c. Analysing costs of business processes.
d. The role of information systems, especially from information system services point of view.

As a result of the study, additional information is provided that can be utilized when other significant changes appear related to the electricity distribution business.

This thesis is a combination of electrical energy engineering and industrial economics. Electricity distribution business specific research including technical aspects is supplemented with industrial economics theory.

1.2 Research design

The research strategy in this study is deductive. This means adopting theoretical framework into new area [Olk93]. Theoretical framework is selected to be Business model and it is used to discuss Smart metering. According to [ZoAm11] usage of term Business model has increased since 1995 in articles published in academic and especially in non-academic journals. As a conclusion [ZoAM11] also states that many different definitions of Business model are used depending of author. According to [Sep08] model presented in [Ost04] is one of the most suitable ones. Business model does not cover all the aspects of company operating. One of the reasons is that it is placed by the theoretical framework described earlier between strategy and business processes. Additionally elements such as product portfolio and complexity, life-cycle, production volume, time and quality with their flexibility describe operating. Operational strategy is more suitable theoretical framework covering these. Main reasons for selecting Business model for theoretical framework were that it is becoming increasingly popular, it is used on many other areas of business and it includes elements that consider the change in business [LiCa00].

As implementations and new technical innovations have created new knowledge related to Smart metering, it has been important to include it into the process trying to understand Smart metering in context of this research. Additionally, Smart metering is a relatively new research area with a limited amount of information. Large scale implementations of Smart metering especially in Europe have started during this study. It is one of the large changes that have started to take place in electricity distribution business in recent years. The goal of understanding the change and details related to it is important when combining results to a more systematic model.

The research approach is selected to be action research oriented. This approach shares common characteristics with constructive approach [Kalu93]. According to [Olk93], a close relation between researcher and target is typical of this approach. Additionally, conclusions are based on researchers' understanding of the target. Also typical of action-oriented research, the majority of the research data is qualitative. The main findings in this work are based on qualitative data. This is carried out by gathering the information from sources that can be seen reliable and are expected to offer reliable answers. In this study it means questionnaires and interviews with electricity distribution business professionals. Quantitative data is collected for publication [P4] using questionnaire study.

The main research method in this study is case study. This means that the selected research target is studied with several methods [Olk93]. The main idea of the method is to gain understanding of the research target [Yin94]. The questionnaire studies are targeted to provide primary research material from distribution business professionals such as employees of DSO´s. This has been supplemented with more detailed interviews based on issues that have been analysed from a larger amount of answers. The Business model theory has been studied on a deeper level in terms of the objectives mentioned above.

Methods and approach related to business and cost modelling are generic but validation and more detailed discussion is based on case studies in the Finnish electricity distribution business. Parts of it can be utilized in businesses similar to electricity distribution such as district heating and water distribution.

The heading of this dissertation is separated onto three different fields:

1. Business model theory
2. Smart metering
3. Information technology and services

Each field is discussed in more detail in publications [P1]-[P9]. The relation of the publications to the content of this work is explained in Figure 1. The used research methods are also listed.

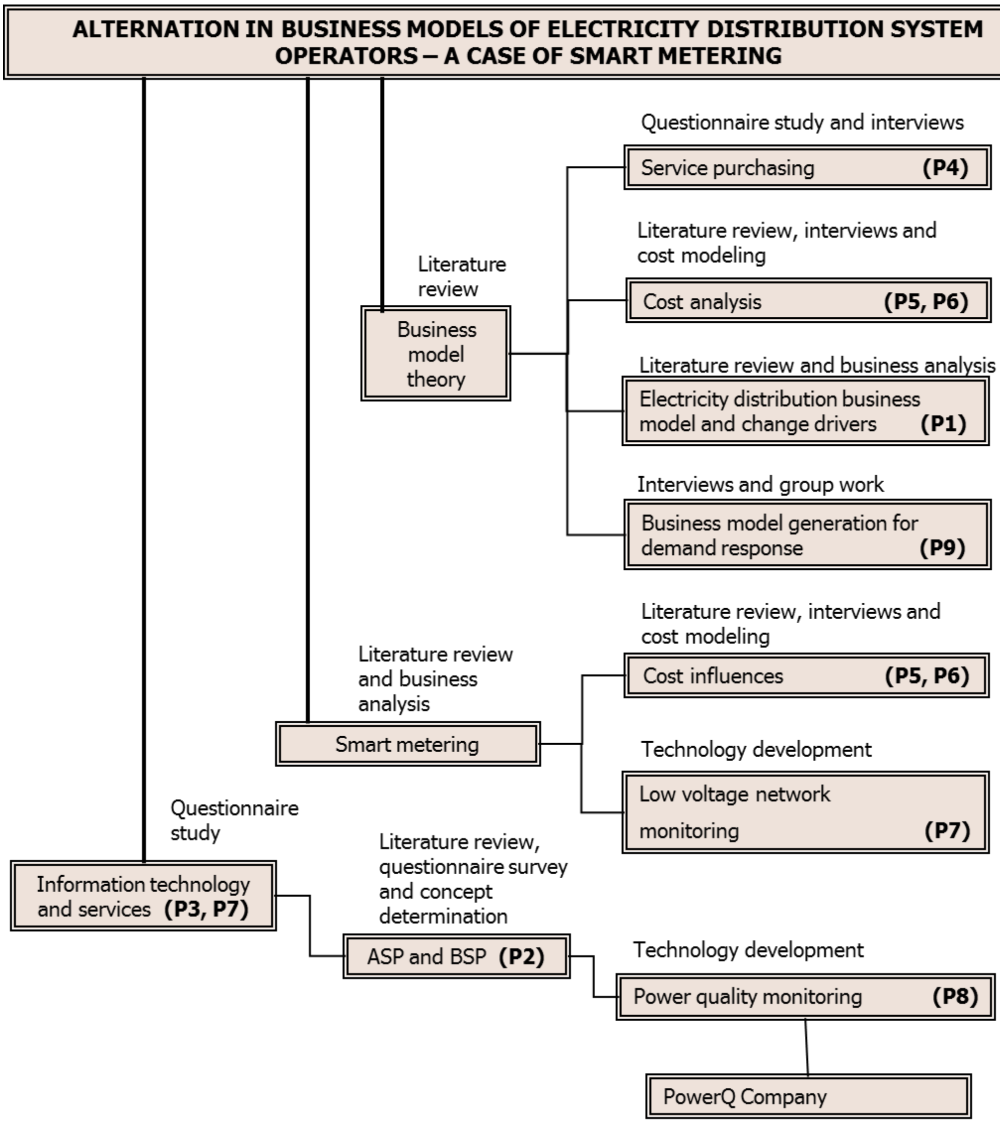

Figure 1. Content of this dissertation. P with number is a reference to the publication related to the dissertation and above each topic is the used research method.

Details of each publication are presented in chapter 1.3. The Business model framework is discussed in publications [P1], [P4], [P5], [P6] and [P9]. Publication [P1] includes general Business model and change factor discussion regarding the electricity distribution business. Publication [P4] discusses service purchasing. Publications [P5] and [P6] introduce public cost information of Smart metering collected from actual DSO´s in Finland. Publication [P9] introduces modelling Demand response functionality using a determined Business model framework. It uses the experiences and information gathered by the Smart metering Business model but put into a future context. Information technology services are discussed in Publications [P2], [P3], [P7] and [P8]. [P3] proposes general information systems update on electricity distribution. [P2] introduces the possibility to adopt ASP to the electricity distribution business. [P7] introduces actual technological and conceptual developments on Smart metering partly based on results in [P5] and [P6]. [P8] is a case presentation of ASP in actual usage in the electricity distribution business. In addition to the publications, the content is completed with a study of additional references and theoretical framework presented in Chapters 1-6 of the introductory part of the thesis.

Publications present the research steps taken during the years of this work. They also present findings from separate research areas to cover different aspects of the Business model framework and development that has taken place in electricity distribution.

Research data has been collected using questionnaires in publications [P2], [P3] and [P4]. Results were gathered from DSO and service providers in electricity distribution business. In publications [P5] and [P6], the actual cost data was collected from DSO´s using case study methods and activity based costing tool in analysing different business process costs related to metering in a traditional way and in adopting Smart metering. [P7] and [P8] include actual technological and related conceptual development projects that were operated in an actual electricity distribution business environment. Sources of information are Finnish DSOs and persons working on management and specialist positions.
Author of this dissertation also has another role of collecting information. This is working in company PowerQ Oy (Ltd.). Company was established in 2003 to provide power quality measurement solutions to distribution companies. The author was one of the five young researchers establishing the company. The company was established based on an agreement where ownership of some research project results was acquired from the Tampere University of Technology. These results included a web based application demonstration for power quality monitoring and analysing as ASP concept. Business concepts of ASP are discussed in [Try03].

In addition to being one of the founders of PowerQ, the author of this dissertation has also acted as Managing Director of the company since 2003. This work has also provided hands-on experiences in measurements related to business in a real DSO's environment. This experience is mainly written to chapter 5.

This study has been conducted between 2003 and 2012. The role of the researcher during this process has included the following actions:

1. Studying application service provisioning (ASP) in 2003-2004.
    a. First step was to collect theory of this new issue in electricity distribution.
    b. Study if ASP is in use in electricity distribution business.
    c. Create theoretical new services that could be carried out as ASP applications.

2. Establish a start-up company PowerQ Oy providing power quality measurements as ASP. The company was established in 2003 and has been working ever since.

   a. Company´s business was based on a theoretical new service created in stage 1 c.
   b. ASP service PQNet has been a part of the company´s product and services portfolio from the beginning and includes interfaces related to Smart metering measurement information.
   c. Smart metering consulting for around 150,000 meters has been done for several Finnish DSO´s including participation in the following tasks: defining tender documentation, comparing offers, negotiating agreements, defining information systems role, interfaces, systems services and network of companies involved in ICT related to Smart metering. Also monitoring of pilot and mass installation of Smart metering projects has been part of some of the consultancy projects.
   d. Participating in technology development projects that have resulted in actual commercial solutions to Smart metering systems and also to comprehensive secondary substation monitoring.

3. Study metering costs in terms of traditional metering compared to Smart metering.
   a. Collecting measurement process information from five Finnish DSO´s.
   b. Utilizing activity based costing (ABC) method to analyse costs for different processes.

4. Participating in electricity distribution Business modelling and development projects.
   a. 2004-2006 project that created alternative scenarios for future electricity distribution business developments.
   b. 2004-2006 information systems study related to electricity distribution business.
   c. 2006-2008 service purchasing research study that collected information of current and future service purchasing.

5. Studying Business models in electricity distribution business 2009-2012.
   a. Analysing new services such as Virtual power plant (VPP) [TrJä08] and Demand response (DR) using Home energy management system (HEMS) and the possibilities of Smart metering related to it.

These research steps are closely related to Smart metering. They cover it from different aspects such as information systems, Smart metering technology development, new services related to it and possible changes it causes to the DSO´s ways of organising their business. Results of each step have been published in several international conferences, journals and events. Majority of the studies have been done in close cooperation with Finnish DSO´s and companies providing products and services to electricity distribution. Additionally, organisations like the Finnish Energy Industries

(Energiateollisuus ry), the Technical Research Centre of Finland (VTT) and the Lappeenranta University of Technology have been involved in these studies.

One of the limitations of this study is that no follow-up study has been conducted. However, similar issues to the ones in the questionnaire related to [P2] have been brought out in a different context in [P4]. This study is limited to the framework described in Figure 1. The electricity distribution business is a regulated monopoly business in Finland and in most European countries. As regulations have country-specific content, they will not be discussed in detail in this dissertation. Other legislation-related issues are discussed only if they have broader coverage such as the EU legislation. Technological issues discussed are limited to the studies discussed in publications. As they are partly done by companies in the market, the solutions may present issues that cannot be discussed publically. Information of any specific company with the name of the company for example related to discussions, technology or answers in questionnaires are not published unless described as a reference. Cost results in publications [P5] and [P6] are based on experiences of piloting Smart metering systems. This is due to the fact that no DSO in Finland had mass installed Smart metering in operation at that time. There is no follow-up study on what the costs are after Smart metering is installed as a mass to the majority of the customers. Tools used in creating each DSO´s cost analysis results have been given to the DSOs. By utilizing the results the DSO´s could have updated their cost data and find issues to change in mass installations. This means that the costs results may have been used in managing costs. However no such information is received from the DSO´s.

1.3 Structure of the dissertation

This dissertation´s introductory part is organized into the following six chapters:

- Chapter 1 introduces the research topic and methodology.
- Chapter 2 introduces Business model general theory with additions of cost analysis theory and service purchasing.
- Chapter 3 discusses the electricity distribution business specialities compared to a general theory of Business model.
- Chapter 4 describes Smart metering in DSO´s business environment and discusses its Business model. Finally in the chapter, possible change factors for Business model are discussed and a new concept of the Business model related to Smart metering is presented.
- Chapter 5 outlines the author’s experiences in working with measurement service provisioning for DSO´s.
- Chapter 6 presents discussion about results, assessment of research and future studies.

1.4 Main content of the publications

This dissertation consists of following publications:

1. Publication [P1]: "Changes in Business models of electricity distribution"
   a. Content: Publication describes major change factors and their impacts on electricity distribution Business models.
   b. Support to scientific contribution of this publication is in identifying change factors related to the Business model.
   c. Author's role in this publication has been to identify change factors in electricity distribution business and analyse how change factors have been influencing the Business model so far.
   d. Limitations and possible errors: This publication is not presenting theoretical background of the Business model or defining it exactly. It is concentrating on presenting known changes taking place at the time of publication and combining them with research activities.

2. Publication [P2]: "Implementing ASP to serve energy supply industry"
   a. Content: Publication introduces the Application Service Provisioning (ASP) theory. Additionally, a value network model is created to form a new type of service. Value network model is created for power quality monitoring as ASP service. Finally, a questionnaire is conducted concerning ASP in the electricity distribution business.
   b. Support to scientific contribution: Create theoretical model of a new service for power quality monitoring that could be carried out as ASP applications. Application services presented in the paper were new in electricity distribution business. This was seen especially with the results from the questionnaire study.
   c. Author's role in this publication has been creating theoretical background and value network models. Additionally, the author has carried out a questionnaire study regarding the usage of ASP applications.

3. Publication [P3]: "A survey of information systems in Finnish electricity distribution companies."
   a. Content: Publication provides results of a questionnaire conducted among Finnish DSO´s concerning their information system usage.
   b. Support to scientific contribution: Results provide background information of different systems and key problems related to system implementation, integration and operation.
   c. Author's role in this publication has been to participate in the planning of the questionnaire and analysing of the results.

4. Publication [P4]: “Questionnaire survey of services and outsourcing in Finnish distribution companies.”
    a. Content: Publication provides the latest information of Finnish DSO´s service purchasing at the moment and in the near future. Risks and benefits of different services are also being discussed.
    b. Support to scientific contribution: Provides information of usage of services in organising business processes.
    c. Author’s role in this publication has been to participate in the planning of the questionnaire and analysing of the results.
    d. Limitations and possible errors: This study concentrated on service purchasing. Author and co-authors cannot state that topic discussed has not affected to the results. It is possible that answers are more positive to the actual situation. One reason for this can be that persons interviewed don´t know all the aspects related to their services.

5. Publication [P5]: “Cost structure of energy measurements – a case study.”
    a. Content: Publication provides single DSO´s cost data when comparing traditional manual meter reading to Smart metering.
    b. Support to scientific contribution: Activity-based cost calculation provides accurate data on analysing changes caused by Smart metering to a Business model.
    c. Author’s role in this publication has been to adopt activity based cost calculation into the metering business processes. Additionally, the author has participated in collecting cost data and analysing it.
    d. Limitations and possible errors: Results of this study are based on the pilot phase of the Smart metering. This may cause uncertainty in the results of publication.

6. Publication [P6]: “Comparison of life-cycle costs of energy metering processes”
    a. Content is similar to [P5] except this publication provides a result of several DSO´s and their metering costs including outsourced metering processes.
    b. Support to scientific contribution: Activity-based cost calculation provides accurate data on analysing changes caused by Smart metering to a Business model.
    c. Author’s role in this publication has been to adopt activity-based cost calculation into the metering business processes. Additionally, the author has participated in collecting cost data and analysing it.
    d. Limitations and possible errors: Results presented on paper are based on piloting Smart metering in selected DSO´s. This may cause uncertainty in the results. T-Test results’ concerning urban and rural area have low

correlation but on the contrary to what is written in the publication, it doesn’t mean that they are statistically different.

7. Publication [P7]: “Providing additional value for AMR with integration to operational systems”,
    a. Content of this publication is the technological development project of Smart metering. The additional features of Smart metering in terms of low voltage network monitoring are presented in more detail.
    b. Support to scientific contribution: Cost analysis in publications [P5] and [P6] indicated that additional features may be needed to get the best possible value to a Smart metering investment. This publication provides the technological concept of additional values.
    c. Author’s role in this publication is to describe power quality data management in this project.
    d. Limitations and possible errors: Publication describes development and results of actual commercial solutions. This limits the results published in the publication.

8. Publication [P8]: “A comprehensive secondary substation monitoring system.”
    a. Content: Publication describes comprehensive secondary substation monitoring. This technological project is in operational use by an actual DSO. It also follows the ASP value network model introduced in publication [P2] in terms of measurement data management as ASP service.
    b. Support to scientific contribution has been that ASP can be used in a relative large and complex technical solution so that it is attractive to a real customer.
    c. Author’s role in this publication has been to describe the technical concept of measurement data management as ASP service. Additionally, some aspects of data exploitation are discussed.
    d. Limitations and possible errors: Publication describes development and results of actual commercial solutions. This limits the results published in the publication.

9. Publication [P9]: “Cost – benefit analysis of load control aggregation service using home automation.”
    a. Content: Publication presents Demand response Business model based on home energy management system (HEMS).
    b. Support to scientific contribution is to present the Business model of a functionality that is most likely to take place in the near future.
    c. Author’s role in this publication has been to apply Business model framework for creating DR functionality. Inputs to the model have been

collected from four group work meetings with researchers, DSO and home automation manufacturer representatives.

d. Limitations and possible errors: This publication presents a theoretical model of a possible new service. More detailed analysis should be conducted to make it work for an actual company for example in terms of resources.

2 Aspects of changes in Business models

The concept of the Business model is widely used in many presentations, articles and general discussion. In many cases it is not explained and sometimes it is even used to describe any action in business causing income to a company. This may lead to a misunderstanding of the definition.

The Business model is created to conceptualize and standardize the business framework of a particular company. The idea is to describe certain parts of how the business operates. It is said to improve the possibilities of understanding success factors and factors for failures in business. This however requires that model is implemented into a actual company.

2.1 Concept of Business model

2.1.1 Definitions

The concept of the Business model (BM) is relatively new. It became part of economic theories during the expanding of the Internet and ebusiness or e-Commerce [Ost04] although there are indications of BM´s from the 1970´s [Bou03]. Many new companies were founded during that time and many of the companies had a new type of way of organizing their business processes. The new companies produce value to their customers by combining different value creation components in a new way. They could also adapt to a changing business environment faster than so called traditional companies [Tap97] and [BoLi00]. On the other hand, criticism has also been presented. The usefulness of the idea of BM has even been criticized [GlKe95]. This criticism claims that Business model does not offer proper framework actual business analysis.

A common conceptual base is still limited and needs more research. Most common definitions discusses about interaction and value creation between activities in companies and networks [ZoAm10]. Interaction can be related to company confidential issues, and public concepts may not include all the important information.

Looking at published definitions of the concept of BM, it is obvious that the concept has many different interpretations. According to [AmZo01] BM is a description of who is doing what to generate value. Value is also among the things to be defined. Their description states that the Business model is a value network and it describes how the network participants act. Another network based interpretation is presented by [FaBa03]. They see BM as means for a business network to produce value with different technological means. Their perspective is to define what is the role of a single company in the value creating business network. [Mah00] has stated that it defines three essential flows in between business partners and customers: value, logistics and earnings. [Mar02] defines it as a story that tells how the company is operating. The interaction between business process and BM is being discussed by [PeKi01], which claims that BM explains why the business processes are designed as they are. Also the interaction with BM and the company's strategy is one of the definitions by [RaRo01]. Their interpretation is that BM expresses the strategy of a company. This expression includes product strategy and models for service logistics and earnings. According to [Tim98] BM is architecture and income description of product, service and flow of information. He highlights the relationships, interactions and structures of different business parties.

Later and more general definitions are that BM generally speaking defines today's market structures and companies' location in them [Bou03]. BM and their analysing frameworks help to understand business (value) networks [Ost04]. One obvious conclusion of the definitions is that today's business environment is networked and business models are one possible tool for understanding these networks. Business model interaction with company´s strategy is one of the dimensions defined in the literature [RaRo01], [Ost04] and [OsPi05]. [Ost04] and [OsPi05] also define that the dimensions of the business model include connection to the company´s organisation and ICT as they are one elements of the resources of company.

Taking into consideration all the definitions of the business model, Figure 2 presents them as a synthesis with the literature mentioned above.

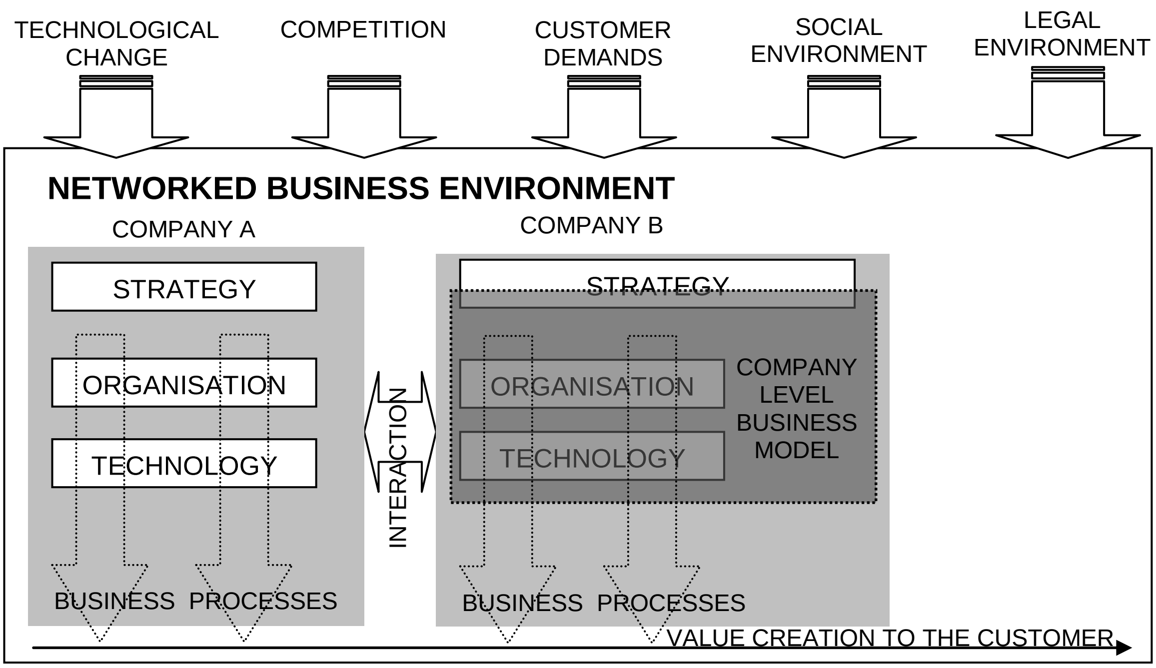

Figure 2. Business model definition as a synthesis of the literature studied.

The Business model can be seen as the middle piece of the pile. Strategy is the top level direction for a company. It also gives the main principles and formulas to the Business model. On the bottom, creating the value for the customer, are the business processes. They are defined by the Business model and also the given resources and other means.

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 (A-D) and nine building blocks (1-9) as follows:

A. Infrastructure

1. Key Activities: The activities necessary to execute a company's Business model.
2. Key Resources: The resources that are necessary to create value for the customer.
3. Partner Network: The business alliances which complement other aspects of the Business model.

B. Offering

4. Value Proposition: The products and services a business offers. [Ost04] describes value proposition as an overall view of products and services that together represent value for a specific customer segment. It describes the way a firm differentiates itself from its competitors and is the reason why customers buy from a certain firm and not from another.

C. Customers

5. Customer Segments: The target audience for a business' products and services.
6. Channels: The means by which a company delivers products and services to customers. This includes the company's marketing and distribution strategy.
7. Customer Relationship: The links a company establishes between itself and its different customer segments. The process of managing customer relationships is referred to as customer relationship management.

D. Finances

8. Cost Structure: The monetary consequences of the means employed in the Business model. Defines costs and can be used to analyse whether to make or buy from partner.
9. Revenue Streams: The way a company makes money through a variety of revenue flows. Defines income.

The model is still developing and the work related to improving it continues. [ZoAm11] reminds that the term can also mean different definitions for different authors. [Sep08] presents the problem of measuring resources and provides improvements related to it.

2.1.2 Changing Business model

Time and its´ effect on a Business model is not discussed much in literature. A Business model is typically seen as a snapshot [OsPi05]. [Ham00] and [LiCa00] discuss the fact that Business models change and this creates a need for a more conceptual and shared way of describing them. They also state that companies can use Business model as a goal that they are trying to reach. [LiCa00] categorizes these into four models: realization, renewal, extension and journey models.

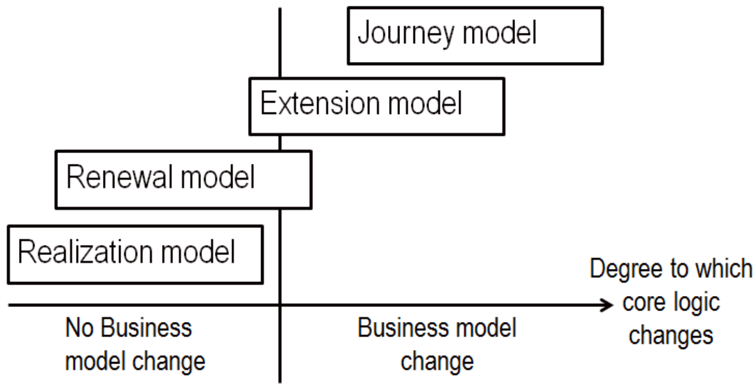

Figure 3. Business model types in change [LiCa00].

On *Journey model* the changes are the most radical and most of the nine basic building blocks mentioned in chapter 2.1.1 should be affected. On *Extension model* parts of the model remain the same but the majority is to be renewed. On *Renewal model* only some blocks are changed. *Realization model* is actually a description of the existing business model.

[Ost04] and [OsPi05] define the factors causing constant change externally to the following (currently and in the near future):

- Technological change: How the latest technology is made to serve the company best?
- Competitive forces: How to best adapt to current competition situation?
- Customer demands: What the customers want and what are the trends?
- Social environment (ethics, values etc.): How do the customers react to the values and ethics of the business?
- Legal environment: What legal, tax and other barrier factors can have an effect on the value to the customer?

The external drivers can cause change to any part of the Business model. According to definitions, it also seems that change in certain part may affect the whole network of companies. This means that the drivers can have an effect on many parts of the company level Business model. The change factors can be general but also business specific e.g. regulation in electricity distribution business.

Technological changes may be the most important factor which causes significant changes to competition and market offering. This is caused by the fact that many companies are not doing enough innovations as they concentrate on doing incremental improvements. This results in the present strategies repeating themselves. Business model changing is not taken into account sufficiently by the strategy in many companies. [Laa05]

Organization in terms of number of employees and know-how are another part of the business model change. This means that a change of business model may result in increasing or decreasing the number of employees. Additionally, it may cause the need for a new type of know-how or that existing know-how is not needed.

Traditional in-house type of structure for activities is changing towards a networked business model. The driving forces towards this change are the international players on the markets, future mass retiring and new possibilities provided by technology. In the new model, multiple partners participate to the whole process with their own core activities. This change also has an impact on companies' organizations where a new kind of know-how is needed. Outsourcing, service purchasing and management will be increasing activities in network companies. Information systems must better support new business models. This interaction is discussed more in publication [P1].

Figure 4. Interaction inside a Business model.

2.2 Activity based costing for analysing business process costs

In Business model definitions, one part of the model is to define costs. Cost calculation itself is a significant part of economic sciences and has been studied actively. Significant reference for cost calculation is for example [KaRo87].

Cost calculation is divided into two areas. General accounting, also referred as external accounting, contains methodology for creating income statement and balance sheet. The purpose of management accounting or internal accounting is to create information to support decision making, planning and operating the company [Dru00]. Management accounting has been discussed to have a significant role on the management of a company or a network of companies [Ten06].

The Activity Based Costing method (ABC) was presented first for manufacturing industry purposes [KaRo87]. Activity based costing is an improved and more accurate method for management accounting. Additionally, a balanced scorecard is developed to support the follow-up of long term goals.

Every economical unit can identify end product. In most cases there is a need for identifying the cost of the end product. An economical unit can be a single company, a single production plant or a group of companies. To be precise, the need is to identify the costs of products to be able to make decisions about them. The product decisions include decisions like what is the product portfolio, what are the manufacturing methods and what is done in-house and what is being purchased as service.

Activity based costing is a detailed model identifying the reasons for costs. It is based on the idea that each business process has separate functions. Each function consumes resources such as capital, tools etc. This usage of resources is the reason for costs.

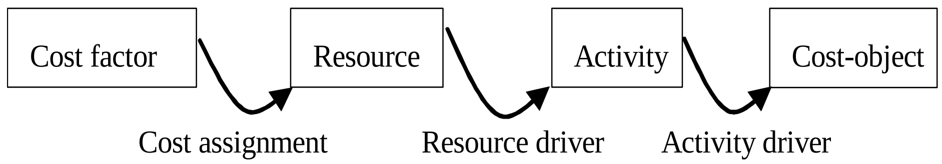

Figure 5. The principal idea of cost analysis for activity based costing.

Without proper tools and capabilities, the information systems gathering the cost data may require a lot of manual work. Firstly, the number of business process activities should be gathered. This creates the foundation for understanding their costs. Secondly, IT systems can support the automatic creation of accurate cost data of the activities if they are requested to do so. Energy sector specific software may not always support this for example in terms of collecting the number of processes conducted annually. This may limit the possibilities of collecting the required data from processes. Finally, the costs must be managed by the management of the company. This also requires know-how and good understanding of the results of the cost analysis.

One of the purposes of Smart metering cost analyses was to identify changes in business models. Also the “make yourself or buy as a service” type of aspects were studied.

Finally, costs and benefits were analysed. A key factor in succeeding in these was to use an accurate cost calculation method and have experience on similar projects. These analyses created later studies for example on more advanced Smart metering technology and service purchasing.

Make or buy decisions were not identified in the DSOs that participated in the Smart metering cost analysis project. Typically other aspects had been the issues these decisions were based on. One reason for this seemed to be that companies did not know the theoretical background completely and were unable to make these cost analyses by themselves. Also cost data gathering and support for this in the information systems were inadequate.

Activity based costing results can also be used as a framework for managing service purchasing. This has been discussed in more detail in publications [P5] and [P6].

ABC method requires more detailed data and calculations are more complex than in other methods. There are methods like Lean accounting. It is less complex but on the other hand offers limited support for service purchasing decisions. ABC method for company networks is studied in [Kul03] and results indicate that accurate methods providing reliable cost data are needed for company networks.

2.3 Service purchasing

In a Business model, a partner network is one of the elements that is discussed. This means that something is purchased from a partner in the network. According to [RoAr98] typically the reasons include issues like the need for special know-how, need for additional resources, decreasing or controlling operational costs, need to free own resources for other purposes and possibility to use service provider‘s best practices. Chapters 2.3.1 and 2.3.2 discuss succeeding in service purchasing and type of IT service. Chapter 3.2 and Publication [P4] discuss the results of a study conducted in the electricity distribution business.

2.3.1 Succeeding in service purchasing

Purchasing services requires preparations and studies on business processes. One framework for transformation from in-house processes into purchasing services has been presented in [Mci05]. It includes the following steps:

1. phase includes defining companies’ processes, organisational borders and especially different business processes.
2. phase consists of analysing the business processes’ value creation and criticality.

3. phase evaluates companies know-how related to that what is available at the service markets. In this phase at the latest it is also important to conduct cost analysis for example using ABC analysis. Also quality aspects such as delivery time and service level should be included into the analysis.
4. phase analyses finally the make or buy decision.
5. phase defines cooperation with service provider. One possibility is to use the purchasing portfolio [Kra83].
6. phase is the beginning of cooperation. This phase includes the selection of service provider, contracting and management of cooperation.

Before any company purchases a significant amount of any new type of service that they have not used before, preparations are needed. Firstly, an analysis of the company's own know-how, costs for processes and quality of in-house process is being analysed. These analyses can be conducted separately or as part of the companies' normal internal studies and collected information as part of on-going self-analysis. If necessary information for example of internal process costs are known, this may result in service purchasing requiring less resources and time and being done based on facts that can be benchmarked with possible service provider. For example, if accurate cost analysis is not conducted it is difficult to analyse the price of services by comparing them to your own work. As stated in ABC cost analysis, on paper the costs of in-house processes may not cover all actual costs. To avoid this it is better to use accurate cost analysis methods to have more accurate cost comparison.

2.3.2 Information system services

The Internet has opened many new business opportunities and changed the way many of the existing companies operate. It has been a large technological change driver for Business models. IT has also changed to as a result of the Internet. According to [BaWy02] IT outsourcing started at Client Server in the 1980´s and continued with web hosting service providers in the 1990´s.

Application Service Provisioning (ASP) or Software as a Service (SaaS) means that the application is running on a remote server also known as "cloud" and is operated by using an Internet browser. Usage of the Internet is the key feature compared to the traditional model of purchasing and maintaining software applications. ASP applications are programs that are used through a web page browser. Applications are located on distant and centralised servers that are operated by the Application Service Provider (ASP) or its partners. In addition to purchasing software as ASP, the purchase can include more value and is called Business Service Provisioning (BSP).

General discussion about ASP is presented in [P1]. ASP has advantages compared to traditional information systems installed to users own ICT infra. It also has challenges which can be managed using Service Level Agreements (SLA). Advantages of ASP are that less human resources are needed for operating systems. These resources can be used for more core type of tasks in companies. Also specified IT persons are needed less. ASP makes is possible for Small and Medium Size Enterprise (SME) to acquire more expensive software solutions for their purposes. Applications can be scaled for different size of usage. The amount of ICT equipment especially servers and their support equipment are needed less and this saves costs. Implementation can be done faster as installation phase is not needed in same extend that in traditional information system. ASP solution is more efficient in delivering information and this is important in networked company environment. Challenges that ASP faces can also be identified. At the time ASP was not established the usage of the Internet was seen possible threat. Information security requirement in ASP is more important than in traditional software. Another important issue is who owns the information and can use it. Customer specific tailoring is expensive as ASP is same solution for all. Finally reliability of ASP company is what makes the solution safe for users. SLA agreement defines responsibilities and rights of each party. This is important to define at the time implementing. Usually this relates to problems and faults. SLA also defines service level and compensation when it is not met.

3 Electricity distribution business characteristics

3.1 Electricity distribution business in general

Identity of the Electricity distribution business can be described with highest concern on safety. Technology used must fill safety requirements that are higher than in many other businesses. After safety reliability requirement is important. Society is increasingly depending of electricity. After these requirements costs are considered. Finally the life-cycles of technologies are typically several decades. These factors define electricity distribution business. New technology and service innovations must meet these requirements. Electricity distribution is not considered the most advanced business and changes typically happen slowly compared to other businesses.

Distribution system operators (DSO) receive their income from distributing electricity to its customers. This is done through an electricity distribution network which is the main asset of DSO´s. Owning and managing the distribution network consists of several business processes. Regulation sets the framework for pricing and quality of the electricity. This is due to the fact that distribution business is a monopoly business where the customer cannot select from different suppliers.

Planning takes place in several business processes. In addition to any general business and development planning, network, terrain, work, structure and investment planning are parts of DSO planning processes. After the planning processes, network construction takes place. This can either be building new network or replacing the existing network. Condition inspection and monitoring are done to the network and its components throughout its life-cycle. Maintenance work is also important with long life-cycles and reliability requirements.

Network operation takes care of operating the network so that it is safe for the customers and electricity availability is the best possible even in fault situations. Especially overhead lines may suffer weather related faults and fault repairing is done after faults are being detected.

Measuring energy consumption from the customers is the basic function for income for the DSO. Additionally, measurements from different parts of the network provide information for several business processes such as network operation and planning. Measured consumptions are processed in balance settling. Customer service is about taking care of customer contacts related to billing or for example fault issues.

Typically the processes of the distribution business are done in-house. However, outsourcing and service purchasing have become part of the distribution business in the recent years.

Information systems have important roles in many of the processes. A distribution business can be characterized as information intensive business. Also many of the ICT solutions are business specific, so managing them is part of many of the processes.

3.2 From in-house operations to networked Business model

The future of the network level Business model was studied in [PaVi05]. Alternative future scenarios were created and then a relatively large group was asked which is the most likely and desired alternative for future business models. The result was that the networked Business model scenario was the most attractive and most likely one ~~by~~ according to the group of industry professionals. This means that DSO´s are transferring from in-house to outsourced operations. This means that the complexity of the distribution business is increasing, also in the management of IT systems as presented in Figure 6. The number of service providers is also increasing in many of the business processes in the near future.

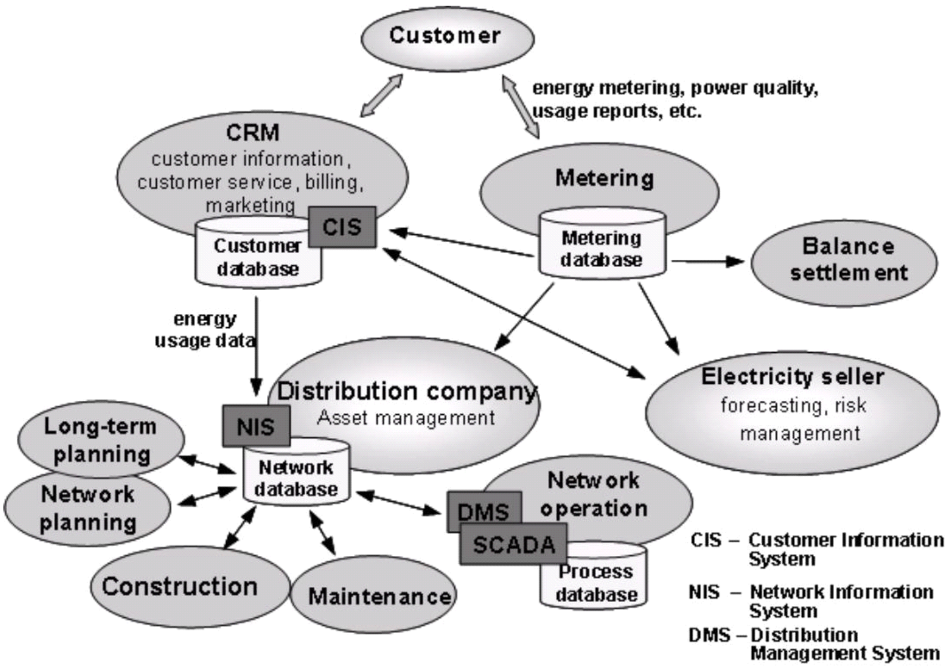

Figure 6. Data management in a future business environment [P3].

3.2.1 Experiences in electricity distribution industry

In publication [P4] the general findings were that service purchasing is increasing in electricity distribution industry. This also means that part of the internal management is changing to managing resources outside the company. Succeeding in this requires both knowledge of the theory of service purchasing and experience in it. With this know-how it is possible to update the strategy of the company and create a Business model supporting these types of business processes.

General findings on the risks and benefits of purchasing services have been presented for example in [KrTu06]. In [P4] risks related to service purchasing identified by DSO´s were:

1. The number of service providers is too small for a truly functioning market of services
2. Targeted cost savings aren't realized
3. IT systems cannot support service purchasing
4. The relationship between service buyers and providers doesn't meet expectations
5. Loss of know-how in the organization of the DSO that is purchasing services

Correspondingly, the benefits of service purchasing were identified in order of importance:

1. Getting additional resources becomes easier
2. Possibility for the DSO to concentrate on the core business
3. Cost savings
4. Access to the best practices
5. Better cost awareness

Risks and benefits varied a little in case of each process although those presented above cover the majority of them. When asked about satisfaction and reaching goals set for services, the results were positive. Key results of publication [P4] are presented in Tables 1 and 2. Benefits from the service purchasing seem to surpass the risks as satisfaction towards the services purchased was high when considering answers on a general level.

Table 1. Met goals for purchased services according to company size.

Reaching goals	Large	Medium size
During first year	52 %	64 %
During first 3 years	40 %	32 %
Not reached	8 %	4 %

In [P4] one of the findings was that medium size companies are more active in purchasing services. In Table 1 it is also seen that they seem to meet goals set for purchasing services faster than large DSOs. Meeting goals along the agreement period with the service provider is also higher among medium size DSOs.

Qualitative results from services were collected by asking the DSOs´ for their level of satisfaction towards the purchased services. Results for this according to company size have been presented in Table 2.

Table 2. DSOs opinions of the services purchased on a general level.

Experiences from services	**Large**	**Medium size**
Very satisfied	6 %	19 %
Satisfied	72 %	51 %
Neutral	17 %	20 %
Unsatisfied	4 %	7 %
Very unsatisfied	1 %	3 %

Publication [P4] also indicated that service purchasing is generally increasing and transferring towards independent service providers. So far service providers that have shared ownership with service purchasing DSOs are common partnerships in many services.

The role of IT systems is significant in service purchasing and according to [P4] they also cause a significant risk and an actual barrier limiting the usage of services. DSOs should make an effort to actively look for solutions to these problems and invest on systems supporting service purchasing. Case studies also revealed that the best practice is to benefit IT also in tender and order phases. This means sharing documentation and providing access to IT systems. One DSO said that this is obligatory for the managing services purchased.

Changing from in-house business processes towards a networked Business model also requires changes inside the distribution companies. Previously know-how has been used on work management but in service purchasing it must be used on defining what is being purchased, what are the key performance indexes (KPI´s) to measure quality of service, what kind of legal agreements are set, how the information systems are following service purchasing and how to support service markets. The risks DSOs see related to service purchasing can be controlled.

This is not an easy task and it seems to take several rounds of purchasing to practice it. From distribution companies’ management point of view, this change in the Business model should be taken into close consideration. Success in management makes this transformation a lot easier in long term.

Related to services there are frameworks that are designed to improve organization's performance. One of these is Capability maturity model Integration for acquisition (CMMI-ACQ) presented in [SEI10]. It defines different levels of organization's maturity to acquire services. On the highest optimization level organization is gathering information to further improve its acquisition processes that are defined, trained and managed.

In electricity distribution business network construction is one of the most mature service. This is due to the it´s well defined content and methods. For example network structures are defined so that they are similar so that each contractor offers more comparable service. Also the information exchange is defined on information system interface level and different systems support this. This type of service purchasing can be used as a benchmark for improving processes for purchasing other services.

3.3 Information systems and their role in business processes

It is often said that electricity distribution is very capital intensive. Additionally, it can also be characterized as an information intensive business. The role of information systems is often very important in many of the business processes. This also has an impact when possibilities and limitations on business development are studied in the field of electricity distribution. As most of the systems are highly specified only to electricity distribution, they are also big assets to the electricity distribution companies.

Typically each system has its own role which must be carefully considered when looking at possibilities and limitations for business process development. Often even excellent ideas are very difficult to carry out as replacing or developing information systems cause significant costs and may limit the possible savings on business process development.

Many of the DSO´s information systems are used in several business processes. The systems also use information from many other systems which creates a need for interfaces between different systems. Also a great deal of information is exchanged between a distribution company and other parties such as customers, electricity suppliers and service providers. This makes the information systems very important for the DSO´s. Change drivers of Business models may result in situations where the IT systems can also limit the possibilities to cope with the change.

According to [P3] the most significant problems for DSOs using information systems are system interface problems, technical problems or inoperability, lack of user skills resulting in not being able to fully benefit from systems and also program errors. Results also indicated that many systems are underutilized so that only a part of the system features are used. Other problems that the survey showed were integration problems, long implementation process and problems with software specification. Distribution companies defined that in implementing a new system, 15-50% of the total system cost is the company's own work effort.

From the final results of the survey it can be seen that application integration is clearly the biggest problem as it is time-consuming and costly. Also the number of system vendors makes the integration challenging as there are different systems from different vendors.

Inoperative connections result in underutilization and storing multiple data. The same data may be stored in many systems in slightly different forms and with slightly different names. During integration this inconsistent use of identifiers causes additional work and can make the testing more demanding.

As a result, these aspects should be taken into account when DSO evaluates their systems and their know-how when business model faces a change.

The 1995 electricity market liberalization introduced the separation of electricity sales and distribution. This change did not cause significant changes in the information systems although it was recognized that especially customer information systems were not fulfilling their tasks completely in the new business environment.

Information systems also have life-cycles. Even as systems are updated they still have an end to their life-cycle. This issue should be considered in distribution companies when they analyse their Business model concerning information systems.

In a questionnaire survey carried out in early 2003 for Finnish distribution companies and service providers [Try03], Application Service Provisioning (ASP) was mainly used in supporting business processes such as office type of work. Since then the amount of different applications and customers using them has increased. Currently ASP service is used also in electricity distribution business. In [P4] Smart metering as ASP is increasing. Also more advanced measurement systems such as one presented in [P8] are becoming more common.

As discussed in chapter 2.3.2, information system services may provide solutions to the problems mentioned earlier related to system integration difficulties.

4 Smart metering development

4.1 Functionalities and implementation

Smart metering is currently being installed in many DSOs especially in Europe. As Smart metering is a large investment in electricity distribution, it has also been researched. Studies cover a wide variety of issues starting from implementations to technical details of specific parts of Smart metering. Many studies such as ones presented later in this chapter have also been written on the additional features of Smart metering.

Generally, the legal and regulatory drivers for Smart metering are country-specific. Also the details related to organizing metering functions may vary in different countries. For this reason it is most reasonable to cover the drivers with longer and more general impact. Climate change and environmental issues are in many cases the most significant global issues pushing advanced metering.

Actual processes for creating laws trying to push for the implementation of Smart metering were made in around 2007. The European Parliament introduced "The EU climate and energy package" in which they set targets to be met by 2020, also known as the 20-20-20 targets, that included:

1. A reduction in EU greenhouse gas emissions of at least 20% below the 1990 levels
2. 20% of EU energy consumption to come from renewable resources
3. A 20% reduction in primary energy use compared with projected levels, to be achieved by improving energy efficiency.

In January 2008, the European Commission proposed binding legislation to implement the 20-20-20 targets. This 'climate and energy package' was agreed by the European Parliament and Council in December 2008 and became law in June 2009.

More detailed following obligations have been set to member states:

1. Energy end use efficiency and energy services directive 2005: Provide for the possibility of using energy efficiency and demand side management as alternatives to new supply and for environmental protection.
2. 2006/32/EC2006/32/EC Article 13 & 3rd Energy Package: Member States shall ensure the implementation of intelligent metering systems – subject to an economic assessment.
3. 2006/32/EC2006/32/EC: The consumer should be provided with information on actual consumption often enough to enable customer to regulate his own energy consumption.

Following the EU legal development, Smart metering projects have been started in many European countries. A more detailed country by country situation during spring 2011 is presented in Table 3. Update on Norway can be found in [SaKr12].

Table 3. Status of Smart metering in European countries [Str10]:

Country	**Status**
Sweden	Completed
Italy	Completed
Finland	80 % by 1.1.2014
Norway	1.1.2017 [SaKr12]
Denmark	Discussion
UK	Mandatory
France	2012-2017
Spain	2018
Austria	Discussion
Belgium	Discussion
Germany	Postponed
Netherlands	Postponed
Portugal	Postponed
Greece	Postponed

Smart metering has been studied around the world from several perspectives. Following paragraphs presents different studies that provide more information about concept of smart metering. Total concept by author is presented in Figure 7.

Extensive implementation considerations have been studied [MaRa95]. [MaCh99] describes the complexity of Smart metering systems and presents technical development pathways to understand the competing driving forces in developing Smart metering systems. Possibilities of providing energy and non-energy related services with Smart metering ´s telecommunication are being discussed in [New96]. Home automation and integration with Smart metering has been discussed since the 90´s for example in [HoKu91]. More up-to-date home automation solutions related to Smart metering and including dynamic pricing based controls is presented in [Voj08]. Also the role of smart loading of electrical cars is discussed [RaRe10]. The multi-utility concept meaning the utilizing of Smart metering to collect other quantities such as water, gas, central heating etc. is studied and evaluated in [LeEu08].

Single technical feature and value adding services are being discussed in many publications. In some markets, the important feature is detecting illegal electricity usage [PaMi07]. Load studies are presented at least in [Sur91], [YuYa06], [WaBa07], [KePh08] and [MuRe11]. Also state estimation can be seen as a possible tool using Smart metering [MeTr05] and [MuRu11]. In Nordic countries, load management is seen as one of the most important issues and it is discussed for example in [GrIk04]. Using Smart metering in transformer condition assessment is presented in [Pyl10]. The idea is to use Smart metering measurements with calculation methods to estimate the life cycle of a transformer. Developing countries also seek benefits and concepts for Smart metering. For example, a study made for India is presented in [Ker05].

Power Quality monitoring using Smart metering is studied e.g. in [MäPa01] and [MoDe08]. Wider perspective and higher level of data automation including ICT has been presented in [Cha05]. Also a more comprehensive low voltage network management concept including medium voltage network monitoring capabilities has been presented in [JäVe07]. This publication presents many new aspects on using Smart metering in network monitoring. Each functionality is built starting from the user's perspective and finally ending to the meter. This improves the total concept as also the users are taken into account and not just a certain part of meter or ICT. Figure 7 describes Smart metering structure and functionalities.

Smart metering can be seen as layers of functionalities and features. The basic infrastructure consists of Smart meter, communication into the main system, management software and parameters including meter asset data such as meter types and features like breaker attached to the meter. This data can include information like meter number, number of user site and possible registers that can be used related to other Smart metering functionalities. The interfaces and additional devices layer consists of devices and interfaces that provide physical components to increase value that the system can provide. Smart meters can gather information also from multi-utility meters or sensors. This information can be related for example to water and gas. Home automation interface can be used for example for providing real time consumption data for home display or more advanced home automation. Breaker device can cut off power supply from the customer. It can be made automatic such as in [JäVe07] or it can be manually operated for example due to unpaid invoices. Another version of control can be provided adding controllable relays to meters. This can be used for controlling loads such as water heating based on time tariff or with more price variant tariffs when the selected price limit is passed. It may also provide possibilities to apply demand response based on need from the energy retailer or DSO. Basic register layers provide information for billing, balance settling, usage reporting, outage reporting and finally to DSO´s network planning and monitoring processes that utilize load data in their information systems. On top of these basic functionalities, Smart meters can be equipped with more advanced metering and calculation features. Smart meters have functionalities to electricity network fault, electricity fraud, fuse current and voltage quality detections. These 4 layers of functionalities create the Smart metering concept. The total value of it for the customer, DSO and energy retailer however is created by integrating Smart metering into operating systems. This also requires that systems can utilize functionalities offered by Smart metering.

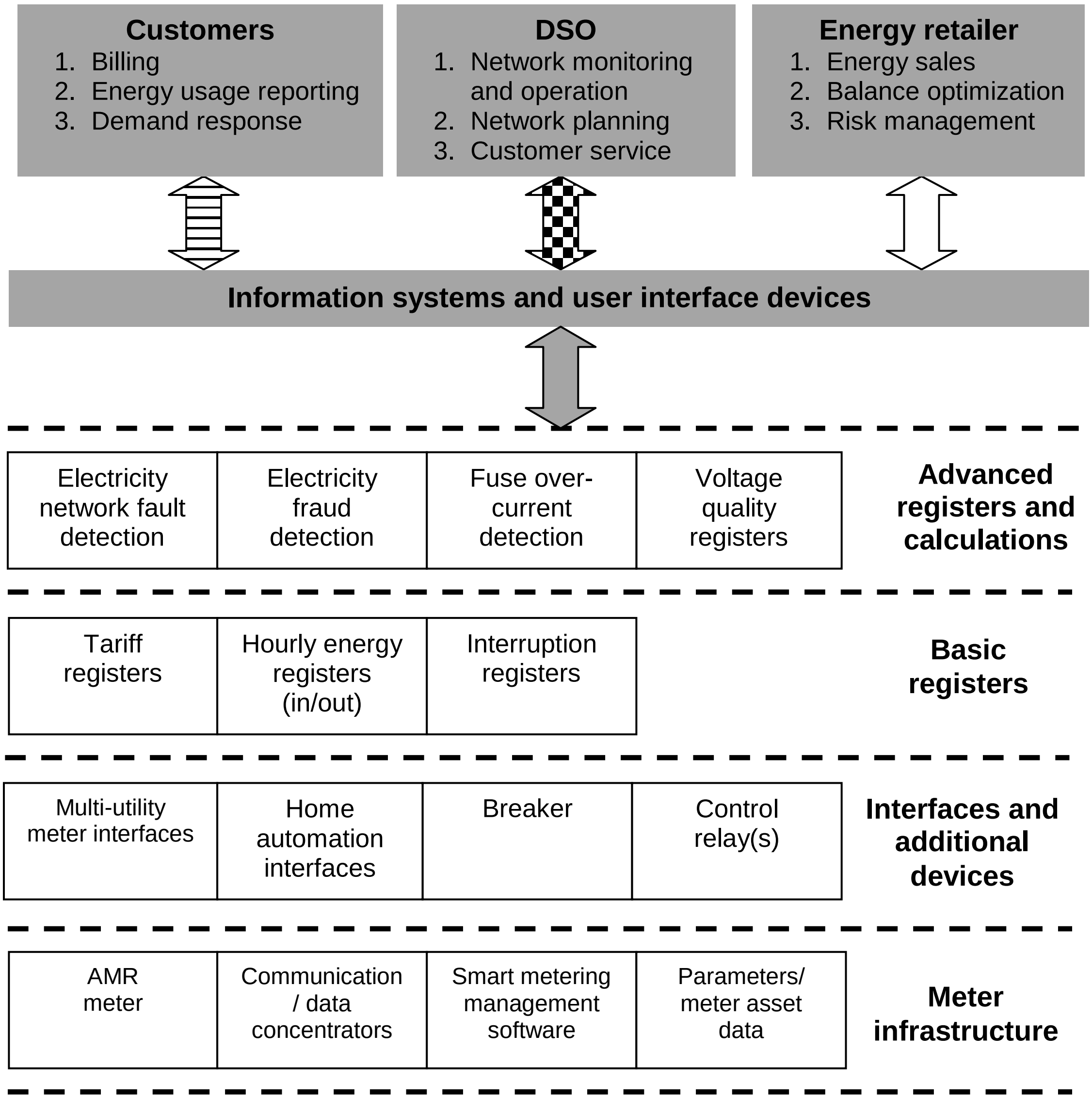

Figure 7. Organized Smart metering structure with functionalities and information using.

As discussed in the literature, Smart metering offers a large variety of functionalities. The change from a single energy consumption reading on site to daily and automatically collected hourly data is quite large. Advanced functionalities delivering additional value discussed in Figure 7 add to the complexity of Smart metering. To make implementation easier, the final realization should cover a wide variety of issues. This kind of analysis are presented in [TrJä06]. The final functionality of Smart metering is not only a matter of the DSO´s selection. Regulation and legislation may drive them to implement new functionalities of Smart metering. For this it is important to follow the legal aspects that may force changes to take place.

When considering the desired Smart metering, there are a lot of details to study. Firstly, the meter price should be in balance with the benefits available. Looking at the life-cycle costs analysis results presented in [P6] it can be seen that the meter itself presents a large portion of the cost. Secondly, utilizing all the possible features requires more than just installing new meters. The integration to information systems and designing them to support the desired Smart metering features is not a very simple task. This was one of the problems related to developing concept presented in [P7]. As stated earlier [P3] the integration issues cause challenges to DSOs. Data exchange between different systems is not always designed to function in different systems. Also not all the features are supported by existing operational systems. This may result in the need to update or replace them. Finally, information systems also need the users. Most of the features also require human interaction and involvement. This means that resources in terms of amount and know-how are needed for utilizing the value offered by Smart metering.

4.2 Smart metering business model framework for DSO

For more detailed and systematic analysis for discussing Smart metering, this dissertation is using the Business Model framework. According to the Business model theory presented earlier in this dissertation, an organized model can create better understanding of a selected business area. Transfer from traditional meter reading has changed many of the DSO´s processes.

Before Smart metering, the majority of electricity consumption metering was done manually. Consumption was one number per year that was collected from the meters either by the DSO´s specific meter reading employees or by the customer who sent it to the DSO. Electricity billing was based on this single annual consumption figure. Loading models or curves presented a more detailed estimated consumption on functionalities that required more detailed data. Balance settling and network calculations were based on these factors. Majority of the costs for operating manual meters were labour-related.

Automated meter reading and requirements for hourly consumption metering have changed the organizing of energy consumption metering. When looking at the cost comparison presented in [P5] and [P6] the capital costs for Smart metering infra are the highest cost factors. This cost difference between traditional and automated meter reading also indicates the differences in these two models. Applying the Business model for Smart metering can create a broader understanding of this issue and provide additional information on how to analyse similar changes in future electricity distribution.

The following chapters 4.2.1-4.2.9 discuss Smart metering Business model based on a Business model by [Ost04]. The idea of this model is to present it so that it can be either part of a DSO or a separate functionality.

4.2.1 Value proposition

The main offering of Smart metering is to provide billing data. In the DSO´s environment it is mainly electricity consumption but it can also be other quantities such as heat and water. Resolution of data may vary depending on regulation and type of customer. This data is used to bill electricity distribution. Additionally, it is distributed to energy retailers for their billing purposes. For example in Finland the regulation will require the DSO to deliver hourly consumption data once a day. Additionally, meters can contain registers for example for monthly readings or they can be created in billing systems calculated from hourly readings. Smart metering is the only option when detailed consumption is required on a frequent level. The only solution suitable for delivering hourly data every day is Smart metering. Or at least collecting values manually so that it is available daily is not possible by traditional manual meter reading unless the consumers do it by themselves. In this model DSO cannot trust that this is working every single day from every customer. Billing data can also be distributed back to the consumers via separate reporting systems so that they can monitor their own electricity consumption on a higher resolution. This can also be used for energy efficiency improvement purposes by the customers.

Compared to traditional metering, Smart metering can also offer additional value. In publication [JäVe07] low voltage network monitoring development is presented. This project started from the DSO´s idea to get additional value from a Smart metering investment. This was based on more accurate data presented in [P6]. The basic idea was to create functionality that can create information of different network faults. This information is then delivered to operational information systems monitoring the network. Later, similar functionalities are in operation in several Finnish DSOs. Actual load profiles can also be used in network planning purposes depending on whether or not the information systems support this type of functionality.

Additional value can also be created by measuring if customers have electricity available. Depending of the manufacturer power quality related information can be monitored on a basic level. Relays in Smart metering meters can also be used for several purposes. These can be connecting/disconnecting loads based on tariffs. Additionally, they can be used for Demand response purposes. Street lighting can also is controlled by relays in Smart meters. If meter and metering system has support distributed generation(DG) can be monitored and even controlled by relays in meter.

When defining the final value that Smart metering provides, it is important to understand that not everything needs to be done using Smart metering. In some cases more cost effective solutions with higher offerings can be used. One example of a system providing support for network operation and several other functions such as life-cycle analysis and fault analysis, is presented in publication [P8]. Presented system has capabilities that AMR system cannot offer, for example fault detection or recording accurate disturbance data.

In many of the presented value propositions, there is a common feature. Smart metering acts as a system providing the possibility to adopt additional features. But utilizing these additional values takes place in other information systems than Smart metering. This is because Smart metering provides the information but has limited reporting features itself. [P3] presents many problems related to information systems and their interfaces. These problems include for example system interface problems, inoperability and lack of user skills. Such problems may cause technical and operational issues that must be solved to fully exploit the value proposition of Smart metering. Also when purchasing a Smart metering system it is necessary to define what the offering is that is needed by the regulation and what is needed from the DSO´s own perspective. New functionality can be added later with updates but their costs may be high, for example if Smart meters cannot be updated remotely. Updates can include new tariffs and new features related to meters capabilities. This is done based on new regulation or recommendations or by DSO´s needs.

4.2.2 Key activities

Defining activities for Smart metering is related to the actual offering Smart metering provides. Activities can be divided into acquisition, operation and renewal of the system when its life cycle is nearing its end.

Typically a Smart metering system is a large investment. Depending of the acquired solution it may exceed budget of DSO for single year. This is one of the reasons why this purchase process may be under legislation in many countries. In European Union, the Act of Public Contracts defines procedures to DSOs that are publically owned. This law also known as the public procurement law sets limits for purchases that must follow specified procedures. Typically Smart metering investments fall into this category. For example when preparing to acquire Smart metering, the DSOs must make a public announcement of the plan. They must also specify the details of their acquisition plans. When making the final decisions, all the offers must be considered equally and aspects of the final decision must be published. When looking at purchasing activities, one of them is defining the purchased Smart metering concept and following the guidelines of the purchasing law and making sure that local regulations concerning metering is met.

After this the final contract is to be signed and for that also legal knowledge is needed. Installing Smart meters in the field and to the Smart metering system is one of the tasks related to implementing the system. This task includes replacing old meters for existing customers and installing new meters to new customers. Additionally, faulty meters may have to be replaced. Handling the logistics and storing of meters is part of the installation process. Other dimension is that the installation process should be done so that meter and consumption information are handled properly. This means that metering information and customer information must be updated correctly. This may require an interface from the customer information system to the Smart metering system to support this data exchange. In some cases meter installers use field computers to make the data exchange to different systems in the DSO. These functionalities must be available before the mass installation begins so that installation at metering site is optimized. Visiting the metering site is one of the largest costs in the metering life cycle as presented in [P6]. Lowering the amount of visits per meter is important for making the cost structure as optimal as possible. In the implementation stage, the integrations from Smart metering to different operational systems must be planned so that functionality requirements are met. This may require discussions with different system vendors. Interfaces are important when the offering of Smart metering is to be exploited. One standard supporting the system integrations is e.g. IEC 61968-9. Additionally, the systems receiving Smart metering data must support this by their functionalities. If not, additional development is required which may present the need for the DSO to participate in the specification process. Publication [P3] presents a more detailed discussion about IT systems in the energy distribution business.

In the production stage, running the system is one of the key activities needed. Some DSOs prepare for production with piloting the system. This may also be part of the final contract. One of the activities is to monitor that the system is delivering the required information. This process is typically constant and should be done so that for example missing data can be found with enough time for maintenance work. Missing readings may require an on-site visit. If they are received later, this must be taken into account in interfaces with different systems. If readings are lost the way of solving this must be specified. It can be for example estimation based on previous data. This can be done in Smart metering reading system or systems handling Smart metering data. Local regulations and recommendations may set procedures and time limits for repairing measurement data. As discussed before, the role of the metering businesses is to deliver information to other business functionalities that exploit it. These business processes may need help and support related to Smart metering system and its features. Support may include issues like false and missing readings, updates on other DSO´s operational information systems or in Smart metering systems providing new functionalities.

A Smart metering system has to be replaced when it is nearing the end of its life cycle. Basically this means that there is a need for preparing the replacement. Similar activities are needed as in the previous acquisition process parallel to running the current system until its replacement.

When looking at other activities related to Smart metering described earlier, the know-how of different aspects of Smart metering is important. It is also different compared to traditional metering. For example the role of communication and more advanced information system interfaces require new types of knowledge. This is one of the aspects to discuss when considering resources.

4.2.3 Key resources

Resources can be described as physical, intellectual, human and financial. These are elements that are needed for creating the value proposition. The whole Smart metering system consists of several physical elements. One key element in Smart metering is the Smart meter. It includes physical components as well as software. Metering data is delivered from the meter using communication. For communication there are several solutions in use. They can be wired, wireless or a combination of the two. In Finland, the most typical ones in use are Power Line Carrier (PLC), Mobile or radio communication. For energy measurement purposes communication requirements are that for example hourly data must be delivered to DSO daily. This is data consisting for example 24 values in each register of the meter. Delivering this does not require high bandwidth but reliability so that it can be delivered for example in some hours. Other features such as network fault detection require more real time communication. One key resource is the main software for Smart metering management. For this, proper servers and related IT components are needed. For communication data, security systems such as Virtual private network (VPN), encryption method and firewalls may be needed. Other physical components can be field computers and other installation and testing tools. Physical resources are part of capital expenses that are calculated in publications [P5] and [P6].

Data is one of the forms of intellectual resources. Smart metering creates and contains significant amounts of different kinds of data. Smart metering infra itself has several identifiers and addresses. Additionally, there is data required to produce the value proposition discussed in Chapter 4.2.1. Also backups to restore the system or parts of it are needed.

Human resources can be discussed in terms of capacity and know-how. The majority of resources can be defined by looking at the key activities in Chapter 4.2.2. Smart metering concept definition, purchasing process and contacting require human resources. Installation project for meters and systems require planning and executing resources. The operational phase also requires the capacity to monitor the system, conduct maintenance operations and give support. More detailed resource planning can be based for example in cost analysis. Amount of direct, indirect and fixed labour is presented in publications [P5] and [P6].

Finally, financial resources are needed to cover the Smart metering investment. The final contract agreed with a selected Smart metering solution vendor defines part of the need for financial resources. As Smart metering is usually a relatively big investment, it is important to find the proper financing method.

4.2.4 Partner network

According to [Ost04] three motivations for partnerships are optimization and economy, reduction of risk and uncertainty and acquisition of particular resources and activities. Publication [P4] presents studies of DSO´s service purchasing from different partners. The publication also presents short theoretical background for this issue. The make or buy decision concerns several of the resources discussed in Chapter 4.2.3.

Firstly, the Smart metering system vendor or vendors are the key partners. They provide the technology or part of it. They can sell meters but also provide Smart metering system as a service. Alternatively they can sell the Smart metering system and provide support for it. The second possible partner is a telecommunications provider. In some cases it may be better to use a partner rather than build an entire telecommunication infra by yourself. The need for a telecommunication partner may also depend on the acquired Smart metering system and its technology. At least in Finland there are Smart metering system vendors and telecommunication companies providing services such as meter reading service.

In the acquisition process, possible partners can be used for tender process in such tasks as preparing the tender, providing assistance in comparing offers and assisting in legal issues. After the conclusion, independent partners may be used for project management. Installation resources can also come from a partner.

Cost calculations and analysis of own resources in terms of capacity and required know-how are important when selecting partners. In publication [P4] the main issues for purchasing from partners were:

1. Getting additional resources becomes easier
2. Possibility to concentrate on the core business
3. Cost savings
4. Access to the best practices
5. Better cost awareness

4.2.5 Cost structures

Costs of traditional metering compared to Smart metering are different. In [P5] and [P6], the activity based costing (ABC) method is used to analyse metering cost structures of five actual Finnish DSO´s. The Smart metering infra increases the capital costs compared to traditional metering. On the other hand it creates possibilities to offer additional values that traditional metering cannot offer. In Figures 8 and 9 actual life cycle cost analysis results from Finnish DSO´s are presented. In both figures numbers 1-5 in parenthesis in front of each process names indicate different DSO.

From five different companies the result is 11 optional ways of producing metering function. This was done by calculating all the possible solutions when using the traditional / AMR reading and in-house / outsourced operations.

Parameters used in calculating the results are following:

1. 20 year life cycle.
2. One meter assembly in each life cycle cost.
3. The results have been calculated to be more comparable by calculating annual reading once a year in to all of the processes.
4. The rate of moving used is every 5th year. In 20 year life cycle this means 4 move readings.

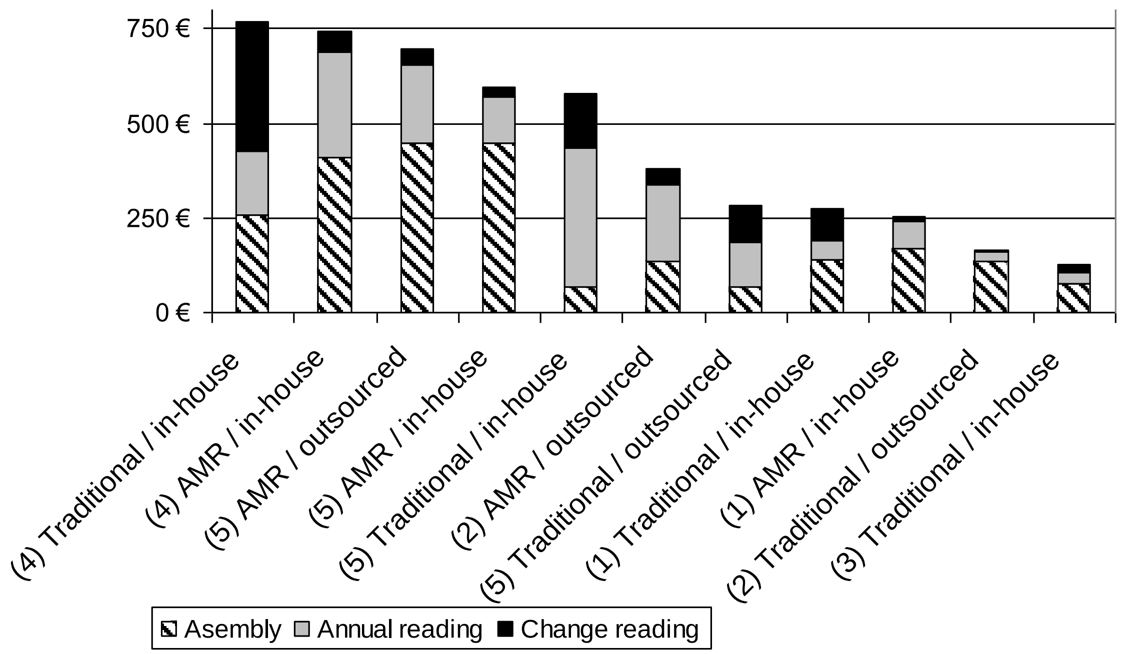

Figure 8. Metering life cycle costs in a 20 year period by different activities.

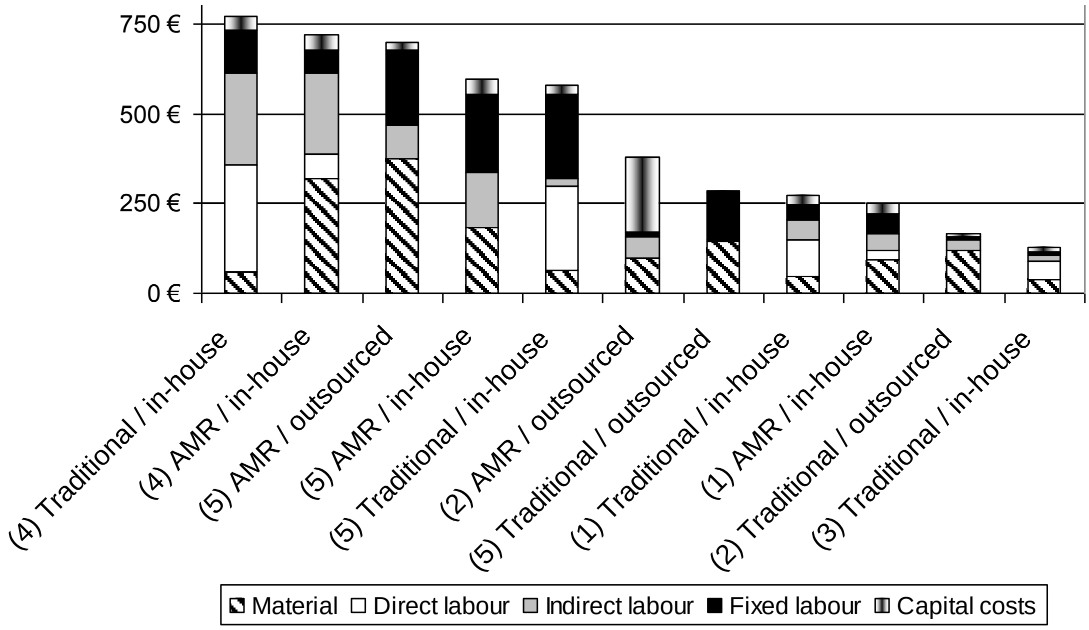

Figure 9. Metering life cycle costs in a 20 year period by different cost factors.

Cost structures vary depending on the type of organization, area and customer density. Statistical analyses of the possible explaining factors are presented in publication [P6]. However the data collected has limited reliability for accurate statistical analysis. This is due to different cost data gathering and reporting processes, small amount of DSO´s and the fact that costs are based on testing Smart metering rather that full scale optimized solution. Additionally to statistical analyses following discussion can be presented of Figures 8 and 9.

In Figure 8, the costs for different activities from meter assembly to readings are presented. In traditional metering, the reading that follows a customer moving out and another one moving in forms a significant portion of total costs at least at three DSO´s results. In Smart metering this change reading portion of costs is lower. This is due to that the reading can be done similarly than in annual reading. This means lower resources and lower costs. Other differences of costs in different processes can be explained by the differences in organizations and also in the process design. For example relation between reading meters on site and by reading card sent by customers is different. In change reading the amount of readings and how the process was organized causes the cost differences. Also the distribution area size and customer density can be explaining differences.

In Figure 9 differences between five presented companies can be explained several factors. One is that results are gathered based on testing Smart metering solutions on a small scale. Different amount of labour can depend from organizational issues and also on what were actual tasks and how was the work reported to the systems. Material cost differences are explained by meter costs. In AMR outsources the large portion of capital cost is due to calculating service cost as capital cost. Amount of fixed labour is different in different companies and even in processes in same company. Fixed labour is work done by general employees not related to metering.

When results for [P5] and [P6] were gathered DSOs were on very early pilot phases. Also the processes related were not optimized. The amount of work related to implementation and operation was also uncertain or not reported. These uncertainty factors limit the possibilities of further analysing the data. Results can give magnitude of the different processes but not the exact life-cycle cost. However the ABC method could be used also for this kind of research. It covers own costs of DSO and as such gives better information to support decision should Smart metering be purchased or do self. These types of results could also be used for following stages by DSOs. Cost structures can be managed. For example amount of fixed labour could be analysed in more detailed. Is this due to not enough resources on teams or employees working closely with metering or processes that needs optimizing. Such analyses require sufficient information of the DSOs´ processes. Cost management means that target levels for costs are set and then monitored. This can mean both own and a partner's costs. More about this is presented in [P5].

4.2.6 Revenue streams

Revenue streams of Smart metering are more difficult to define due to the following reasons:

1. As electricity distribution business in a monopoly, there is no competition of how metering is priced. This is the case when the DSO is responsible for metering. If energy retailers are responsible, there are possibly more transparent revenues of metering.
2. When the DSO is responsible for metering, the metering revenues may have been included in the total price of distribution and cannot be easily separated. If metering is purchased as a service from a service provider, this revenue can cover all costs or alternatively the DSO can purchase meters and buy only the reading service for example for monthly fee.
3. The value from metering is divided into the DSO´s processes where they can exploit revenues as additional benefits for their own operations.

In [KäKo06] revenues of Smart metering or AMI as used in reference have been divided into three different groups:

1. Revenues of Smart metering for Distribution system operators are:
    - Load optimization to replace network investments
    - Fault detection and faster fault clearing to reduce outage compensations

- Billing of consumption and production
- Better calculation of losses
- Possibility to recognize some Power Quality problems
- End of non-scheduled manual readings etc. when people move

2. Revenues of Smart metering for the end customers:
   - Faster customer service
   - Possibility to save energy on peak price hours (only if tariff causes peak prices and demand side management is possible)
   - Possibility to have more accurate data on consumption (required for example in the EU by the 20-20-20 target)
   - Different kind of billing options

3. Revenues of Smart metering for energy sales:
   - Real time knowledge of the actual consumption
   - Limit the uncertainty of type curve calculations
   - Possibility for better optimization of purchases in electricity exchange
   - Renunciation of the balance calculation (not needed anymore)

4.2.7 Customer segments

As stated in Chapters 4.2.1 and 4.2.6, depending on the Smart metering concept and local regulation, the DSO’s other processes and end customers can be customers of Smart metering. For example network operation and planning can exploit Smart metering data in their processes and improve their performance compared to traditional metering. In addition to the DSO´s processes, the customers of the DSO´s can utilize benefits from Smart metering. They also benefit from the DSO´s processes being improved by Smart metering. End customer segments can be found when looking at what the customers can achieve through the DSO´s Smart metering:

1. Customers can see their energy consumption in more. This benefits especially larger customers.
2. Customers can have shorter outages after faults if Smart metering system supports this kind of functionality.
3. Customers can have electricity bills based on their actual consumption for example monthly.
4. Customers can benefit from quicker power quality problem solving if DSO´s can utilize this monitoring from customers meters.

Customer segments for different kinds of Smart metering functionalities can be for example:

1. Customers with tariffs that have different prices in different times.

2. Customers that are sensitive to power quality problems or potentially cause problems themselves for example with distributed generation.
3. Customers that are subject to outages for example during storms (e.g. indication of burnt fuse in one phase, broken neutral conductor or information when electricity distribution is restored).
4. Customers that need better situational awareness. For example police or fire department. For example if backup generators fail after outage in critical place like hospital fire department could offer equipment or start evacuation sooner.

These customers can be different kinds of consumers, industrial, service or public actors that can utilize the benefits of the DSO using Smart metering. Customer segments could be categorized also in terms value to them. Depending of the customer the most important value can be best possible quality of supply or faster information delivery. In some cases for example to industrial customers cost savings such as the operation of their compensation capacitors could be important.

4.2.8 Channels

As discussed earlier, the benefits of Smart metering come from exploiting it in the DSO´s processes. This also means that the channels that deliver benefits can come from several sources. At least the following channels can be identified:

1. Smart metering system is the main channel supporting the DSO´s processes and IT systems. This is the primary channel delivering the value of Smart metering to the DSO. Other channels have relation to this and can be called secondary channels. This is due to the fact that many of the other channels utilize the primary channel.
2. Electricity distribution network is one channel as quality of supply may increase.
3. Calling customer service can provide more accurate information from the customer. These can include electricity consumption and possibly other registrations that have been registered by the Smart metering system.
4. Smart metering system can also be integrated to provide information for example using mobile text messages.
5. Web services can include customer specific consumption and fault data for customers to see.
6. Also media and different authorities can use this more detailed situational awareness information for example based on outage information on map.
7. In terms of knowing the electricity consumption, the electricity bill can also be one channel of interacting with the customer.

Service channel and service type relation framework is presented in [JaVe92]. Channels and services of Smart metering can be categorized using this model. Value creating services of Smart metering presented in this model are presented in Figure 10.

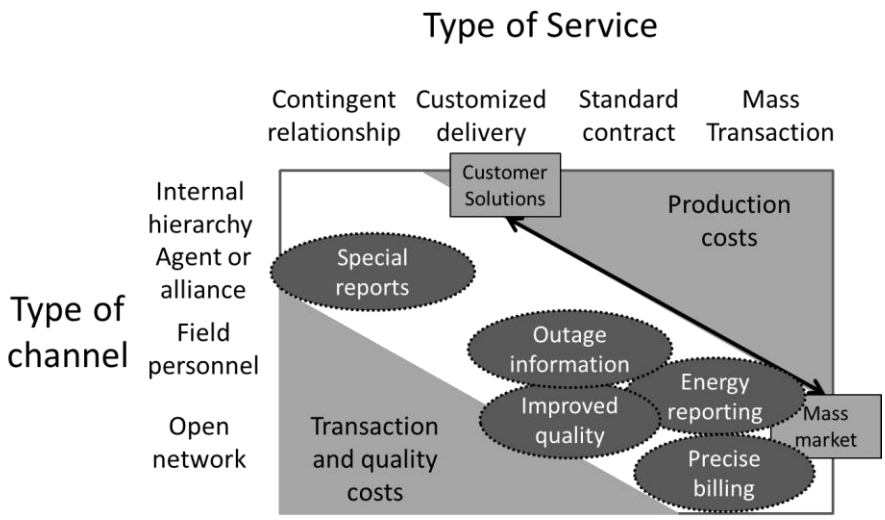

Figure 10.Different types of services related to Smart metering in relation of their delivery channel based on [JaVe92] in Finnish electricity distribution business environment.

Mass market services in Smart metering are billing based on hourly measured values and energy reporting. These services are obligatory by regulation in Finland. Depending of DSO´s Smart metering solution it can also utilize Smart metering for improving quality of supply and outage information of customer. For example low voltage network monitoring is one such solution. Outage information and improved quality of supply can be categorized also as mass market solutions but with limitation that DSO has technology needed and also is operating it. Customer solution type of services mostly includes analysing information from Smart metering for example in case where electricity consumption values are different after installing Smart metering.

At the moment majority of efforts on developing services in Finland is concentrated on obligatory billing and reporting services. Future may bring new service innovations for example related to home automation development. New service innovations can also bring new partners to DSOs´ partner network.

4.2.9 Customer relationships

According to [Ost04] different kinds of relationships can be for example: personal and dedicated personal assistance, self-service, automated services, communities and co-creation. In the case of Smart metering, automated services are needed so that other systems receive and can send or ask information from the Smart metering system. This requires working interfaces and features from other systems that support the needs of each DSO´s process where Smart metering is intended to be exploited. When looking at different channels discussed in chapter 4.2.8, customer relationships can be:

- Self-service in web services including both customer specific and general situational awareness services.
- Personal assistance offered in customer service by phone.
- Larger customers such as industrial ones can have dedicated personal assistance.
- Communities or co-creation may take place for example in terms of different customers sharing their energy consumption for others. This can happen independently from the DSO´s or alternatively they can offer such services to those interested.

4.3 Identified factors that may cause changes to Business models

The energy business is under pressure to change. Factors such as role and provider of customer service are being discussed currently in electricity distribution business. Table 4 presents factors causing change pressure. Many of them seem to have background based on laws or recommendations.

These general classes of drivers for change can also be found in electricity distribution even though it is a natural monopoly. There are general and industry specific factors that act as drivers for change [PaVi05]:

- **Ownership** and its role has changed towards a more business-like way of working. The profit of the network business is hoped to be maximized according to regulation in many DSOs.
- **Customer relation** creates expectations as society has become more and more dependent on electricity. The need from customers is to have low priced and good quality electricity**.**
- **Regulation** is the actor looking after customer rights in a monopoly business like the electricity distribution. Regulation can be carried out by regulating the distribution prices or profit. The aim is to force constant improvements of electricity distribution efficiency without compromising the quality of the distribution. Regulation is also constantly developing and its influence is most likely to increase. They also follow guidelines of such actors as EU.
- **Development of technology** has many impacts on the possibilities of developing electricity distribution businesses efficiency. Telecommunication, information technology, new distribution technologies such as 1 kV and DC, metering technology, technology standards and new technological concepts such as Smart metering have a great impact on the business of electricity distribution.

Technology also has a strong impact on information systems in distribution companies. Most of them also require modifications in their IT systems.

- **Other factors** include distributed generation, energy efficiency needs, electrical vehicles, new players in the market such as home automation etc.

Nordic level study on how the future services such as energy efficiency services can be delivered to the end customer is presented in [Sel10]. Dual point of contact and Supplier-centric market models are being discussed. Dual point of contact market model is a model where the DSO and the supplier serve electricity end-users equally. Depending on the issue, the customer contacts either the DSO or the electricity supplier. This model is in use in Finland and was created during the 1995 electricity market deregulation. In Supplier-centric market model the supplier plays a central role as a single point of contact for the end customer. The supplier-centric model emphasizes the importance of the supplier's customer service, while the supplier handles customer service duties on behalf of all the DSOs. The high number of variable-sized DSOs, which operate in significantly differing environments, might cause troubles [AnVi08]. The supplier-centric model also give opportunities to new innovative services to benefit the end customer. Table 4 summarizes possible change factors that may cause changes in the Business model related to metering.

Table 4. Possible factors that may cause changes in Smart metering Business model.

Change factor	Actual changes
1. Techno-logical change	○ ICT development ○ New metering innovations ○ Interface with smart home control centre for control and reporting ○ Need to be able to manage distributed generation better ○ Need for large scale load management / demand side management ○ Additional values and functionalities for customer service, network operation and asset management ○ New online and extranet reporting services
2. Competitive forces	○ Development of service business and companies' strategy on using services instead of in-house operations. ○ Development of energy sales(products, market players) will require more automation and capacity on handling customer events
3. Customer demands	○ Home automation ○ Loading of electrical vehicles ○ Distributed generation ○ Energy saving
4. Social environment	○ Energy saving will stay fashionable ○ Market ready distributed generation may increase the production
5. Legal environment	○ EU legislation ○ Expanding electricity markets / electricity exchanges ○ Local regulation development in terms of costs and/or quality of supply ○ Recommendations and general laws concerning housing and energy ○ Dual point of contact and Supplier-centric market models for example

4.4 Possible new concepts related to Business Model

Publication [P9] discusses Business model for Demand response (DR) using the Home energy management system (HEMS). The model is created for an independent service provider. Figure 11 illustrates the different actors around the Business model. The main idea is that the service provider acquires resources and sells them to energy retailers, TSO and DSO. The service provider's partners are HEMS manufacturer, communication provider and installing partner.

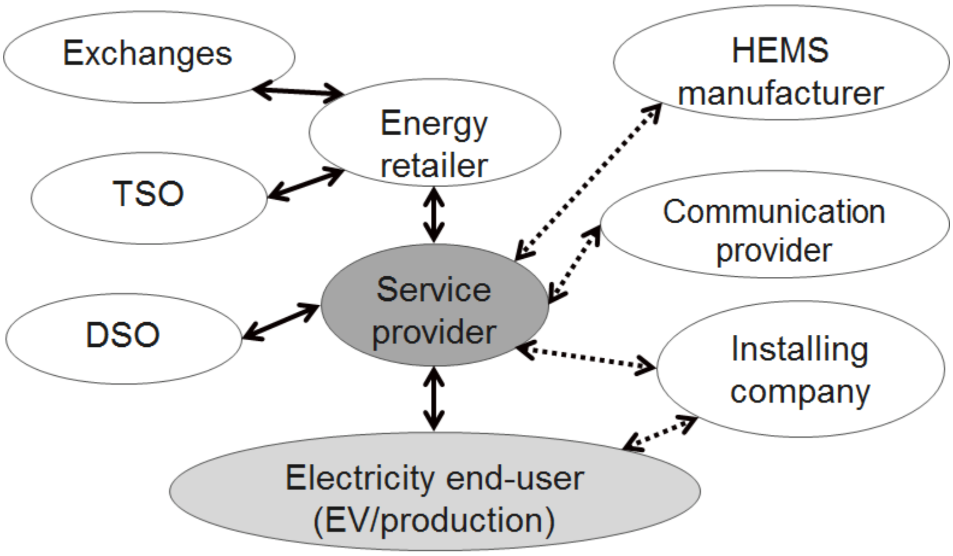

Figure 11. Different actors in an example of a Business model concept related to DR discussed in [P9].

As this model is still hypothetical, experiences from Smart metering Business model discussed in this dissertation have been utilized. As the Business model is created to an independent service provider the actual provider can be someone else. For example if the concept can offer the DSOs benefits over costs, such projects can be studied more closely by them. It is also possible that such new business areas might effect to the Business model of their metering. These changes could be similar that DSOs´ have experienced related to Smart metering.

5 Case PowerQ Oy company – lessons learned and experiences to share related to Business models in electricity distribution

Company PowerQ Oy (Ltd.) was established in 2003 to provide power quality measurement solutions to distribution companies. The author of this dissertation was one of the five young researchers establishing the company. The company was established based on an agreement where ownership of some research project results was acquired from the Tampere University of Technology. These results included a web based application demonstration for power quality monitoring and analysing as ASP concept. Business concepts of ASP are discussed in [Try03].

In addition to being one of the founders of PowerQ, the author of this dissertation has also acted as Managing Director of the company since 2003. This work has also provided hands-on experiences in measurements related to business in a real DSO's environment.

In the beginning, the technology was more than just a trendy way of creating software. The author of this dissertation studied Application Service Provisioning (ASP) at that time [P2]. The aim was to utilize new technology to act as part of a business network providing measurement data solutions to the DSOs. The business plan was to provide readings of power quality meters, an open and advanced database and sophisticated analysing tools on a web user interface. The system was named PQNet and could be delivered as a system or as an ASP service.

The business started slowly as a new vendor founded by people who were new to the business due to young age. The key of starting new projects was to be able to deliver information system as service. This capability to provide software as service has been important since the beginning of the first customer relationship in the company´s short history.

New business innovations were also sought by attending new business networks. For example the low voltage network management [JäVe07] and the comprehensive secondary substation system [P8] were created in such a new innovative business network. Both of them are currently in the market and in use by several Finnish and international DSOs. Succeeding in such a demanding concept developing process has also been proof of succeeding in business networks. The Finnish Technological Funding Agency Tekes has also played a significant role in both of them as it has funded and supported these business networks.

These projects have increased understanding and knowledge about business networks. Based on these experiences, a Business model can be used to systematically describe the projects and their networks. Many of the findings can be stated publicly but some must be left unpublished as they are related to confidential business issues such as pricing, exact functionality or cooperation agreement contents. Summarizing the lessons learned and experiences to share from actual development projects are discussed in the following chapters.

One of the leading issues in creating both development projects has been creating additional value to the investment. For example, accurate cost calculations were conducted to see Smart metering´s cost effects [P6]. The participation of the DSO is critical so that value from their perspective is clear. Both projects managed to create concepts that provide additional value compared to a minimum investment, and according to a discussion with the DSO´s, these additional values are higher than their increased costs.

Identifying each company's main activities related to the final goal is important. Responsibilities and avoiding the overlapping of work should be managed and discussed carefully. Saving time and costs in a development project can be achieved for example by making sure that information is available to everyone who needs it. Role of communication cannot be under estimated. A network with low organizational borders and accurately coordinated efforts can bring better results. This however requires everyone to work for a common goal. Organizations are formed by the people working there. This means that also personal relationships have played significant roles and should not be forgotten. From real-life experience it is easy to see that good personal relationships are important. This can also reduce unnecessary bureaucracy in such projects. And when finally adding this partner issue to the customer relationship, it is important that the DSO´s are involved for one more reason. This participation, testing and implementation give strong signals to other possible customers that this concept has survived real life tests. Typically these discussions also go past official channels and can thus be much more efficient than official marketing messages. And if things are not working, this information is most likely also delivered through these unofficial channels.

From the resource perspective the amount of management and development alone is not enough to create successful development. As has been said earlier, the participation of the DSO with their know-how is needed. Additionally, the research function is needed to make sure that methods used are correct and tested. Know-how is equally important when it comes to resources.

Factors that may create pressure to re-evaluate the DSO´s Business models were discovered in these projects. these factors are listed below.

1. Technological change: In both cases the technology existed. The actual change is adopting it to new areas. This increases the benefits, but also from the DSO´s point of view, increases the challenge of implementing new functionalities. In both cases solving IT interfaces, protocol and security issues took time and resources. IT with flexible and open integration possibilities improves succeeding in these types of projects. This is also one recognized problem among Finnish distribution companies [P3]. Electricity distribution business is highly information intensive and the amount of specialized IT systems is larger than in most other business. This means that distribution companies should think carefully about how their IT is managed specially in terms of tailoring systems and interfaces. If these features are limited, it may prevent projects such as the ones described here. Fortunately in both of these projects they did not prevent development. When looking at the size of DSO in terms of productivity in challenging development project, there are differences. Smaller DSO´s typically have persons with more tasks included in their vacancies. Coordination of projects requires less work than in larger organizations. Know-how and innovation orientation are the key elements and these can be found from different sizes of DSO. Larger organizations can benefit from their attractiveness in recruiting. Also depending of the task they can be more specialized. This supports know-how. In larger organizations project organization with suitable persons can reduce the coordination efforts and provide innovative environment for development projects.
2. Technological change can also change the key activities and resources in terms of know-how. This became clear after the actual piloting of developed concepts took place. For example employees responsible for network operation faced new situations that needed training and process redesigning. So after all the technical changes, the work processes were also discussed in terms of responsibilities and process outcomes. Without these work modifications the new concepts would have been more difficult to implement. This finding may be of a general nature and the experience could be utilized in many new technology development projects. Also the customers could evaluate in early stages of the project resources in terms of amount of employees and know how requirements.
3. Competitive forces: In both of the projects new technological standard has been set. For example in the low voltage network management project several distribution companies have been requesting these functionalities in their specifications. Also other manufacturers have been following the demands and have developed their own solutions. So far this is mainly a Finnish market specific issue but can spread further as the term “Smart Grid” is highly popular.
4. Customer demands: At least among Finnish DSO´s the variety in terms of needs and demands is quite large. In the projects it was discussed that after successful pilot implementations it may take several years before the majority of the

companies recognize the need and benefits over the costs. This factor may increase the costs of new concepts and requires careful planning when considering. Long sales processes also increase the risk of the project failing.

5. Social environment (ethics, values etc.): In early stages of these projects, one very popular issue was change resistance over the new concepts. The benefits were hard to explain and the costs and additional work they would require took the majority of the attention. It seems that there were Finnish DSO´s who didn´t want anything to change. This means that some DSOs' desire for developing technological solutions is limited. This may be explained by the fact that change factors can be difficult to analyse and the company culture doesn't include systematic analysis and development tasks. This may be due to the monopoly nature of the business. Unfortunately this is difficult to evaluate but it is based on discussions with the DSO´s employees. As these projects have significant impacts on the customers' quality of supply, change resistance still existed. This brings out the question of the relationship between the customer and the distribution companies. Are there DSO´s that could do more to better serve their customers?
6. Legal environment: Automated meter reading became obligatory in Finland which started the planning of investment projects in all distribution companies. This is a change in many of the aspects of the distribution business. However this was the only legal driver related to the low voltage network management project but it did not include the functionalities developed. Still many distribution companies requested these functionalities in their specifications. So only after legal requirements did also the new features become requested by the majority of the distribution companies in Finland. This is a positive outcome, but the legal drivers should not be the only ones guiding the development in electricity distribution. Manufacturers also have a responsibility to look for innovative but cost effective solutions that provide benefits over cost ratio. The author's personal experience is that a working business network including suppliers, universities and distribution companies seems to be one good option for delivering these types of new concepts.

Business model evaluation can increase understanding of the so-called big picture. Additionally, when a Business model exists, analysing change factors may require less work. Many projects are heavily concentrated on technology and not taking into consideration issues that are part of the Business model. Public discussions of companies' Business models usually remain on a general level and important issues may not be noticed. But when done properly and confidentially inside a company it helps to deal with issues that might be forgotten in a simple investment or delivery plan. It helps companies to define their own resources in long term and outline what is required of them.

In PowerQ, the author has been involved with Smart metering tendering projects from creating specifications and comparing tenders to an implementation project related to around 150 000 meters. Additionally, PowerQ has been involved in integration projects of Smart metering systems and DMS in terms of low voltage network management. Looking back on the projects and the increased understanding of the Business model in both academic and company work it can be stated that the Business model has its advantages. When Smart metering investments were planned, many DSO´s would have saved time and money if they would have taken a more organized approach to the change that will affect their processes significantly. All aspects of change could have been taken into a more detailed evaluation. For example integrations have been planned after purchasing Smart metering system. This may have caused delays and replacements of other systems such as the Customer information system (CIS) in a tight schedule in the middle of the Smart metering implementation.

6 Discussion and conclusions

6.1 Discussion of the results

The main research question in this thesis is that can Business model theory be used to model and analyse the change of the electricity distribution business due to the Smart metering implementation. Additionally, this can be divided into more detailed secondary questions:

1. Can the Business model theoretical framework be implemented to Smart metering in electricity distribution business environment?
2. What types of analysis and information is needed?
3. What is the importance of information systems in changing the business environment of electricity distribution?
4. What is the role of service purchasing in electricity distribution business?

Answers to the secondary research questions can be formulated from the previous chapters. For question number one the answer is that Business model can be used to create framework also for Smart metering. This model has been presented on Chapter 4.2. However as there is no actual DSO as a case company to implement it the model presented lacks definitions that are specific for actual company such as its own resources.

Question number two asks about analysis and information needed. Business model framework has 9 specific areas that need to be described. Chapters 4.2.1-4.2.9 presents methods and tools that can be used for more thorough analysis. Value proposition describes what the offering of this concept is. In case of Smart metering offering has been increased with technology development [P7]. When developing new technology it must be made sure that offering can be supported from resources in the Business model. In Smart metering this means that IT systems need to support functionality that is offered. Smart metering case also proves that there are alternatives like the one presented in [P8]. Not everything needs to be implemented in Smart metering or alternative solutions have advantages that prove them better. Resources needed and available needs to be analysed also. IT systems as well as know-how need to be included. In Smart metering new know-how was needed as well as updates to IT systems. Some tasks became unnecessary such as manual meter reading. This is a good example that resources may need to be relocated and trained in changes like Smart metering. Companies don´t need to do everything by themselves. Cost analyses are needed to understand the usage of resources. In this study ABC method was used to analyse what type of resources Smart metering uses. When results are available DSO´s management can make decisions concerning doing self or purchasing services. Knowing own costs and also services available are needed for final decision.

Publication [P4] shows that in Finland services are used and usage is increasing. Changing from in-house processes to service purchasing requires that DSO has know-how for it. There are also methods that can be used for service acquisition such as CMMI. Their goal is to improve processes related to services. Channels that are used to offer services to customers can be put into framework with the type of service. In Figure 10 this model was presented with services related to Smart metering. As a conclusion to question two there are different aspects that need to be considered and tools that can be used to support creating Business model.

For question three regarding the answer is that in electricity distribution business the role of IT systems is important. In case of Smart metering the value of it is created mainly in the operational IT systems. This means also that if systems cannot be updated or the interfaces are difficult to create not all of the value of new concept cannot be utilized. In future big changes such as Smart metering has been it is important to consider requirements and possibilities of IT systems.

The role of service purchasing in question four can be identified based on publication [P4]. DSO must know what is available as a service. Services can be used to substitute own deficiencies or expand own resources. These resources can be human resources such as the ones related to network construction. They can as well be consultation that offers know-how that DSO is lacking. They can also be IT systems as service. Related also to question three IT services have advantages that can be help overcome problems discussed in [P3]. These IT systems services also called ASP have developed also in electricity distribution business. When looking at results in publications [P2] and [P8] there are actual and proven ASP services available. Based experiences from PowerQ company ASP service is faster to implement compared to traditional information systems. Also the pricing policy is attractive especially in the beginning as it is based on pay by usage as traditional systems require larger investment in the beginning.

Finally the primary research question and answer to it. Considering aspects presented, it can be said that Business model can be used for modelling electricity distribution businesses change related to Smart metering. Business model offers systematic method for analysing the change. It is not the only method available. There are studies that have been done earlier. For example [MaCh99] is modelling technological development. Other type of analysis called dynamic business simulation DBS is presented in [Wen05]. The idea is to provide a method for better asset management. However these do not answer to the need of defining many of the non-technical aspects. Operational strategy can offer alternative theoretical framework. It covers aspects such as quality that are not included in Business model. Addition of being alternative it could be used as an addition. Business model was selected for this research due to increased usage of it and also because in theoretical background it offers coverage for changes in business. This is one of the advantages that Business model has and for this reason it gives better understanding of the extent of change that takes place when DSO implements Smart metering. This may help the management of DSO to manage change so that it is controlled and well planned.

Business model has time relation. It can be created to describe the current situation as well as the situation the company is heading to. Constant updating and monitoring also requires identification of possible change factors. Factors like technological change, competitive forces, customer demands, social environment (ethics, values etc) and legal environment can create a need for changing the Business model to keep the competitive advantage or create more of it. This is a task that the management of the DSO should also recognize.

6.2 Assessment of the research

As scientific contribution this research presents a Business model framework in electricity distribution business for Smart metering. To be more exact, the contribution consists of the following details:

1. Theoretical background for the Business model and application to Smart metering.
2. Theoretical background for accurate cost analysis and results of traditional metering and Smart metering. These results support item number one as cost analyses are needed for Business model when analysing resources and cost structures.
3. Results of the DSO´s usage of services in their business. These results support item number one as resources related to the Business model can be acquired from a partner network.
4. Results of information systems' usage in electricity distribution by the DSOs. This result supports item number one as Smart metering is integrated into the DSO´s systems, and to understand the value Smart metering provides, the role of IT systems and problems related to them must also be taken into account.

The relevancy of the research can be validated based on three issues. Smart metering is being implemented globally in several countries in the future. In Europe Italy, Sweden and the UK have Smart metering in large scale operation and Finland is following by the end of 2013. More of the situation in European countries is presented in Table 3. Results of this research can be utilized for discussing the implementation and operation of Smart metering. Secondly, literature analyses indicate that research concerning Smart metering is focused on technical aspects and aspects of limited number of functionalities. This research discusses Smart metering in a broader and more structured form and also includes the business aspects of it. Thirdly, future business concepts that have similarities with Smart metering are being presented. For example Demand response discussed in publication [P9] can cause changes to the metering business. The separate HEMS system may require more value adding functionalities from Smart metering or Smart metering can replace separate systems as technical solutions of providing DR. With these aspects this study can be assessed to be relevant.

The measures selected for research describe the validity of the work. Validity is defined based on how well the selected methods present what is the aim of the study. When looking at the validity of this work there are issues that need more detailed analyses. Firstly, this study is conducted between the years 2003 and 2012. During that period of time many significant changes related to Smart metering in Finland where the research is conducted have taken place. Transfer from preliminary studies and piloting has developed into a mandatory installation required by regulatory framework. The research conducted is published in different publications based on the situation at the time. Looking back, increased information on the topic could have changed some of the aspects. The impact of the development of the topic is not studied with follow-up research at the moment. Secondary technology of Smart metering has developed continuously. Measures selected in this research are based on general methods and theoretical background. For example cost analyses are based on activity based costing used in several other businesses. Questionnaire studies have been created based on theoretical background to minimize the possibilities of directing answers. When it comes to technological aspects, the developed technology that is discussed in this research has been commercialised which may indicate that the correct development projects have been carried out. Finally, the Business model concept being adopted is based on selecting the most popular one. The validity of the model is also studied from different literature sources. On the other hand, the author has used the Business model without specifying it for example in publication [P1]. For this reason a literature background and more systematic Business model for metering are presented in chapter 4.2.

According to [KaLu93] in constructive approach validity of results can be examined using market tests.

- Weak market test: Has any manager responsible for the financial results of his or her business unit been willing to apply the construction in question in his or her actual decision making?
- Semi-strong market test: Has the construction become widely adopted by companies?
- Strong market test: Have the business units applying the construction systematically produced better financial results that those are not using it?

Business model framework for Smart metering created in this dissertation comply weekly with the market tests. This is due to that Smart metering implementations have been done in many DSOs before results of this study have been published. So the

Business model itself has a whole has not been tested. Market tests can also be looked to parts of the Business model of this dissertation. In this study the cost analyses in [P5] and [P6] were done before Smart metering was stated obligatory by regulator. Cost analyses were conducted to five different DSOs. Four of them have not reported the usage of the cost analyses but one has used results for decision making. This can be confirmed by that fact that low voltage network management concept presented in [P7] was partly based on the result that Smart metering for only energy measurements was not profitable when compared to traditional metering as discussed in publication [P6]. Strong market test for this is not available but can be seen as possible future research. Another part of the business model is the increase in the Smart metering services. According to [P4] DSOs have answered that they will increase the service purchase. This indicates that using services is on their interest even the factors causing this are not known.

Another method of assessing Business model is presented in [KiMa05]. It presents four distinct questions on how to assess the created Business model. These questions are in rank order so that each question has to receive a positive answer; otherwise the whole model should be put under reconsideration. If each question has a positive response, the created Business model may be commercially viable. The questions are:

1. Does the Business model include exceptional value for the customer?
2. Can most of our customers buy easily with a 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 them?

Answer to question is partly based on additional value the Smart metering offers. Values like more detailed monitoring of energy usage, saving possibilities and improved quality of supply are offered by Smart metering. For question two the answer is also positive as majority of the new values are available to all customers. This is ensured also by the regulator. The nature of electricity distribution business has impact on question number three. Smart metering costs are not shown to customer but billed as part of electricity distribution fees. But because of the distribution price is controlled by regulator the costs of Smart metering have to on acceptable level. Finally DSOs have already successfully implemented Smart metering. Unfortunately there is not yet evidence that Business model presented here could have made difference.

Reliability answers the question if it is possible to have the same results that were presented in this study. The selected research approach accepts that the researcher may have an impact on the results and they can still be reliable. However, the researcher’s understanding of the issue studied must be presented to increase understanding of the reliability of the results. The researcher’s role is significant in issues that relate to confidential information with the companies involved. These issues include for example detailed features of software, pricing and cooperation agreements. What can be published is presented separately in chapter 5 so that it could also be discussed separately. In this aspect the same results cannot be easily obtained. Another part of the study that needs to be discussed is for example related to service purchasing. In these studies it cannot be ruled out completely that the issue discussed may have affected the results. The Business model generated is on a general level and as such cannot be implemented into a real company. It was created to provide a framework and an example on issues that relate to Smart metering in addition to technical aspects. For implementing in an actual company, the model must be revised with existing or desired business structures. In cost analyses, the results of making such analyses at the moment could give different results. So renewing these results may not be possible as results are based on the situation at the time. It is also possible that results have affected costs so that measures have been taken to manage costs. However there is no evidence of this. Technologies and the general development of Smart metering may also have influenced results. In order to improve reliability, updating results with follow-up type research would most likely increase the reliability at least related to cost analyses. As a conclusion it can be stated that there are aspects that could improve the reliability of the work but generally results present an adequate level of reliability.

When discussing generalizability it is necessary to find the constraints of the research topic. This study is conducted in Finland and concentrates on the electricity distribution business. The most constraining factors of this work are now specified. As described in chapter 3, the electricity distribution business has non-general features such as regulation. However it is not discussed in this study to make the results more general to be applicable in other countries as well. In terms of other businesses, there might be other fields that have a similar business environment. Theoretical framework and tools are generally used. It is possible that results can be used for comparisons with results from other businesses. For example cost analysis results may be comparable to ones related to the district heating business. The Business model described in chapter 4.2 may offer a framework for other functionalities in the electricity distribution business but may require similar research that was conducted here related to Smart metering.

6.3 Future research

Smart metering has changed many things in electricity distribution. But the change is not going to stop as both needs and technologies are developing. Based on this study, at least the following issues need to be researched:

- New features of Smart meters that create more value to different parties related to electricity distribution.

- Updated cost analyses of current Smart metering solutions that take for example the resources related to metering into consideration more widely. These results could also be utilized for cost estimations for new functionalities.
- In addition to cost analyses the results from several companies could be used for benchmarking companies.
- Data exchange between different systems to improve the development of Smart metering related functionalities.
- Follow-up research of ASP in electricity distribution business currently and in the future. These results would also describe how the partner networks are developing.
- As the currently installed Smart metering generation is aging, the replacement projects are started within the next years. A more general concept development taking into consideration the lessons learned from the current generation of Smart metering.
- How would operational strategy be used in addition to Business model for actual DSO.
- Semi-strong and strong market tests for Smart metering Business model presented here.

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Publication 2

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Implementing ASP to serve energy supply industry

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Abstract:

This paper presents Application Service Provisioning (ASP) model and its implementation issues to energy supply industry. ASP model is a new way of using software applications. Usage of Internet is the key feature compared to traditional model of purchasing and maintaining of software applications. Customer uses applications through internet connection and pays monthly fee of the usage. The ASP model allows customers to concentrate their resources to their core business, rationalizes the IT-costs, speeds up the implementation time and transfers the responsibility of the data security to a service provider.

The possibilities to organize ASP business are presented in the paper. Applications Service Provider (ASP) can offer the whole service chain based on its own resources or it can focus only on limited tasks. From customers point of view ASP customer contract is the most important matter when ASP applications usability is considered.

One possibility is to present measurement information in ASP application. Energy consumption measurements are one possible usage of ASP in energy supply industry. Ancillary services like power quality monitoring and condition monitoring can be attached to these measurements.

Tampere University of Technology (TUT) has going on projects on power quality data management. One aim has been to integrate power quality monitoring with distribution automation and other computer systems. One approach has been to apply ASP model for this purpose. A spin-off company PowerQ Oy was established to commercialize methods developed in the research project.

What is ASP?

Application Service Provisioning (ASP) model is a new way of using software applications. Usage of Internet is the key feature compared to traditional model of purchasing and maintaining of software applications. ASP applications are programs that are used through web page browser. Applications are located on distant and centralised servers that are operated by the Application Service Provider (ASP) or its partners.

The history of ASP model is based on Client Server applications on 80´s. Those days the remote access was limited to a much smaller scale. The Internet made possible of remote access to almost anywhere in the world. Late 90´s it was discovered that old Client Server idea could be implemented and improved in the Internet environment.

Figure 1 shows that the areas Application Service Provider takes care of are support, applications and infrastructure in general. Figure 1 also illustrates the importance of the ASP contract. More details about these contracts are later on this paper.

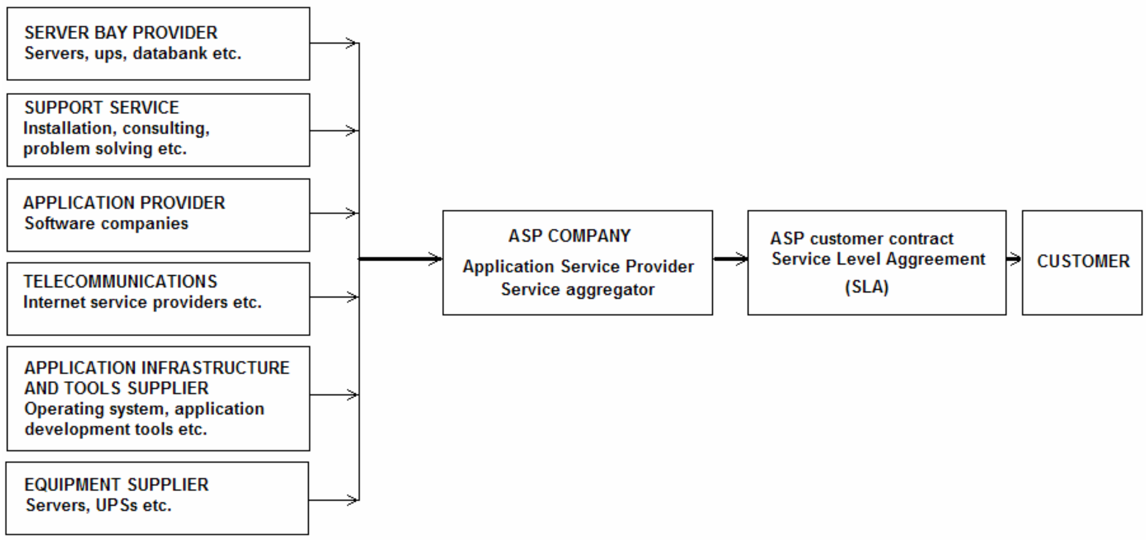

Figure 1.Application Service Provisioning (ASP) model [1]

Customer uses applications through internet connection. Pricing policy is typically based on monthly fee. Alternative choice is to base the pricing on the usage of the service. ASP applications can also be considered as rental software.

Advantages of the ASP model

Reasons why ASP model has become more and more popular are based on its many advantages compared to traditional purchasing and maintaining model. [1] Most of the advantages are consequences of the basic idea of ASP. The application is concentrated only to a single location and it is designed to meet the demands of many customers. Application Service Provider takes the overall responsibility of the applications it offers to customers.

Operating and maintaining IT is complicated and requires a lot of expertise. Also the costs of IT are very diverse. Some of the costs are easy to take in to a count. IT personnel's salaries, software costs and computer purchases are recognizable costs. Much harder costs to count are so called hidden costs. Technological follow-up, lost time in software or other infrastructure failures and also the inefficiency of IT department are costs that usually cannot be taken into a count. All these hidden costs can lowered significantly by operating ASP applications.

Many companies are currently focusing on their core business because it is shown that total operating efficiency can be achieved only concentrating to those business areas that company can make profitably. In most company IT is just a tool to make business and a lot of resources are wasted to poor handling of this business area. By operating ASP applications company can concentrate on those business areas that it has it's strengths and leave the IT to those who will do it more efficiently.

ASP lowers the costs also because the application can be offered to many companies according the same format. This lowers the costs for each customer operating the ASP application. This makes also possible for small and midsize companies to implement softwares that were earlier affordable to big companies only.

The implementation time and updates are important factor among those who have chosen ASP. Compared to traditional software the implementation can be carried out in fractions of the time. One typical phase of adopting ASP is when new applications are being considered. Most customers see that operating ASP is just much faster and efficient compared to purchasing own software and maintaining them. Updates can be taken into operative use so that customer doesn't have any outages or problems operating ASP application. This is also significant advantage for many customers.

ASP has also an advantage in delivering the information compared to the traditional software model. This is the advantage that Internet allows. It is possible to use ASP application is independently of the location. The same information can be delivered easily to different parties that require it without any installations. This is a significant advantage for example for projects that consist of different organisations.

Challenges that occur implementing ASP

There are naturally issues that must be considered carefully before implementing ASP model.[1] Usage of the Internet is the most important issue that ASP is having critical opinions. It is true that a lot of uncertainty takes place when Internet is involved. Data security, viruses and unwanted parties breaking into system are threats that cannot be overlooked.

The attitude towards new operating models has been shown one critical opinion towards ASP. Companies want to take critical attitude towards models that haven't got long reference history. On one hand this criticism is understandable and vice even. But at some point disbelief is harming the innovativeness of companies' decision making. More marketing and successful cases of ASP are needed to make this good model achieving bigger scales.

Information that is in the ASP application is located to service provider and this is one big concern about the data security. Many customers see it very hard to hand out data to a third party. They fear that data is no longer under their control and even that service provider can use this data on dishonest purposes. But from service provider point of view this is not very genuine threat. By handing out the data to those who should not have access on it the company would basically make criminal action and this means it will sign its own destiny. At service providers interest as in any business is to have good reputation and long term customer relationships.

Factors described above are not simply just faults but more of challenges that can be handled with careful planning and with proper ASP customer contract. Next chapter will deal with issues that ASP customer contract should involve.

ASP customer contracts

Customer implements ASP application by agreeing ASP contract. In this agreement the ASP service is defined precisely and responsibilities of customer and service provider are described. As in traditional purchasing and maintaining model customer agrees licence agreement must customer also agree ASP agreement in ASP model. It is important that agreements are singed and kept on date according changes in services. Also lack of agreement practices can slow ASP model spreading to new business areas. [2, 3]

Usually at the beginning of agreement both parties are described with their responsibilities. ASP client usually is responsible of reporting problems or changes concerning the service and service provider must according its best skills maintain and develop software and take care of information security and data storage. This part of the agreement must also define where is the border of responsibilities between customer and service provider. It is not recommended that service provider is responsible of the network in general because those issues are not under their control and these issues should be negotiated whit internet connection providing company.

Secondly the contract must include the precise description of the service that customer has chosen. This must include all software components, the number of persons having access to the software with their own user name, pricing of the service, contract time and service quality. The quality is usually characterized as service level including network capacity and response time of the service Also the outages in service must be covered and in good spirit of service outage usually means compensation to customer. Important part of the service level is also give promise to customer in what time are outages being repaired and service made available for the customer.

As the ASP contract is usually made for certain time period it is natural that updates and technical support is also described in the contract. Depending of the strategy service provider has chosen updates can be included in the price paid of the service. Also usage training at the implementation stage is described and if additional training is required etc. in updated versions it is also described.

Copyrights of the applications and information gathered with it must also be stated in the customer contract. Copyrights of the software are usually owned by the service provider and information that is gathered by customer. But according to the customer needs these matters can be negotiated and taken into a count at pricing of the service.

As in any contract cancellation of an agreement and what are the issues that make this possible must be negotiated. Usually cancellation requires severe failures in responsibilities. But just in case these terms must be stated. Also the terms of making changes in the agreement must be included and these issues are more likely to be taken into a count.

ASP customer contract must not be underestimated because it makes the rules of service to both parties. To ASP company well and fairly made agreements are important image factors in long run. Usually legitimate help guarantees that contract is made properly and both parties have their rights secured. This also helps both parties to trust each other and first of all trust the concept of ASP.

Choosing ASP strategy to best meet customer needs

From ASP services providing company's point of view there are many possibilities of organizing its operations.[4] This is important strategic issue and has a great effect on business profitability. The strategy that company chooses depends of its know-how concerning IT issues and also its resources. Small and middle size companies usually have different kind of strategy compared to those which are significant players on the market.

On possible strategy to choose is to simply take the role of service aggregator. This usually means that it has limited resources or capabilities of taking care of the whole ASP chain. Service aggregator has partners taking care of certain area of the ASP business. One partner can take care of servers and data security and also data storage. Another partner can be responsible of software development. Third party can act as a helpdesk providing on-line help on problems faced during usage. The original service aggregator has now on its responsibilities the contract to partners and to the customer. It can also take care of the money transactions. This includes charging the customer and paying to its partners their share of the total income.

The alternative strategic choice is to take care of the whole ASP chain. This means that company takes care of the servers and other IT infrastructure, software development, helpdesk, sales and customer contract. Usually the big players organize their ASP business like this because they have plenty of resources and knowledge on the areas that ASP chain requires.

ASP in energy supply industry

In energy supply industry ASP can be implemented many ways. Currently there are many software types on the market that support ASP model and more are coming. At some applications the advantages of ASP are clearer and make bigger difference. Even though Internet has many advantages the possibility of network connection losses must be considered when implementing ASP model to software.

One of the types of applications that support ASP is office tools. These programs consist of text processing, chart programs and presentation wizards. Compared to traditional software these ASP applications have the advantage of outsourced maintenance.

The ASP model has also been applied for information systems and applications for energy delivery systems. [5] Considering the type of information and time limits concerning control signals the Internet connections security and reliability must be on very high level. If the connection can be secured in all circumstances ASP can also bi applied for Energy Delivery Resource Planning (EDRP).

Different kind of reporting tools have also become more popular. One possibility is to present measurement information in ASP application. ASP model has been applied, e.g., for the management of measurement data, especially of energy measurements. Because the nature of information delivered through this type of application the network connections reliability is not so crucial. In case of connection loss the metering goes on and data can be read when the connection returns.

Definition of a customer can also become more unclear when Electricity Company implements ASP applications delivered by external service provider company. The Electricity Company and it’s customers are both customers to ASP company. This is the case e.g. in energy measurement services. The Electricity Company has access to all data measured from it’s network and the end customer can have access to data measured from his consumption point. Three different kind of service provisioning chains are illustrated in figure 2. In first chain a external service provider delivers service to Electricity company and to a customer e.g. energy measurements. In second chain only the Electricity company is customer to certain service. And in third chain Electricity Company delivers service based on it’s own resources and know-how to it’s customers.

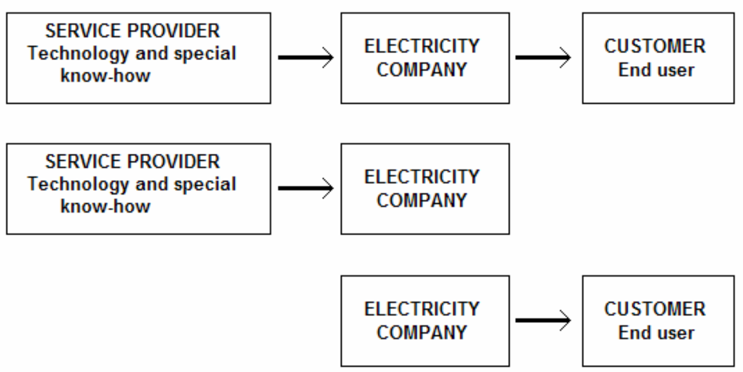

Figure 2. Three service chains in energy supply industry.

An example of an ASP – case of Power Quality monitoring

Power Quality has become more important factor in electricity supplying. Particularly industrial customers are in some cases concerned about the effects of poor power quality. It causes losses in production and may result broken machinery. From customers point of view power quality metering is useful ancillary service.

Power quality management can be carried out efficiently as an ASP service. When customers energy meter is replaced with smart kWh meter with power quality functions is implementing of ASP power quality management possible. The meter is crucial component in measurement chain. Implementing ASP model demands that meter can be read remote. Also quantities that meter can measure set the level of ancillary services that can be attached to ASP application. In addition of energy measurements power quality, condition monitoring and outage information can be calculated and separated from energy measurement data with suitable meter equipment. After installing the new energy meter ASP service provider can take control of the meter. According the ASP model no software installations are required and service provider takes full responsibility of the power quality management. Customer and Electricity Company receive their own identifications and can follow the power quality on-line. The results of this monitoring can be used in negotiating with the electricity company how to handle possible problems in power quality. ASP power quality monitoring is discussed in more detailed in reference [6].

The price of this kind of service can be lowered based on ASP model's character on delivering same service model to many customer. Also the implementation time is fast. In future this kind of service can become more popular. It can also replace totally or in some cases partially traditional consulting services in solving power quality problems.

At the institute of Power Engineering in Tampere University of Technology (TUT) there are currently research project concerning with new business models and intelligent metering methods in electric supply industry. One of the methods that are being used to analyse and develop business models is value network theory. Other theories used on same purposes are also possible. [7]

Part of this project has been to defined value networks to intelligent metering. The idea of value network is to describe organisation and resources of certain business function.

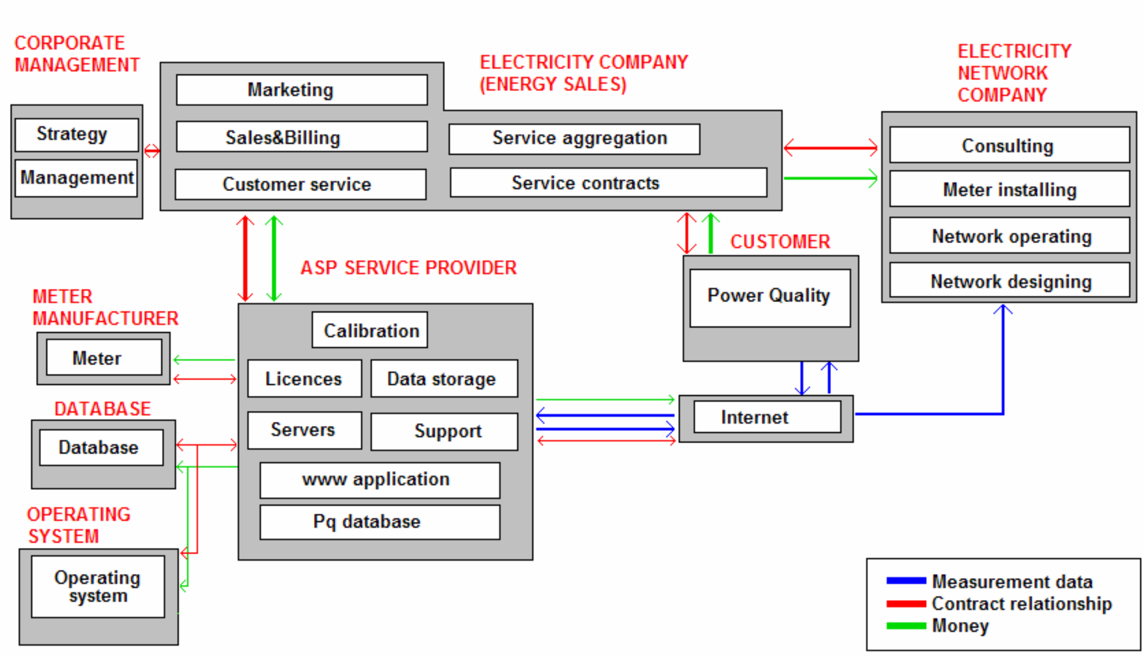

Figure 3. Example of a value network for power quality measurement.

Figure 3 presents the value network model that was created in the project for a power quality measurement as an ASP service. The model is based on few basic assumptions. Firstly the contact to end customers is taken care of by electricity company. It also takes care of the billing and customer contract to individual end customers. ASP company takes care of metering the power quality and provides the data to electricity company and also to the end customer. Consulting and negotiations are taken care of by the electricity company. This method has been carried out with real customers in co-operation with the Electricity Company. In the research project the model has been shown to be successful in energy supply industry in Finland.

Spin-off company PowerQ Oy was established to commercialize methods developed in the research project described earlier. PowerQ Oy provides power quality monitoring as an ASP service.

Conclusions

The Application Service Provisioning (ASP) model can offer many possibilities in energy sector. It has many advantages that serve the purposes of measurements, special applications and even traditional programs. A lot depends of how service providers can meet the customers' needs and what are the real needs of efficiency in operations of energy companies.

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Publication 3

Toivonen, J., Trygg, P., Mäkinen, A. & Järventausta, P., ”A survey of information systems in finnish electricity distribution companies”, Proceedings of the Nordic distribution and asset management conference (NORDAC 2006), 21-22 August, 2006, Stockholm, Sweden.

A SURVEY OF INFORMATION SYSTEMS IN FINNISH ELECTRICITY DISTRIBUTION COMPANIES

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ABSTRACT

A questionnaire study has been conducted to survey the current state of operational information systems in Finnish electricity distribution companies. Instead of being only a technical study, the survey concerns utilization and procurement of information systems, and problems and development needs related to distribution utility information systems. Effects of the development of distribution business have also been discussed in the research. Some of the main results of the survey will be discussed in this paper.

INTRODUCTION

Various information systems are needed to support electricity distribution business operations such as network planning and operation, maintenance, energy metering, and customer service. The following information systems among others are commonly used in electricity distribution companies: network information system (NIS), distribution management system (DMS), SCADA (Supervisory Control and Data Acquisition) system, customer information system (CIS), energy management system (EMS), and systems for metering data collection and management. Applications for construction, maintenance, materials management, and crew management are also available on the market either as separate systems or included in the above-mentioned systems. Naturally, there are many other applications, such as financial management systems and office applications, used in distribution companies but these have not been included in this research.

Network information system, which usually includes geographic information system (GIS) functionality, contains the essential documentation of the distribution network and its components. The main functions of NIS are network calculation and planning. NIS is usually interfaced with CIS that contains customer information, such as the electricity usage of a customer. SCADA system is used for monitoring the distribution system and controlling remote controlled network components. Distribution management system integrates NIS, CIS and SCADA together and visualizes the state of the whole distribution network on a geographic background map. DMS enables real-time management of the switching situation of electricity distribution network and, for example, speeds up fault location and restoration.

Business models of electricity distribution are changing and the development brings new challenges for the information systems, too [1]. The number of actors in distribution business is increasing as a result of outsourcing business processes. In other words, distribution business is fragmenting into separate operations that are performed by various service providers. Network construction and maintenance, for example, are typical outsourcing services already at present. This kind of fragmented business environment requires wide-ranging information sharing among a distribution company and service providers.

Furthermore, most of the present information systems are used in several operations and a service provider may need information from several sources.

Figure 1 illustrates the need for sharing information in a fragmented business environment. The information in NIS, for example, is the basis for many operations, such as network planning, operation, maintenance and construction. When outsourcing a business operation, the distribution company should be able to provide the service provider with access to the information, but only to the information that is necessary for the task in question.

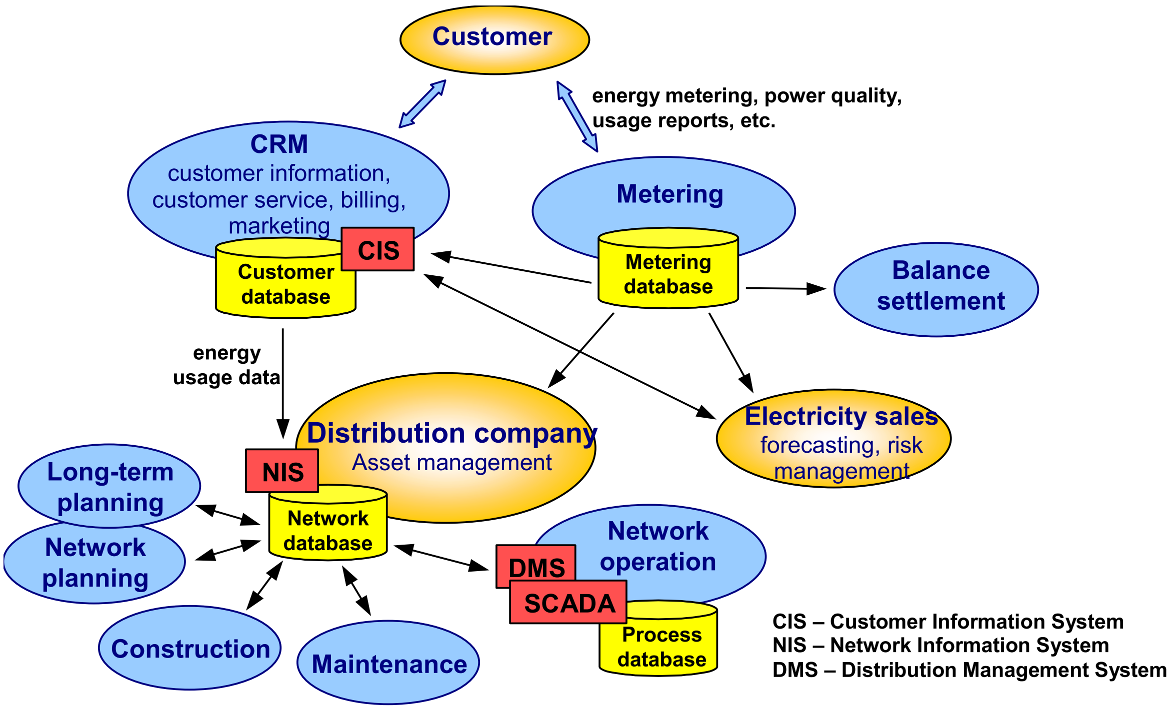

Fig. 1. Information sharing needs in a fragmented business environment

AIM OF THE SURVEY

The objective of the questionnaire study [2] has been to survey the current status of using operational information systems in Finnish electricity distribution companies. Effects of the development of distribution business have also been discussed in the research. The survey covers a wide range of topics concerning information technology applications in electricity distribution. With the confines of this paper, every section of the survey cannot be described here in detail, though. The results presented in this paper describe what information systems are companies using and how the applications are utilized. Problems and development needs related to information systems are also discussed.

The survey is a part of a joint project of Tampere University of Technology (TUT) and Lappeenranta University of Technology (LUT) concerning the development of electricity distribution business. [3]

The questionnaire was sent to 87 (out of 90) Finnish distribution system operators in September 2004. A response was received from 28 different sized companies (see Fig. 2). The survey results are a relatively representative sample of the subject, since the respondent companies cover 56 percent of Finland's customers and 62 percent of the total length of the

Finnish electricity distribution network. The questionnaire, which has been composed of both closed multiple-choice questions and open questions, was delivered to recipients in electronic form by e-mail.

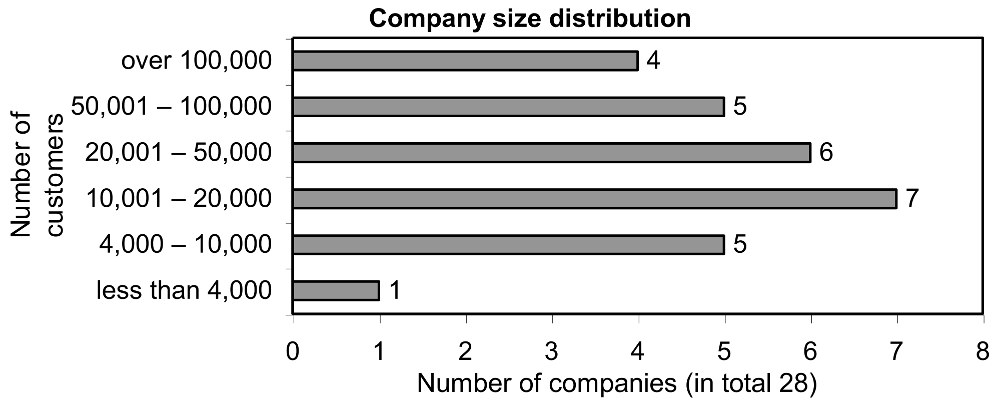

Fig. 2. Company sizes of the respondents

SURVEY RESULTS

The main information systems

CIS, NIS, SCADA, and systems for collecting and managing metering data are information systems that are commonly used in most of the distribution companies today. Distribution management systems are a little less common as yet but are, however, used by over 60 percent of the respondents. Ages of the main information systems are presented in the table 1, which shows that part of the DMS systems were still in implementation stage, so DMS seems to become even more general in the near future. Other systems besides DMS are becoming rather old in many companies but there are also many new NIS systems. It seems that many of the older systems, especially CIS and metering information systems, have been purchased at the time the Finnish electricity market was opening up for competition. The gradual opening of the electricity market started with the Electricity Market Act in 1995 and in 1998 every customer, including households, was allowed to buy electricity from the competitive market. New procedures, such as balance settlement, required new information systems.

Table 1. Ages of the main information systems

Age	CIS	NIS	SCADA	DMS	Meter reading systems	Metering data management systems
In implementation stage	0 %	19 %	0 %	24 %	10 %	0 %
< 2 years	0 %	22 %	15 %	29 %	30 %	10 %
2 – 5 years	42 %	7 %	26 %	24 %	15 %	33 %
5 – 10 years	54 %	33 %	37 %	24 %	40 %	57 %
> 10 years	4 %	19 %	22 %	0 %	5 %	0%

Traditionally, metering data has been stored in CIS, and according to the survey results, CIS is still quite commonly (21 % of the respondents) used for metering data management. As automatic meter reading (AMR) becomes more general, the amount of metering data will increase vastly and therefore traditional CIS will be unsuitable for metering data management.

According to the survey, the three leading CIS vendors in Finland are TietoEnator Oyj (software name: Forum), WM-Data Utilities Oyj (APM), and CCC Group (Ellarex). The three leading NIS vendors are ABB Oy (Integra), Tekla Oyj (Xpower), and TietoEnator Oyj (PowerGrid). The three leading SCADA vendors are ABB Oy (MicroSCADA), Netcontrol Oy (Nematic), and Siemens (Spectrum). For DMS there are two vendors: ABB Oy (Opera) and Tekla Oyj (Xpower DMS).

Information systems for electricity distribution network maintenance management were also enquired. The most common system for maintenance appeared to be network information system (or an application included in it), which is used for saving maintenance data of network field inspections, for example. There are also some particular maintenance applications used for maintenance management but none of them is generally used, however.

Other typical information systems in distribution utilities are applications for network construction and materials management. The majority of the respondent companies have developed some kind of applications by themselves, too. These self-made applications are typically used for all kinds of reports and calculations.

Utilization of information systems

As described in the introduction, the survey results prove that a single information system is typically used in number of business operations. In addition, one application needs information from several databases. Customer service, for example, is an operation in which many other systems besides CIS are used, and also CIS is used for several other purposes and by many other applications. Therefore connections between different information systems are needed. Furthermore, despite the restructuring in the electric utility industry, the same CIS is still used by both the distribution company and the electricity sales company of a former electric utility. Table 2 presents the utilization of four information systems in different business operations. The dots indicate the commonness of using a system for the operation in question.

Table 2. Utilization of information systems in different business operations

System	Distribution	Selling	Customer service	Metering	Construction	Maintenance
CIS	•••	•••	•••	•••	•	•
NIS	•••	•	••	•	••	•••
SCADA	•••	•	•	••	•	•
DMS	•••	•	••	•	•	••
The percentage of companies using a particular system: • < 30 % •• 30-60 % ••• > 60 %						

The utilization factors (i.e. efficiency of the use) of the information systems were examined by asking how big part of a system's features is efficiently used. The results show that some systems, especially maintenance and construction systems but also NIS and DMS systems, are in quite inefficient use in many cases. For example, approximately a third of the companies are using less than a half of the features of NIS. Apparently, redundant features are often included in modern information systems. Other possible reasons for the underutilization might be lack of expertise of users and technical problems in systems integration, for example. The most efficiently used systems proved to be SCADA and metering systems.

Importance of some factors related to utilizing information systems were examined by a multiple-choice question in which the factors listed in Fig. 3 were rated on a scale of one (insignificant) to six (very important). The mean values of the answers are presented in the diagram. The most important things appeared to be possibility of integration to other systems, clear user interface, and ease of use. User training was considered important, too, and there is also need for exporting data to a spreadsheet, for example. Mobility of a system was not considered to be very important, though opinions about this can change in the near future due to the rapid development of mobile technology.

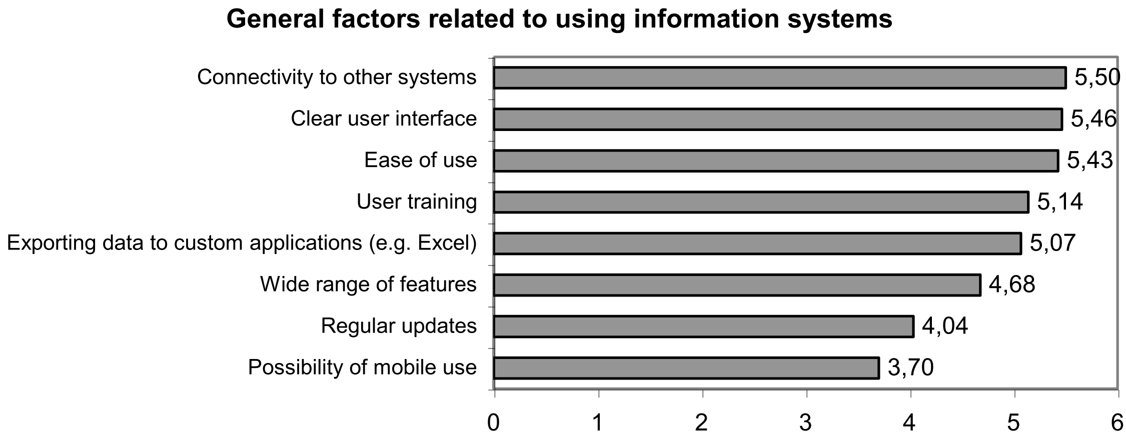

Fig. 3. Importance of things related to utilization of information systems (1=insignificant, 6=very important)

Utilization related problems were surveyed similarly to the above question. The results are presented in Fig. 4, which shows again that integration problems are the most significant issue. It is also quite interesting to note that lack of user skills is among the top three problems of this list. However, it seems that there are no significant problems with user training.

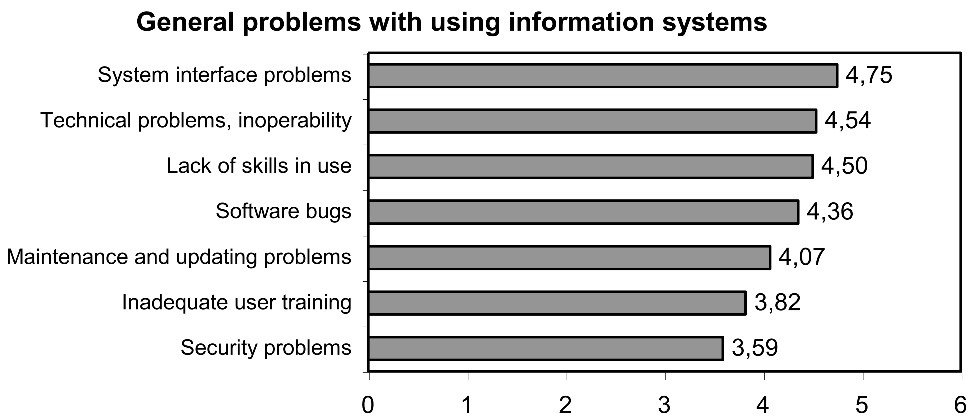

Fig. 4. Significance of problems related to utilization of information systems (1=insignificant, 6=very significant)

Software procurement and implementation

Fig. 5 shows what are the general selection criteria for an information system. Again, the respondents have rated each point of the list on a scale of one to six according to their own experience. Functionality of the system and reliability of the vendor proved to be the most decisive factors but almost equally important are compatibility, availability of support, vendor's expertise in the power industry, and ease of use.

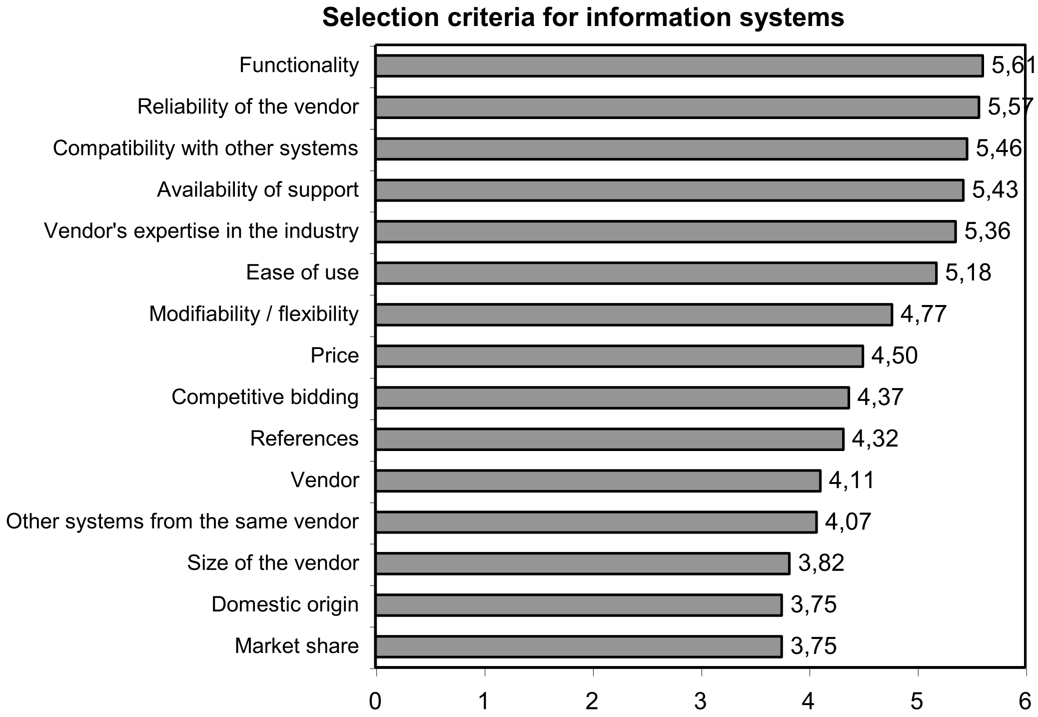

Fig. 5. Significance of factors related to choosing a software product (1= insignificant, 6=very significant)

Software procurement and implementation related problems are rated in the Fig. 6, which shows that integration is the prime problem once again. Other general problems are the duration of implementation process and difficulties with requirement specification of the system.

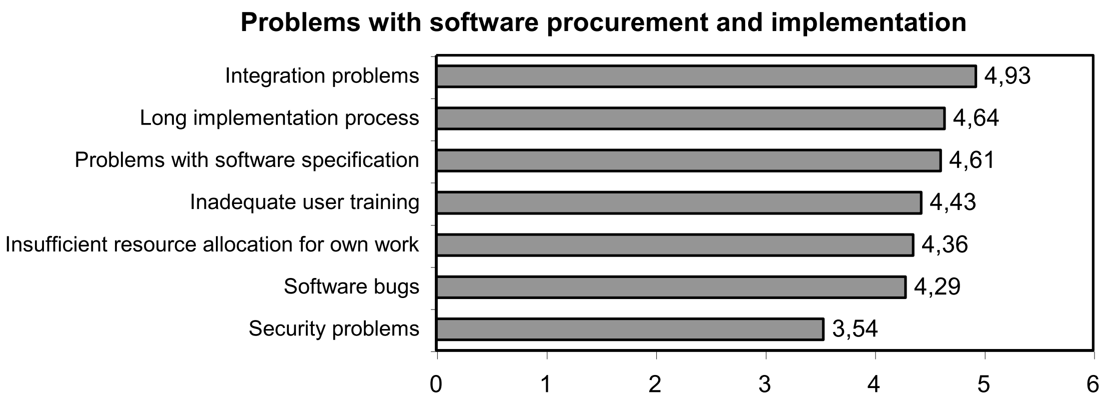

Fig. 6. Significance of problems related to software procurement and implementation (1= insignificant, 6=very significant)

According to the above diagram (Fig. 6), the respondent companies have had problems with resource allocation for procurement and implementation work. In other words, distribution company's own work contribution that is required to complete the project may be higher than expected. This issue was covered more detailed in the survey by questioning about the proportion of own labour in total software cost including purchase price and cost of labour. Cost of labour was estimated generally, not for a specific information system. The results of this question are presented in the table 3, from which we can see that in most cases labour cost is between 15 and 50 percent of total cost. Thus a considerable number of man-hours are needed to get the system into everyday use.

Table 3. Percentage of labour cost to total cost of software procurement

Cost of labour	< 15 %	15 – 29 %	30 - 49 %	50 - 74 %	≥ 75 %
Percentage of the answers	19 %	46 %	27 %	4 %	4 %

Integration problems and identification codes

As expected, the most significant problems with information systems proved to be integration issues. Especially connecting an existing application with a new one, or applications from different vendors, is time-consuming and costly due to incompatibility and lack of standard interfaces. Thus open standards are needed for application integration to achieve better interoperability between applications and to prevent multiple storing of the same data, for instance.

Inconsistence of identification codes, such as identifiers for electricity supply points, complicates integration even more. Almost every distribution company has its own specific practise for identifying the electricity supply point of a customer, and there is no coherent terminology. This issue has also been covered in the survey. Identifiers for supply points, energy meters, and customers are typical identification codes that exist in NIS, CIS, and metering information systems. It was shown that in many cases different terms are used for the same code in the systems of a distribution company. In addition, the same term may also have different meanings in different companies. So it is obvious that the incoherence complicates integration, especially from the service markets' point of view because besides inter-company application integration, information has to be shared also with service providers.

CONCLUSIONS

Operational information systems in Finnish electricity distribution companies have been studied in this research. CIS, NIS, SCADA, and systems for energy metering are information systems that are commonly used in most of the distribution companies today and also DMS systems are becoming general. The survey results showed that the systems are rather old in many companies. In addition, the fragmenting distribution business brings new challenges for the information systems, so the present systems may be insufficient for the future needs.

Utilization of information systems has been covered widely in the survey. The most significant issues that came out in most of the questions proved to be related to integration of information systems. Open standards are needed for application integration and identification codes need to be standardized, too. Results also showed that in many cases systems are underutilized so that only a part of the system features are used. A possible reason for this is, for example, lack of user skills.

Also software procurement and implementation was surveyed. For example, the cost of company's own labour in software procurement was examined and it proved to be a significant proportion of the total cost.

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Publication 4

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Questionnaire Survey of Services and Outsourcing in Finnish Distribution Companies

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Abstract: The aim of this study was to find out what types of services Finnish distribution companies were purchasing and what is the future trend related to them. Results were gathered from Finnish distribution companies using questionnaire. Theoretical background was collected from literacy to get more information of benefits and risks. Results indicate that purchasing services especially from independent service providers is increasing. Also the benefits are greater than the risks related to service purchasing.

Key words: Electricity distribution, service purchasing, outsourcing, business model, business processes.

1. Introduction

Service purchasing and outsourcing in different industries have been discussed widely in the publications for example in economics. Surveys of specific industries have been done. For example survey concerning logistics suggests that companies can improve customer service and reduce costs by outsourcing multiple logistics functions [1]. Succeeding in this requires that purchasing process is designed properly [2]. In some cases services can be purchased with responsibility of certain entity such as maintenance [3]. One of the goals in purchasing service is to improve companies'efficiency. This improvement must be somehow measureable. Example of this type of method is described in Refs. [4, 5].

Electricity distribution business is monopoly business by nature and many of the utilities are municipally owned. Efficiency measurements are being conducted for example in Ref. [6]. In broader context privatization is one possible way of improving efficiency in electricity distribution [7]. Research on what distribution companies are willing to buy as service now and in future is not published earlier.

Electricity distribution business in Finland is changing towards networked business model [8]. This paper deals with a project studying purchasing of services in the Finnish electricity distribution currently. The project was divided to subtasks, from which web questionnaire for distribution companies and service providers were one. This paper focuses on the results of the questionnaires. The aim of the whole project is to find out following issues:

- What business processes are purchased as service?
- The main reasons for purchasing;
- Ratio of in-house and service business processes now and in future;
- Expected benefits and risks in service purchasing;

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- Experiences of service purchasing;
- Activities and steps in successful service purchasing;
- Prerequisites and barriers of successful outsourcing;
- Best practices in the market;
- New innovative service business concepts.

2. Beginning of Service Purchasing

The service purchasing begins with finding out the possibilities to purchase service. Second phase is to ask tender from service providers. If the decision after tender analysis is that service is being purchased the agreement is negotiated. The portion of each process and their level of involvement in each phase have been presented in Table 1.

From Table 1 it can be seen that according to results medium size companies are using more services than the large utilities. The number from small utilities is not presented as the number of answers was so small.

When comparing the portion in each step, it can be seen that in many cases the portion of tender request is the smallest. This may be due to utility already knowing the partner providing the service.

Fig. 1 presents the number of new services being purchased annually by the Finnish distribution companies.

Year 1995 is the highest peak in number of beginnings in business process purchasing as a service. Looking at individual results one company made seven process service starts but still it is a highest number annually. Finnish electricity market was liberated in 1995 which may have increased the number in that year. Also the change of the century is another high rate of service beginnings. No clear reason for this was found based on the questionnaire results. The years include both full and additional service acquisitions. More detailed analysis of the start-up phase of the service purchasing is presented in Ref. [9].

3. Service Purchasing and Future Trend

Utilities can select strategy for approaching their processes in terms of whether to purchase services or do them in-house. Each process can be decided separately

Table 1 Finnish distribution companies answers of number of processes by utility size that they have: (A) made research of possibility to purchase service; (B) put processes out to tender; (C) purchase service.

Category		Large			Medium size		
	Process	A	B	C	A	B	C
Network planning	General planning	11%	0%	0%	22%	11%	22%
	Network planning	44%	33%	33%	56%	33%	33%
	Field planning	67%	33%	56%	89%	67%	67%
	Structure planning	56%	33%	56%	33%	33%	33 %
Network construction	110kV	67%	44%	56%	44%	33%	44%
	Cable network	78%	56%	67%	78%	67%	78%
	Overhead lines	78%	56%	67%	100%	78%	89%
	Substation	78%	56%	67 %	100%	89%	100%
	Warehouse/logistic	56%	33%	56%	67%	67%	44%
Network operation and maintenance	Network operating	11%	11%	11%	56%	22%	44%
	Fault repairing	56%	22%	44%	56%	33%	44%
	Condition inspect	56%	33%	56%	78%	67%	56%
Energy and technical measurements	AMR service	33%	22%	33%	56%	33%	22%
	Mass meter replace	33%	22%	22%	44%	22%	11%
	Balance settling	44%	11%	33%	44%	33%	33%
	Condition monitor	0%	0%	0%	56%	22%	11%
Customer service	Commercial	44%	11%	44%	33%	11%	22%
	Technical	0%	0%	11%	33%	11%	22%

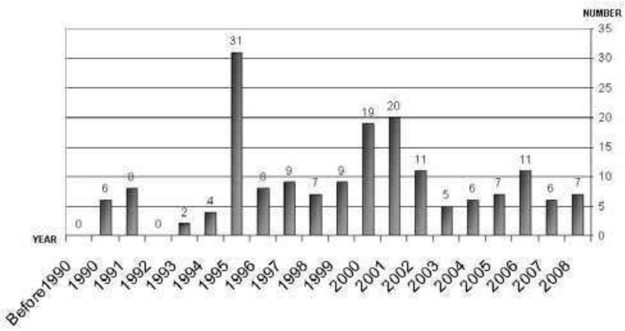

Fig. 1 Number of new service purchasing annually by Finnish distribution companies since 1990.

or companies can make general decision on whether to favour in-house processes or to start using services in large scale.

When looking at results 14 utilities gave totally covering answers on all or almost all of the processes. This is 17% of the total number of companies receiving the questionnaire. In-house processes were dominant in three utilities and also three utilities were favouring full scale service purchasing. Other companies were having both in-house and services in their process organization.

Table 2 presents the main type of organizing business processes in utilities currently. In addition it presents the change in percentage in that by the year 2015. Table 2 is divided into mainly in-house, mainly service purchasing from ownership level service provider or from independent service provider.

As shown in Table 2, the change from today's process organization is that the number of mainly in-house processes is decreasing by 40%. Independent service purchase is increasing it is share by 67% and ownership relation services 22%.

Most typical in-house processes for Finnish utilities are general planning and network planning. This is the current situation and also estimated in 2015. Also most of the network construction processes have high in-house rate excluding 110 kV network. Other processes purchased extensively from independent service providers are substation projecting and balance settling. One of the biggest changes is taking place in measurement processes. Automated Meter Reading AMR service process will be purchased most extensively from independent service provider in 2015. The change is from 45% in-house to 18% in year 2015.

Table 3 presents the additional purchase of services according to type of partner with future trend.

From Table 3 the result is that the number of additional service processes purchased from ownership level partners is increasing by 72%. The number of service processes purchased from independent service providers is increasing totally around 10%. This may be due to that many answers covering 2015 also included the option of purchasing from ownership level partner. This may indicate uncertainty of future strategies of purchasing.

Network planning functions are increasing the portion of additional services purchased and especially from independent service providers by the year 2015. Condition monitoring is decreasing the number of additional services and increasing the total service purchasing from ownership and independent service providers.

Tables 2 and 3 indicate that currently if utility has ownership with the service provider it is most likely that the process is fully purchased as service. If the service provider is independent and agreement is based on competition the level of cooperation is not so deep. In 110 kV network construction and substation projecting functionalities the portion of independent service provider was low. This is due to that in-house processes combined with services being purchased from ownership level partner formed majority of the total number of agreements.

Results in Table 2 indicate the service purchasing is changing towards services purchased from independent service providers. In more detailed the number of mainly purchased services from independent service provider is increasing by 67%.

4. Benefits and Risks of Services

Risks identified by utilities that were common to all of the processes were in order of importance:

Table 2 Comparison of process organizing now and change estimated to year 2015.

Category		Mainly in-house		mainly purchase / ownership		Mainly purchase / independent	
	Process	now	2015	now	2015	now	2015
Network planning	General planning	100%	-7%	0%	0%	0%	7%
	Network planning	100%	0%	0%	0%	0%	0%
	Field planning	86%	-10%	10 %	5%	5%	5%
	Structure planning	88%	0%	6%	0%	6%	0%
Network construction	110 kV	8%	0%	23%	0%	69 %	0%
	Cable network	25%	0%	45%	-10%	30%	10%
	Overhead lines	21%	0%	47%	-11%	32%	11%
	Substation	14%	0%	10%	-5%	76%	5%
	Warehouse/logistic	25%	-8%	50%	-8%	25%	17%
Network operation and maintenance	Network operating	79%	0%	21%	0%	0%	0%
	Fault repairing	21%	0%	64%	-21%	14%	21%
	Condition inspect	17%	0%	67%	-8%	17%	8%
Energy and technical measurements	AMR service	45%	-27%	36%	0%	18%	27%
	Mass meter replace	43%	-29%	43%	14%	14%	14%
	Balance settling	30%	-20%	20%	10%	50%	10%
	Condition monitor	67%	-33%	33%	17%	0%	17%
Customer service	Commer-cial	60%	0%	40%	0%	0%	0%
	Technical	75%	0%	25%	0%	0%	0%

Table 3 Portion of additional services purchased by the utilities and change by the year 2015.

Category		Additional purchase / independent		Additional purchase /ownership	
	process	now	2015	now	2015
Network planning	General planning	7%	0%	0%	+7%
	Network planning	39%	+11%	11%	+6%
	Field planning	57%	+10%	10%	+10%
	Structure planning	50%	+19%	6%	+13%
Network construction	110 kV	23%	-8%	0%	+8%
	Cable network	45%	0%	0%	+5%
	Overhead lines	47%	-5%	0%	+5%
	Substation	24%	-5%	10%	+5%
	Warehouse/logistic	25%	0%	0%	0%
Network operation and maintenance	Network operating	14%	+14%	21%	0%
	Fault repairing	36%	-7%	0%	+7%
	Condition inspect	50%	0%	0%	+8%
Energy and technical measurements	AMR service	18%	+9%	0%	0%
	Mass meter replace	57%	0%	14%	-14%
	Balance settling	0%	0%	0%	+10%
	Condition monitor	50%	-33%	0%	0%
Customer service	Commercial	20%	+20%	20%	+10%
	Technical	0%	0%	25%	+25%

(1) The number of service providers is too small for truly functioning market of services;

(2) Targeted costs savings does not realize;

(3) IT systems can not support service purchasing;

(4) Service purchaser's and service providers relationship does not meet the expectations;

(5) Lose of know-how in organization of service purchasing utility.

Correspondingly benefits from service purchasing were identified in order of importance:

(1) Getting additional resources becomes more easier;

(2) Possibility for the utility to concentrate on the core business;

(3) Cost savings;

(4) Access to the best practices;

(5) Better costs awareness.

Risks and benefits varied a little in case of each process although those presented above cover the majority of those. According to answers benefits from the service purchasing are higher than the risks. This can also be verified by the fact that the satisfaction to services purchased was high.

5. The Role of IT Systems

Information systems have a significant role in creating the services in the current utility environment. As stated in previous chapter the IT systems were seen as one of the most crucial risks. The risk is that they can not support service purchasing. Following processes and their IT risk is discovered:

(1) Condition inspections (most significant risk);

(2) Balance settling (most significant risk);

(3) Structure planning (2nd most significant risk);

(4) Field planning (2nd most significant risk);

(5) Warehousing and logistics (2nd most significant risk);

(6) Meter mass replacing (2nd most significant risk);

(7) Network planning (3rd most significant risk);

(8) AMR measurements and database (3rd most significant risk).

In discussions with the utilities the risk was identified as integration problem. Meaning that transferring data from systems to another and allowing service providers download and update information was not possible or was very difficult. From service providers questionnaire this risk appeared on the list at number 11 as minor risk.

Compared to other IT related studies findings are identical. In Ref. [10] following problems with IT systems were found:

(1) System interface problems (integration);

(2) Technical problems (inoperability);

(3) Lack of user skills (can not fully benefit from systems);

(4) Program errors.

These problems influence on service purchasing. Efforts on developing IT systems should be increased. The pressure from increasing service purchasing also requires this.

6. Helpful Hints

Important factor on service purchasing process is setting goals for the service. These can be quantitative and also qualitative. Types of goals set for services were not asked on this study. However, the time that goals were met was asked. Table 4 presents them according to company size.

Medium size companies are little bit more active on purchasing services. They also seem to meet goals set for purchasing services faster than large utilities. Also meeting goals in some phase along the agreement period with service provider is higher among medium size utilities.

Qualitative results from services were collected by asking utilities level of satisfaction to the purchased services. Results for this according to company size have been presented in Table 5.

7. Discussion

The usage of services is increasing in the future among the Finnish distribution companies. The main reasons are concentration to core business, need for additional resources, access for best practices and cost awareness and saving.

Service purchasing itself is not something to promote. Results indicate that if it is managed well it can have positive outcome and it may help to solve problems related to in-house operations.

Utilities seem to be satisfied with services that they have purchased and in most cases the goals set have been achieved.

Table 4 How the goals set for purchased services were met according to different company sizes.

Reaching goals	Large	Medium size
During first year	52%	64%
During first 3 years	40%	32%
Not reached	8%	4%

Table 5 Utilities opinions about the services being purchased on general level.

Experiences from services	Large	Medium size
Very satisfied	6%	19%
Satisfied	72%	51%
Neutral	17%	20%
Unsatisfied	4%	7%
Very unsatisfied	1%	3%

The effect of the company size does not seem to make big difference on how much of the processes companies purchase as service. Interesting factor is that many distribution companies have service company with ownership relationship. These regional companies are mainly outsourced from the distribution company and take care of network construction and fault repairing.

Results show that in future the trend is towards purchasing services from independent service providers.

The role of IT systems is significant in service purchasing and according to this study they also cause significant risk and actual barrier limiting usage of services. Utilities should take effort on actively finding solutions to these problems and invest on systems supporting service purchasing. Case studies made also reveal that best practice is to benefit IT also in tender and order phases. Some companies say this is obligatory for managing services purchased.

Changing from in-house business processes towards networked business model requires also changes inside the distribution companies. Previously know-how has been on work management but in service purchasing it must be on defining what is being purchased, what are the KPI's (key performance indexes) to measure quality of service, what kind of legal agreements are set, how are the information systems following service purchasing and how to support service markets. Even tough utilities see risks in service purchasing they can be managed with well defined processes and experience.

This is not easy task and seems to take several purchasing rounds to practice it. From distribution companies' management this change in the business model should be taken into close consideration. Success in management makes this transformation easier in long term.

8. Conclusions

This study presents development of service purchasing in Finnish Distribution companies. There are risks related to service purchasing. These can be either common related to any service being purchased or relate to the content of the service.

With experience and well designed processes service purchasing can be successful. Transfer from in-house to networked business model requires careful planning and specific know-how. Finally the positive result of the study is that Finnish distribution companies were satisfied wit the services they purchased and the goals set for them were reached.

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Publication 5

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COST STRUCTURE OF ENERGY MEASUREMENTS – A CASE STUDY

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INTRODUCTION

Electricity distribution business is shifting from traditional utilities to commercially driven companies operating in competitive service markets. Some business segments in the field of electricity distribution business are under corporatization. This change requires studies and development of new kinds of business models. To understand the possibilities these new companies have, it is important to study the cost structures of their operations more closely. The analysis of current cost structures of different processes and activities make it possible to understand the changes required for municipal organizations to enter the competitive service markets.

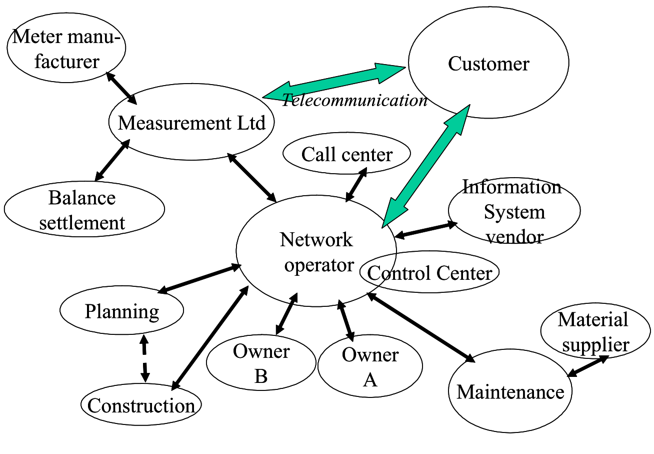

Figure 1. New business operation environment for electricity distribution business.

Figure 1 illustrates the development of distribution business. The shift from traditional and centralized business processes to core business units acting under competition is the predicted development in the electricity distribution business in future. This development has been studied in cooperation with Tampere University of Technology and Lappeenranta University of Technology. The aim of the project is to study the changes taking place in electricity distribution business and forecast the business scenarios for future.

The measurement process is one possible business to be outsourced. In this study, the basis of understanding and analyzing the business framework for measurement in competitive environment is created. Another shift that is going on in electricity business is the rise of Automated Meter Reading (AMR) technology. Investment decisions for automated meter reading are currently under consideration in many European countries. Enel in Italy has published plans to deploy AMR to all of it's 27 million customers. [1] The possibilities that new technology in the form of automated meter reading offers can be studied more closely when cost structures of traditional meter reading are more accurately known.

The aim of this study is to analyze the cost structures of traditional and automated reading, and to compare the differences between these two technologies. The analysis is carried out in one electricity utility in Finland. The analysis supports decision-making when considering whether to outsource measurement or not, and selecting the measurement technology.

This study was carried out as a single case study. In future, it will be broadened to cover larger number of electricity utilities. Exact numbers of costs structures are confidential and they have been replaced by fictive numbers.

RESEARCH METHOD

The aim of activity-based costing (ABC) is to determine the actual product cost by studying activities performed by resources. The idea of ABC is presented in Figure 2. Companies' processes can be described as activities at the selected level of details. In order to reach its goals, an ABC system should assign cost factors to cost-objects via resource and activity drivers. Both activity and resource drivers should be defined according to cost-objects' activity and resource use before this assignment is possible. [2, 3]

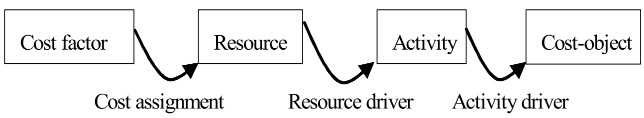

Figure 2. Assignment of cost factors to cost-objects.

Conducting activity and resource analyses needed to follow the procedure of Figure 2 is very complicated because of the time and cost requirements of these analyses. Therefore, a fast interview-based research method was applied in this study.

The study was conducted as a single-case study. The case organization of the study is a Finnish municipal electricity utility. The measurement environment can be described by "Profile meter" which refers to the inhabitant and customer statistics of the utility's service area. There are over 100 000 measures out of which over 20 000 have to be change read every year. This means that, on average, all inhabitants in the area move every fifth year. Furthermore, the measurement process was divided into seven activities: New measure assembly, Annual reading (traditional & automated reading), Change reading, Meter replacement (traditional & automated reading), and Data system integration. These activities were selected as cost-objects, and costs for each of these were measured via resource and activity analyses.

The data for analyzing the activities was gathered from the following sources: the accounting systems of the utility, a vendor for measurement systems and equipment, and the director of the measurement operation. The data of the accounting systems concerning the seven activities mentioned above was examined thoroughly. The representatives of a vendor for measurement systems and equipment were interviewed once. They were asked for, e.g., information about the costs of investment and maintenance of automated reading. The director of the measurement operation was interviewed twice on-site and via telephone a couple of times. The director replenished the information gathered from the accounting systems.

The information of the activities was put together and analyzed in a Microsoft Excel spreadsheet. The spreadsheet included the activities mentioned above and the costs of each activity divided into material, direct labor costs, indirect labor costs, fixed labor costs, and capital costs. An example of the spreadsheet is presented in Figure 3.

		Activity: New measure assembly			
		Costs	Resource driver	Portion of work time (Activ.drv)	Cost factor
Indirect labor costs	Designing	30 000 e	5 persons	25 %	24 000 e
	…	…	…	…	…

Figure 3. An example of the spreadsheet used.

In Figure 3, indirect labor costs were divided e.g. into designing. In this example, the resource driver consisted of the number of designing workers. Percentage of design work time used for "New measure assembly" was put into "portion of work time" (Activity driver). Annual costs for designing (which are assigned for New measure assembly) were calculated by multiplying the average annual pay for a white-collar worker (Cost factor) with the number of designing workers (Resource driver) and with the portion of work time (Activity driver).

In the similar way, all cost factors were assigned to each of the seven cost-objects. All cost values presented in the results section represent real ratios between different cost-objects, but the absolute values represent a fictive indexed currency.

RESULTS

The cost structure analysis of physical work (New measure assembly & Meter replacement, material cost involved) shows that New measure assembly and Meter replacement are lower cost activities when using traditional reading technology than when using automated reading. However, the explanation for this is mainly the high material cost of automated reading. When assembling pilot measures, the number of purchased remote measures was low. Therefore, the economies of scale could not be fully achieved. In this study, the capital cost of automated reading was fully assigned to this activity. Furthermore, as illustrated in Figure 4, the activity costs (everything but material) of assembling and replacing automated reading are much less than in traditional reading. A significant reason for low activity costs in automated meter assembly is that the assembly work has been started from block flat customer segment. In block flats, the assembly work time per customer is low because of the ability to assembly many measures at the same site.

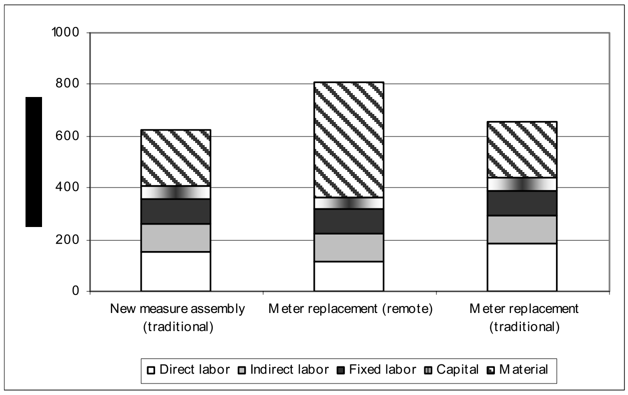

Figure 4. Cost structure of physical work (New measure assembly & Meter replacement).

The cost structure analysis of continuously running activities (Annual & Change reading, no material cost involved) reveals that traditional reading is slightly lower cost operation than automated reading in Annual reading but far more expensive in Change reading. Figure 5 illustrates the situation. The explanation for this is that in traditional reading Annual reading can be well-planned and efficiently carried out, but change reading takes place whenever an inhabitant moves his/her residence. Hence, the measure readers have only few residences per day to read and the measures cover all the area of a city. In automated reading, Change reading is actually the same data system process as Annual reading.

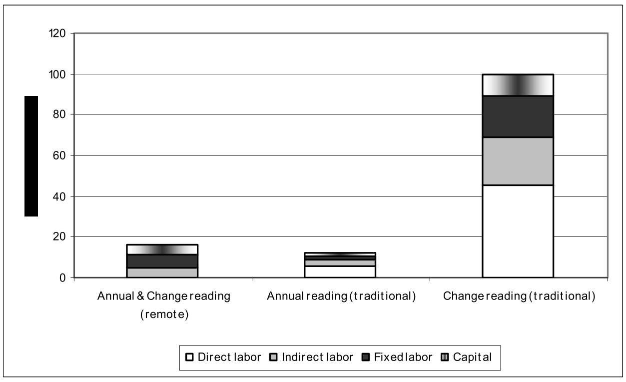

Figure 5. Cost structure of continuously running activities (Annual & Change reading).

The calculated costs for Data system integration (2.6% of total utility costs) could not be assigned to any of the six other activities.

ANALYSIS

The Profile meter of the studied utility is in use for 15 years and during that time three different persons live in the residence. According to this kind of profile, the cost structure of a measure is illustrated in Figure 6. Traditional and automated reading cause almost the same cost but with totally different cost structure. The activity costs of traditional reading are significantly higher. With this current profile, automated reading causes 3% less cost than traditional reading.

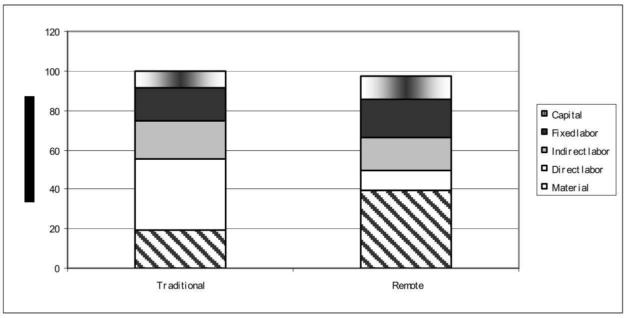

Figure 6. Cost structure (by cost factors) of the Profile meter in the studied utility.

A very simplified sensitivity analysis of changes in the inhabitants' moving behavior reveals that automated reading is recommendable way of measuring in urban areas. In Figure 7, the time of using measures is increased to 18 years and the number of consecutive persons living in the residence is increased to four. This means that the average living time in same residence is decreased from current statistical five years to four and a half years. With this new profile, automated reading causes 11% less cost than traditional reading. In growing urban cities, such as the customer area of the studied utility, this kind of change in the Profile meter can be expected to take place.

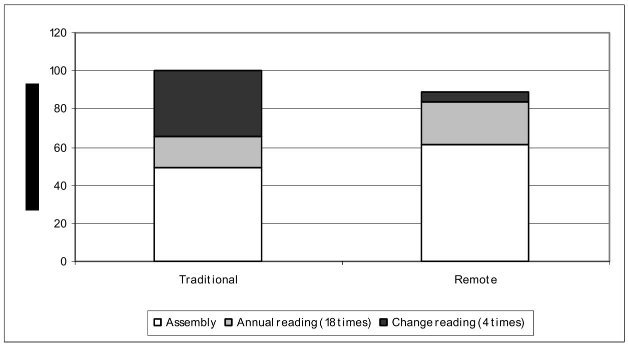

Figure 7. Cost structure (by activities) of the expected Profile meter in the studied utility.

The sensitivity analysis shows that traditional reading is lower cost if the customers do not move often and meters do not last long. Taking the expected changes in the customer behavior into account, automated meter reading seems to lead to cost savings. To be remembered, the meters, being traditional or automated ones, have to be replaced approximately every 15th year. This means that current decision-making situation is not to assembly new measures but to replace the old existing ones.

DISCUSSION

Results show that in urban areas where people move intensively automated meter reading can be more cost efficient. This is caused by the extensive traditional measuring cost in Change reading activity. In AMR, Change reading and typical Annual reading act identically when considering the meter reading costs.

In rural areas, so far, the traditional meter reading is more cost efficient considering only the measuring costs. The possibilities that new technology opens in some parts of the electricity network in form of investment planning through load management are not taken into account in this phase of the study.

New technology improves business most if the business models are tuned to make real all the possible benefits. Automated reading has its impact also on other activities than just measuring the amount of energy spent in certain time frame. In AMR both-way telecommunications is the technological basis of developing new services and business models. New technology makes it easy to cut of the power if a customer fails to pay electricity bills. More advanced load management possibilities exist as well. During peak power hours technology allows to cut off certain loads e.g. heating or air-condition. Also customer service can be improved by allowing customers to see their electricity consumption e.g. in Internet or offering energy saving tips. In wider area of new possibilities, the home automation and security systems can also be attached to AMR.

As suggested in earlier empirical analysis, the unit cost behaviour in outsourcing situations is not very well managed in public sector [4]. Compared to current in-house cost, two time limits for the realized cost after outsourcing have been introduced (See Figure 8).

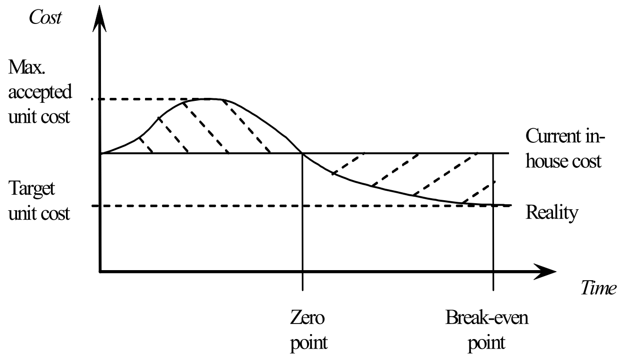

Figure 8. A proposed framework for analyzing the profitability of outsourcing [4].

First, "zero point" is a moment when the total unit costs (all partner's and principal's costs included) of an outsourced activity are equal to the initial in-house costs. At zero point, the temporary increase of unit costs after outsourcing has turned into decreasing trend and no extra costs compared with the initial situation exist. Second, "break-even point" refers to a moment when the realized and reduced unit costs have produced cost savings equal to the losses caused by the increased unit costs in the beginning of the outsourcing (dashed areas represent equal amount of money). At break-even point, the principal's total cost over time is the same as it would have been without outsourcing. Break-even point refers to profitability terms because it illustrates a moment after which a principal can benefit from the outsourcing decision also in the sense of increased unit profitability.

In addition to time limits, two cost limits for the realized cost after outsourcing are introduced. First, "maximum accepted unit cost" refers to the level of unit cost that is accepted to realize after outsourcing. If the unit costs are in any time after outsourcing higher than the accepted maximum, the outsourcing project can be classified as a failure. Second, "targeted unit cost" refers to the unit cost level that is set as a target for the outsourcing project early in the beginning. Without such a target the project may appear as too explorative.

The meaning of the limits is to design the outsourcing project beforehand and to control it in all phases so that the unit costs are not just "taken as they occur" but systematically managed [4]. If outsourcing of measurement process is considered, the in-house cost structure should be compared with the potential measurement service provider's price and manage the outsourcing with the help of the proposed framework.

To broaden the understanding the cost framework of measurement process further studies must be done. The effect of economies of scale on measurement business should be studied more closely. This requires similar kind of analysis to be carried out for a distribution company that has a large scale implementation of automated meter reading. Benchmark data from several companies should be collected in order to publish average costs and further statistical analysis.

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Publication 6

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COMPARISON OF LIFE-CYCLE COSTS OF ENERGY METERING PROCESSES

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ABSTRACT

In this study, the basis of understanding and analyzing the business framework for measurement in competitive environment is created. Metering issues are currently discussed widely because investment decisions for automated meter reading (AMR) are currently under consideration in many European countries. The possibilities that new technology in the form of AMR offers can be studied more closely when cost structures of metering are more accurately known.
In this study life cycle costs for 11 different kind of metering activities are presented. These are combination of 5 different Finnish distribution companies' alternatives to carry out energy measurement. Results show that the nature of metering processes varies according to the way they are carried out. Cost structures show also the parts of organization that put efforts on energy information creation. New technology in form of Automated Meter Reading (AMR) can change the business processes and work in general inside organization. This factor should also be considered. AMR can also cause needs for additional features to fully benefit the investment.

INTRODUCTION

The aim of this study is to analyze the cost structures of different metering activities in distribution companies. There are many factors affecting the cost of metering and knowledge of understanding some of these factors is the results of the study. This paper presents the metering activities and real cost structures to increase understanding of different possibilities in organizing metering.
This study for five Finnish Distribution Network Operators (DNO) was conducted during 2005-2006. The data was collected from the companies' 2003-2004 accounting information. Method used is described more closely on next chapters.
Preliminary results of this study have already been presented in Cired 2005 conference as a single case study of a single company [1].

STUDY METHOD

Understanding the activity and cost structures is a crucial element in evaluating new ways of organizing business processes. Activity based costing (ABC) was applied to provide information on cost structure of energy measurement business processes.
The aim of activity-based costing (ABC) is to determine the actual product cost by studying all activities under each process performed by resources. The idea of ABC is presented in Figure 1. Companies' processes can be described as activities at the selected level of details. In order to reach its goals, an ABC system should assign cost factors to cost-objects via resource and activity drivers. Both activity and resource drivers should be defined according to cost-objects' activity and resource use before this assignment is possible. [2, 3]

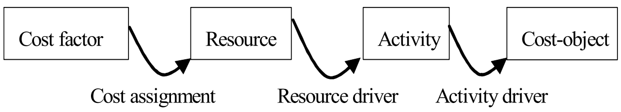

Figure 1. Assignment of cost factors to cost-objects.

Conducting activity and resource analyses needed to follow the procedure of Figure 1 is very complicated because of the time and cost requirements of these analyses. Therefore, a fast interview-based research method was applied in this study.
The study was conducted for five different Finnish DNOs. Companies present large and small utilities. Also the distribution area of the companies varies from small urban area with high customer density to large rural area with low customer density. Also comparison between in-house and outsourced processes can be made from the results of the analysis.
The metering function was divided into following processes for traditional or AMR meters:

- New measure assembly
- Annual reading
- Change reading
- Meter replacement
- Annual or period reading

These processes were selected as cost-objects, and costs for each of these were measured via resource analyses. These processes are presented more closely including some of the activities in next chapter.
The data for analyzing the processes was gathered from the following sources: the accounting systems of the utility, a vendor for measurement systems and equipment, and the personal of the measurement operation. The data of the accounting systems concerning the activities under

processes mentioned above was examined thoroughly.
The information of the processes was put together and analyzed in a Microsoft Excel spreadsheet. The spreadsheet included the processes mentioned above and their costs each divided into material, direct labor costs, indirect labor costs, fixed labor costs, and capital costs.

METERING PROCESSES

This chapter describes the different processes studied.

1. Annual reading of traditional energy meter
The process covers systematic and planned manual readings of energy meters annually and on site. The reading is done by employee of the distribution company or it's subcontractor.
The uncertainty in the process is caused by availability of readings. In some cases the customer cannot be reached and postcard for sending the reading is left on site. Card readings must be inserted into the system separately. This makes confusions in the amount of meter readings inserted in the systems. In Activity Based Costing (ABC) method the number of processes done is important. In some cases this was uncertain and estimations were used.

2. Change reading of traditional energy meter
When customer moves reading must be conducted to complete billing. This process is called change reading. Compared to annual reading the process has different phases. The main difference is, that it is always a single case reading. In some cases the customer informs the distribution company about the meter reading and visit on site is not required. The ratio of these varies according to companies. Also incorrect meter readings cause second visit to the metering site. In some cases the amount of these incorrect readings were known. This causes also uncertainty to the cost of the process.

3. Meter replacement
Meter replacement process includes activities done to change existing meter. Depending of the case the new meter is either traditional or AMR meter. The meter type has effect on the cost of the process. AMR meter present higher material cost due to more expensive meter. Some companies use maximum time for meters in network. This causes annually changing amount of meter replacements. Also miss functioning of the meters cause meter replacements. Due to becoming AMR investments some companies have suspended the annual meter replacements. This cause uncertainty to the process costs.

4. New meter assembly
The process covers establishments of new metering sites on network. Compared to meter replacement more indirect labor is required to establish metering site also to information systems. Meter cost is presented on the material cost and depends also on the type of the meter.

5. AMR meter reading
This process covers the Automated Meter Reading (AMR) activities. Compared to the annual reading process is automated so that the reading is done using telecommunication to acquire the correct reading. Annual reading and change reading are basically the same process and don't require significant extra work. Uncertainty to this process is caused by the fact that in all of the companies studied AMR was more or less on experimental level and processes were not as clear and well organized as in traditional meter reading. Only in one company the AMR meters were implemented under 63 A fuse size. This causes uncertainty in comparing traditional and AMR readings. Results of this single case study can be found from [1].
Usually mobile phone network or Power Line Communication (PLC) is used in telecommunication. In some cases also the combination is possible. Telecommunication provides new possibilities to interact with meter. The new possibilities can be utilized by developing meter's features.

RESULTS OF THE STUDY

In this chapter the life cycle costs for energy measurements for a 20- year-period is presented. To better compare the different options, annual reading is calculated to take place once in a year in both traditional and AMR reading. Technology makes it possible to increase the rate of reading to monthly and even daily reading. Increased rate of reading means additional costs from telecommunications.
In figure 2 the aim is to provide information of different kind of choices and their cost effect on total life cycle. From 5 different companies the result is 11 optional ways of producing metering function. This was done by calculating all the possible solutions when using the traditional / AMR reading and in-house / outsourced operations. Number in parenthesis presents company.
Parameters used in calculating the results are following:

- 20 year life cycle.
- One meter assembly in each life cycle cost.
- The results have been calculated to be more comparable by calculating annual reading once a year in to all of the processes.
- The rate of moving used is every 5th year. In 20 year life cycle this means 4 move readings

Figure 2 illustrates life cycle costs of the studied companies. Each company has been presented according to it's different processes and simulated to be comparable by setting the rate of processes same.

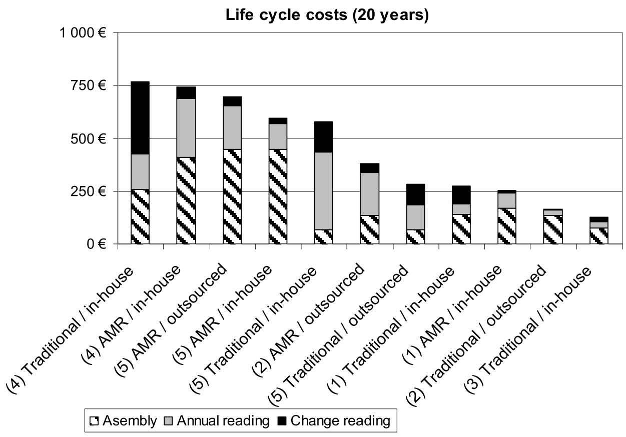

Figure 2. Life-cycle cost in different companies divided into different processes.

The cost variation in life cycle costs is quite high. In general can be said that neither the in-house/outsourced or the AMR/traditional processes are explaining factors when considering the total life cycle cost. This was verified with statistical TTest's. When studying the nature of the distribution area of different DNOs some explaining factors seem to be available. In this study higher customer density with smaller distribution area is reducing the total annual cost most efficiently. TTest show that dependency is very small as described in table 1. This means that the size distribution area combined with low customer density has impact on life cycle cost.

TTest compare statistical dependency of two groups (X_1 and X_2). The equation of performing TTest is:

- $t = (x_1 - x_2)/\sqrt{[(s_1^2/n_1) + (s_2^2/n_2)]}$

Statistical difference can be seen with values under 1 %.

Table 1. TTest results on selected parameters of life-cycle costs in collected data.

Groups	Test 1	Test 2	Test 3
Group 1 (X_1)	In-house	Traditional	Urban
Gropu 2 (X_2)	Outsourced	AMR	Rural
TTest result	**55,6 %**	**26,8 %**	**0,2 %**

Further results show that meter assembly in AMR processes is the most significant cost factor. This is due to the more expensive meter. In future the price of the meter´s is expected to decrease. In traditional metering process change reading process has higher cost affect that in AMR. This is due to the different nature of the annual and change reading process when considering traditional metering process. Annual reading is conducted as single task while annual reading is made cost efficient by its serial work nature. As a broader conclusion it can be said that in any processes the aim should be towards serial type of work when considering the cost efficiency.

When showing the different cost factors for figure 2 more information of the cost structure is revealed. This information is presented in figure 3.

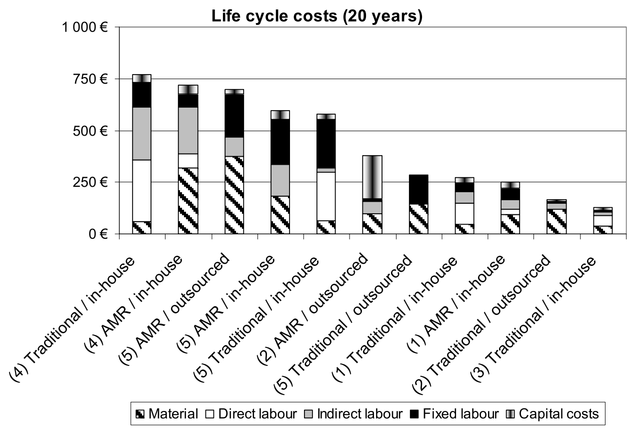

Figure 3. Life-cycle costs of the study presented in different cost factors with same parameters than in figure 2.

Figure 3 gives a good idea of the organisational work on metering. The amount of fixed labour can be seen as a black portion in the total costs. Also the proportion of meter cost can now be more easily seen as the material cost is mainly the cost of meter. Since the years of the data collected for this study some development in meter prices has occurred. This effect can be understood by looking the picture 4 and knowing the current price level of the AMR meters. In outsourced processes material cost is the cost for activities purchased from third party.

Figure 4 illustrates the results according to existing practice in the companies that are analyzed in this study. Difference is that annual readings are done monthly in AMR readings. This causes significant raise in the total costs.

When looking life cycle costs with real monthly rate of AMR reading the change is significant. The increase in the costs is large. This is one element of understanding AMR costs. The rate of reading affects the life-cycle costs. But as the rate of reading increases the rise of cost is not straight forwarded. A rule of a thumb is that when the amount of activities increases the cost for single activity decreases. Conclusion is that the rate of readings should be studied carefully with knowledge of the existing cost structure and possible new features installed to the AMR system. These factors give more benefit of increased reading costs.

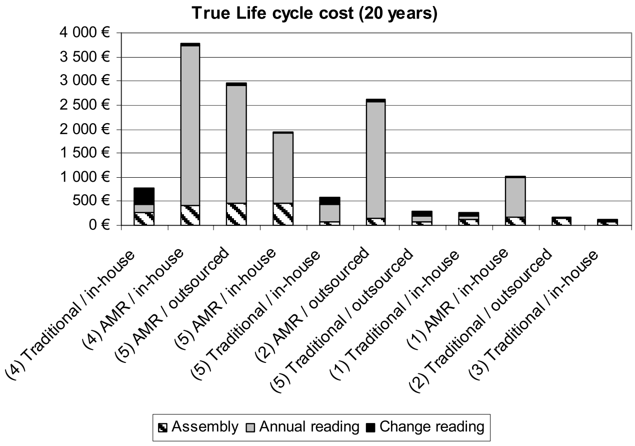

Figure4. Affect of monthly rate of AMR into life cycle costs.

CONCLUSIONS AND DISCUSSION

The AMR investment may decrease the operational costs when implementation is made considering all the aspects of the effects to the metering costs. Decreasing costs also encourage studying new possibilities in way of organizing business processes in general. Outsourcing provides alternative solutions for cost management.

This challenge is also present with current Automatic Meter Reading (AMR) discussion with Nordic DNOs. AMR development not only causes heavy capital investments but also changes some of the business process structures. The challenge is to make choices that fit best for companies needs but also gets full potential of investment in use. Fully utilizing the investment also requires that organization adopts new models.

Other projects currently under study concentrate on developing additional features for AMR. AMR meter is a metering device and this provides multiple possibilities to develop new functions such as low voltage network monitoring. [7]

Combining technical and economical studies with business model creation is the key element of adopting AMR in different levels of business processes. Information and the technological change management causes challenges for the whole organization. Organization also faces decisions of outsourcing. This element also affects the final solution.

Also the costs effects of the new features should be carefully studied to better understand all of the dimensions in AMR. AMR affordability is depending e.g. on following issues:

- Planning and studying AMR implementation [5]
- The customer density and network structure of distribution company
- Good organizing of metering processes
- Rate of readings annually
- Rate of movings
- Additional features such as DSM [4], Power Quality monitoring [6] and network monitoring [7]

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Publication 7

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PROVIDING ADDITIONAL VALUE
FOR AMR WITH INTEGRATION TO OPERATIONAL SYSTEMS

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INTRODUCTION

Energy metering solutions have taken significant steps during last few years. The primary role of Automated Meter Reading (AMR) systems is to provide real time energy consumption data to the utility, but the cost of retrofitting the existing energy metering system may not be justified if the meters are used merely for reading energy consumption once a year.

Telecommunication has been implemented to provide automated meter reading. Current development issues cover measurement features development and integration of AMR into operational information systems.

When investing in AMR system utilities should assure that the system takes advantage of all the possibilities of AMR and possible to implement. The principal motivation for new AMR installations has usually been more accurate energy measurements for billing purposes, cost reduction and improved customer service. In addition to these, the possibilities of AMR include, for example, hourly based energy reporting, demand side management, disconnection and reconnection of electricity supply, determination of load profiles for network calculations, planning and secondary transformer condition monitoring, more accurate interruption statistics, broader basic level power quality monitoring, and the management of low voltage (LV) distribution network.

In this paper development of low voltage distribution network management to provide additional value to AMR is presented.

ADDITIONAL VALUES AND NEW FEATURES OF AMR IN GENERAL

Network companies have made or are making strategic decisions of investments for AMR. In assessment of profitability and benefits of AMR in pure energy remote reading is not enough in many cases, especially in rural areas, where change readings are rare [1]. Benefits are sought out from development of network operation and planning, demand side management (e.g. load control and dynamic tariffs), and customer service.

AMR –technology and modern computer system architecture enable the development of new functions. At the same time business environment and business models are being changed, which open new possibilities and requirements.

Measurement information usage is one of the key elements in getting full benefit from AMR. Approach from main business processes of distribution network operator (DNO) can provide additional requirements for AMR compared to the current solutions in market.

Measurement information from AMR system is traditionally serving the billing and customer service business processes. More accurate data for customer changes and other energy information details decrease the work required to conduct these processes due to more up to date measurement information. In some cases data available is hourly data and it is read automatically once a day. Load analysis and outage reporting can also benefit more detailed information. Remote switching of customer or part of loads is also available in some solutions. This control functionality can also be integrated for controlling for example street lights. Power quality data is also available in some cases in form of voltage levels and registrations of exceeding limits set in the AMR system. These are some examples of additional possibilities provided by current AMR solutions compared to manual measurement information gathering.

Low voltage network is the key element in quality of supply to most of the end customers of DNO. Improving the quality of supply requires that network operation and planning and technical customer service would have access to low voltage network measurement information using their operational systems. This would decrease the amount of work done in these processes. Integrating advanced AMR solution with alarms and more accurate measurement information with additional measurement quantities to current operational information systems provides additional values to improve planning and operation and technical customer service business processes.

Figure 1 describes the integration of AMR into DNO´s business processes to provide additional values to AMR such as the concept of low voltage network management.

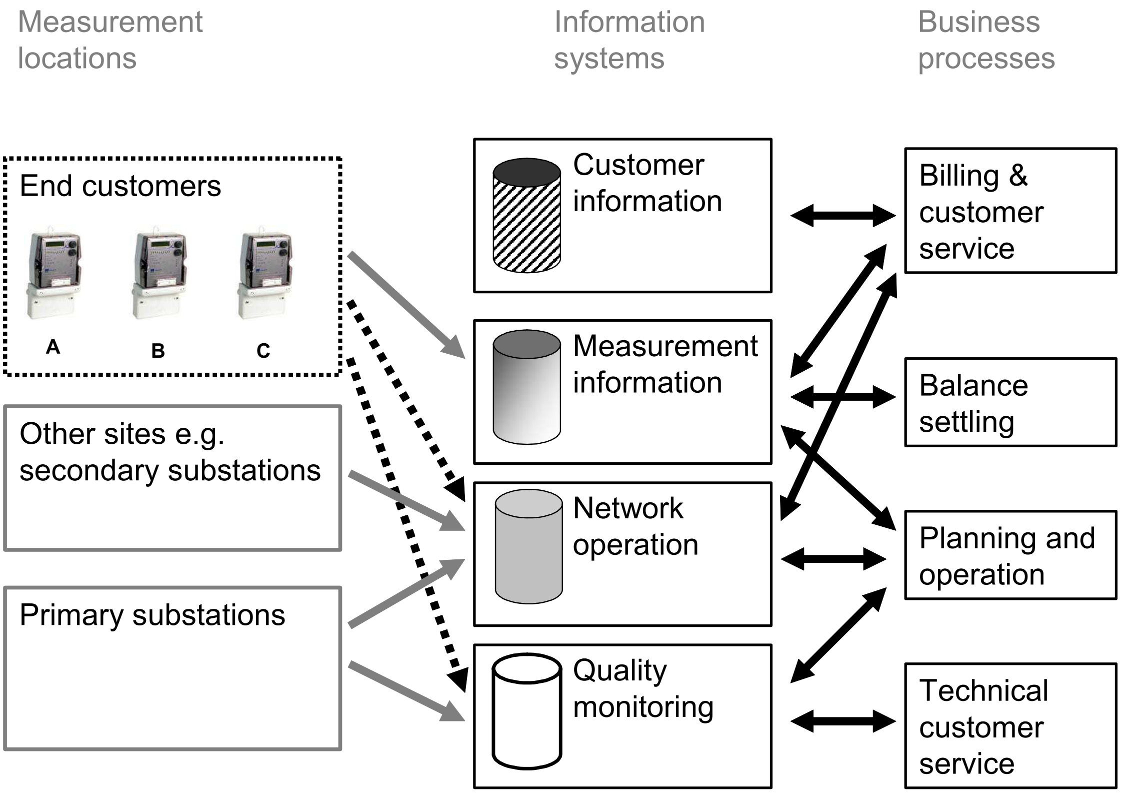

Figure. 1. Using AMR in network management and power quality monitoring as additional value for traditional energy measurement.

Dotted lines illustrate the new integrations necessary compared to current solutions. Planning and operation can benefit alarms from low voltage network and more detailed power quality data is available to solve power quality problems. Advanced meter with modular structure and open architecture in reading system are requirements from business processes needs to AMR capable of low voltage network management.

More additional values to create profitability to AMR can be developed when the meter supports modular structure. Some of the functionalities can be developed inside the meter but some require additional parts. The power quality measurement is good example of the need for modular structure. Basic meter can detect faults and in some extent the voltage levels and outages but for voltages dips, flicker and other EN50160 measurements more powerful measurement capability is required. For this reason special quality modules can be integrated with the meter in selected locations e.g. one for each low voltage feeder is answer for large scale monitoring of power quality.

Another requirement for creating additional value for business processes is the open architecture in the AMR system to provide necessary integration possibilities. Standard integration possibilities e.g. OLE for Process Control or open connectivity via open standards (OPC) makes it possible to develop new types of intelligent system integrations to support business process information requirements.

USING AMR IN DISTRIBUTION NETWORK MANAGEMENT

Traditionally AMR and Distribution Management System (DMS) have been separate systems without any integration with each other as illustrated in Figure 2. The primary role of AMR has been to provide energy consumption data to the utility for billing and balance settlement purposes. AMR system has also been used for load control in some installations. So far automatic monitoring and control center measures by the DMS have been used mostly for operating 20 kV medium voltage networks. A fault in low voltage network is cleared automatically by blown fuse, and no information about that is received to the control center. The existence of a LV-network fault is usually indicated only by customer calls.

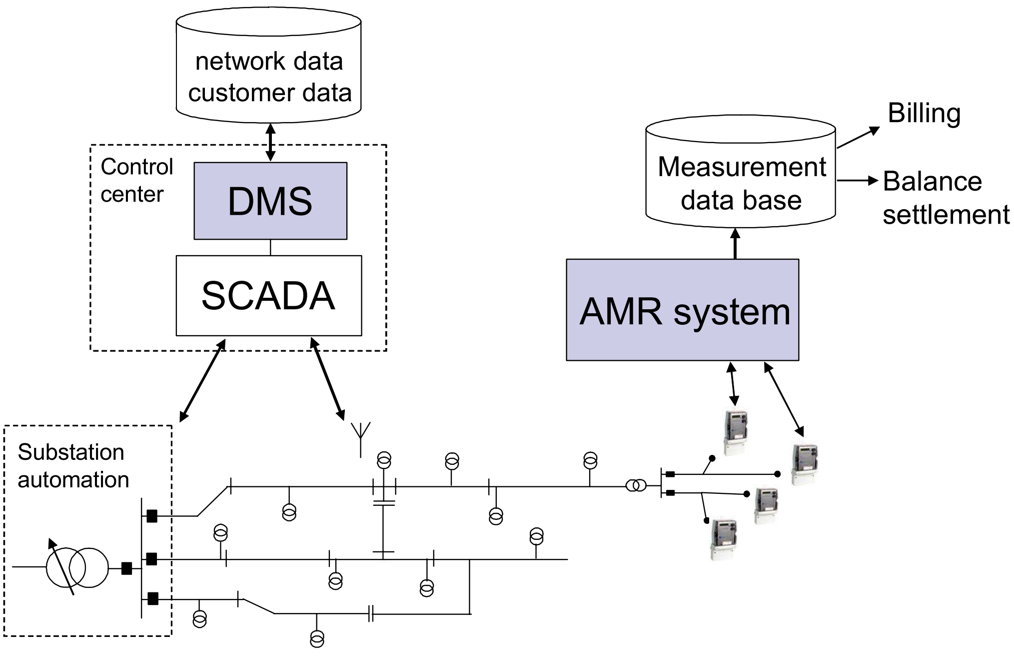

Figure. 2. Traditional way of network management.

Some AMR solutions provides two-way communication to the customer site, which makes it possible to expand on-line network monitoring also to the low-voltage network. In advanced meters this enables alarms based by exceptional events i.e. network faults and voltage violations, and here meters can also have some protective functions adding the safety. The use and integration of AMR in network operation can be seen as an extension of SCADA and distribution automation to the low-voltage level. The Figure 3 presents a new way of network management using integration of AMR, DMS and QMS (i.e Quality Monitoring System) in network operation, asset management, customer service and other functions.

Low voltage network management may include functions, for example, to indicate automatically if a fuse in the low voltage network has burnt or a conductor is broken, to locate the fault, to provide accurate interruption data, to monitor voltages at customer site in real-time and provide voltage level as power quality information for customer service.

The integrated AMR and DMS systems including also power quality monitoring system offer information to be used in overall asset management and network planning. At present advanced network calculation applications of network information systems and DMS use hourly-load curves as load information. AMR system offers mass of measurement data to determine more detailed load models for different purposes in network management and load prediction. Real-time AMR data can be used in state-estimation, but for network planning purposes load models are still needed. For network operation purposes more accurate real-time state estimation of the whole network gives information on voltages, loads, losses, and stressing of components, and also make it possible to optimize e.g. network topology, voltage control, and load control actions. In network planning more accurate load models (e.g. more accurate division of customer groups, regional models, etc.) for network calculations and information on realization of power quality (i.e. interruptions, voltage dips, voltage levels) can be used to allocate measures and investments. More accurate information on hourly variation of losses is also valuable for the network company.

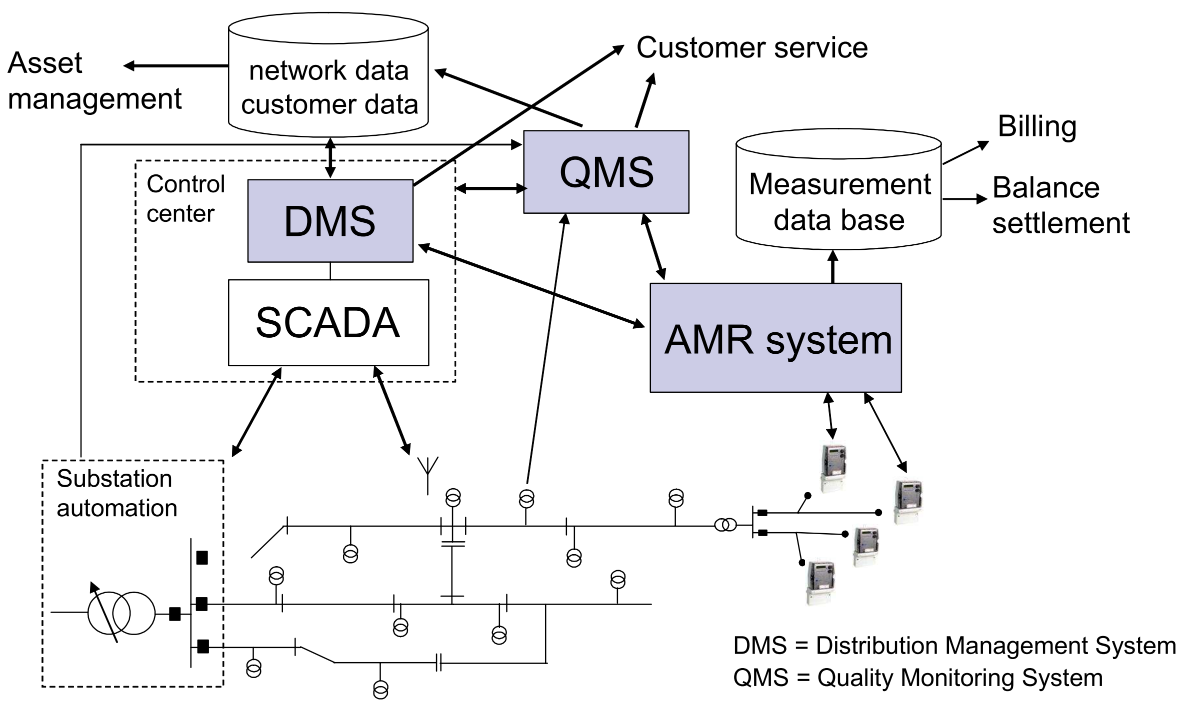

Figure 3. Integrated information systems for comprehensive network management.

APPLICATIONS FOR LOW VOLTAGE NETWORK FAULT INDICATION

In one Finnish distribution company (i.e. Koillis-Satakunnan Sähkö Oy) a development project were realised for developing a comprehensive technology solution of new functions of AMR and related information systems for low voltage network monitoring and management. The aim was to combine new-generation energy meters, data communication solutions and distribution management systems into an entity with an open architecture. The project consortium included different equipment and system vendors (i.e. ABB Oy, Aidon Oy, MX Electrix Oy, PowerQ Oy), the research organisation (i.e Tampere University of Technology) and the pilot distribution company. [2]

The pilot company has an advanced DMS for real time network analysis (i.e. load flow, fault currents), fault location, switching planning etc. However, low voltage network management has been totally in off-line mode since on-line information has been available only from primary substations and from some secondary substations along medium voltage feeders as presented in Figure. 1. The integration of AMR makes it possible cost effectively to monitor low voltage network and analyze fault situations since AMR communication infrastructure can be used. Because network monitoring in SCADA/DMS requires that events from meters are received in near real-time manner an effective way to forward data from AMR is required. In the above mentioned development project OPC (originally OLE for Process Control) technology was selected for this purpose.

An advanced AMR meter works as an intelligent monitoring device and utilizes the communication infrastructure to provide spontaneous event or alarm information to control center with vital information on low voltage network faults and voltage levels. The meter includes algorithms to inference the existence of a fault and type of the fault. In certain cases, e.g. when neutral conductor is broken, the advanced AMR meter even isolates automatically the customer from the network. This requires a specific switching device which can be integrated into the advanced AMR meter.

Figure 4 illustrates a part of DMS screen in a case of broken neutral conductor. Network coloring shows the results of inference to locate the broken line-section.

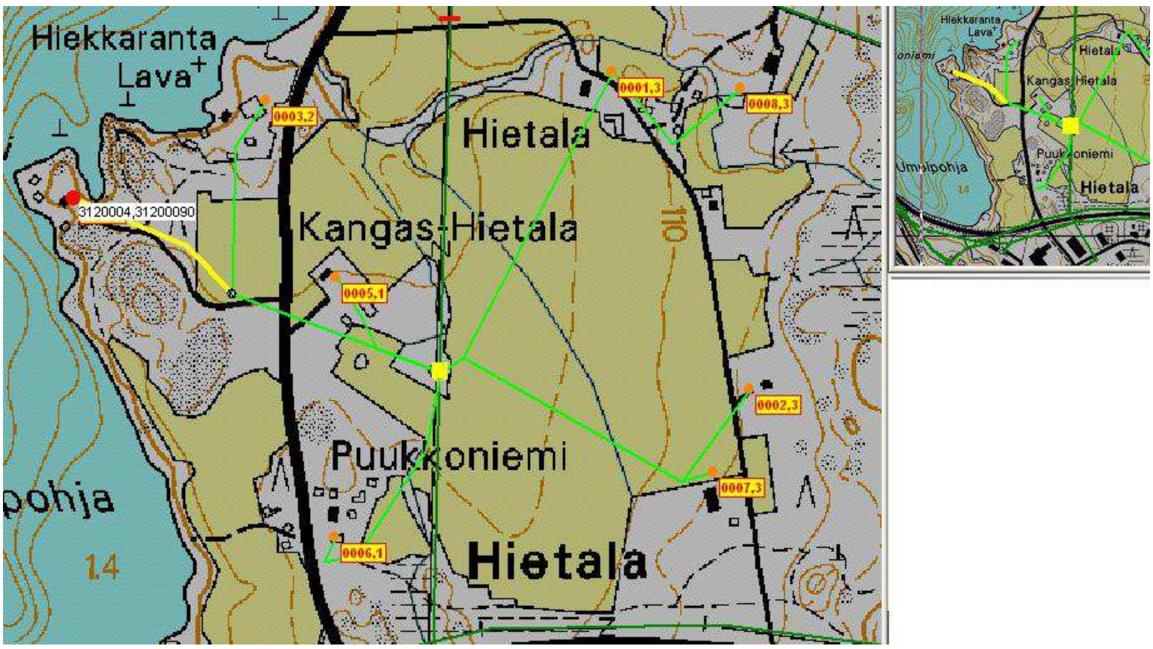

Figure. 4. A case of broken neutral conductor [3].

When event data from meters are combined with topological network model in the DMS the original reason or faulted component can be located. This gives enormous benefits for low voltage network management when, for example, blown fuses, broken conductors and voltage problems can be presented to the operators at control center almost in real time manner.

TESTING THE APPLICATIONS WITH REAL TIME DIGITAL SIMULATOR (RTDS) ENVIRONMENT

Before the present operating phase the features of the integrated applications were tested comprehensively using Real Time Digital Simulator (RTDS) environment at Tampere University of Technology.

RTDS is a power system simulator for real-time studies. The simulator environment includes two essential parts; the hardware equipment and the control software. Hardware of the RTDS comprises different types of processor cards, signal channels and communication modules. An Ethernet connection is used to transfer data between the hardware and the controlling computer. Real external devices can be connected to the system via digital and analog I/O channels. Also closed-loop testing is possible so that the output from the device under test is then fed back into the simulation, thereby affecting the simulation. [4]

Software used to control the physical system is called RSCAD. The most important purpose of the RSCAD is providing a graphical user interface for controlling the hardware. It also provides libraries for typical power system components and models. User can construct the power system studied by drawing circuit diagrams and using the component models. Predefined control-blocks and scripts can be used to control the simulations.

When a large number of simulation cases must be run and evaluated, then an automated multi-run or "batch" operating mode essentially eliminates the required user intervention. The RTDS Simulator provides the Automated Batch Mode capability for running cases, analyzing results, and customizing report generation with limited user interaction.

During simulations the AMR meter behaves here as it would be in a real distribution system. Network voltages are simulated by the RTDS and are sent trough amplifiers. The amplifier raises the currents and voltages to the levels of normal operating values of the AMR meter. If any fault or exceptional event is simulated then the AMR meter can sense voltage changes in real-time. In order to record voltages also more comprehensively a power quality analyzer (EN 61000-4-30 class A) was used beside the AMR meter to verify the AMR meter measures.

The simulated distribution system (see figure 5.) consisted of the following parts: a primary substation, a simplified MV network, a MV/LV substation, a LV feeder and several controlled loads (line to neutral or line to line). Controlled circuit breakers were used to simulate faults.

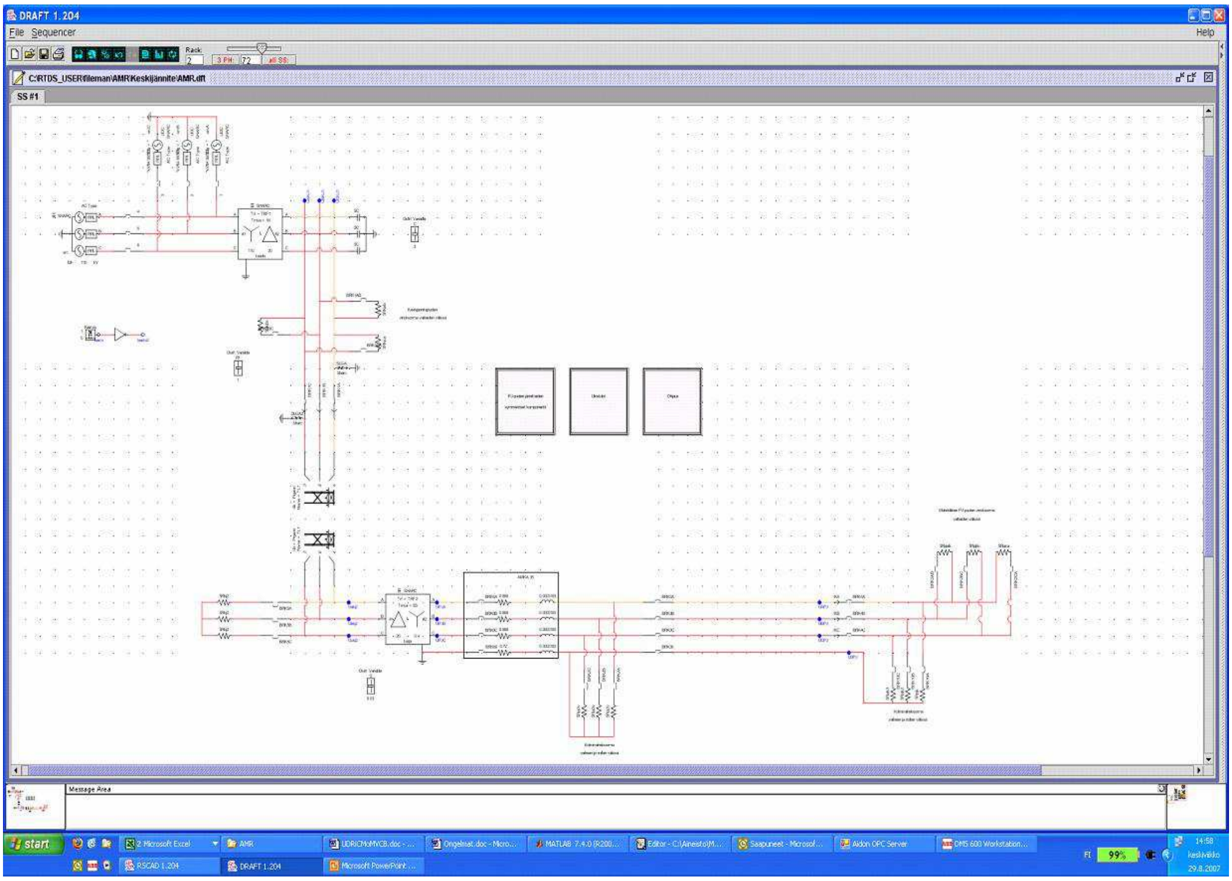

Figure 5. Network model in RTDS

The system module of the AMR meter monitors the rms values of the line to neutral voltages. In the first phase detection of abnormalities and methods for classification of events were based only on these. The tested events were:

- blown LV fuses
- broken LV conductor (line or neutral)
- broken MV conductor with or without an earth contact
- over- and undervoltages.

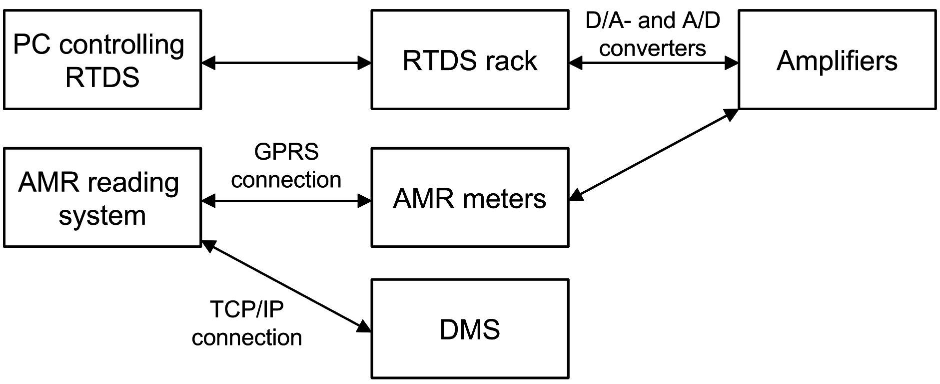

Figure 6. Total system testing environment

The simulation environment in Figure 6 enabled to test effectively the comprehensively integrated applications. Especially following features were full of interest:

- checking the methods for classification of events (different faults and abnormal voltages) and appropriate settings
- communication solutions including data transmission and collection from meter to remote data reading system
- data handling on the DMS level (alarms, settings, readings, notifications of change of state, locating of faults and problems)

During this testing phase some modifications and minor corrections in software were carried out. The conclusion was that the entire system was tested as a whole in the real-time simulator environment so well that testing could fairly be continued in a real network pilot. The new solutions have currently being used at Koillis-Satakunnan Sähkö which has plans on increasing the number of AMR energy meters connected to the DMS in the near future.

THE DEVELOPED APPLICATIONS FOR CUSTOMER-SPECIFIC POWER QUALITY MONITORING

At the moment, voltage quality is usually monitored temporarily at customer sites based on customer reclamations, not comprehensively and continuously from the entire distribution network. Power quality monitoring including continuous voltage quality monitoring in larger extent gives however important information for business processes of DNO.

AMR system capable to low voltage network management includes additional power quality module. This module provides measurement information of 10 minutes RMS values of voltage quantities e.g. phase voltage, unbalance, voltage sags and swells, flicker and Total Harmonic Distortion (THD). With low price and integration possibilities to selected locations this module provides possibility to large scale cost efficient power quality monitoring. Quality modules can be placed on selected locations e.g. one in each low voltage feeder or secondary substation.

The development of systematic procedures for power quality data management supports in general:

- Customer services (e.g. quality reports, clarifying customer requests, planning of compensation of reactive power, instructions for the use of various equipment)
- Distribution network planning and operation (e.g. investment plans and management of voltage drops and fluctuations, harmonics and other disturbances)
- Outage statistics (e.g. needs of the Energy Market Authority).

In recent years the Institute of Power Engineering at Tampere University of Technology has actively been developing a comprehensive power quality management system together with distribution utilities and several different equipment and data system vendors. [5, 6, 7]

The novel AMR technology makes it possible to integrate basic power quality functions to AMR meter. In addition to register interruptions with time-stamps the following quantities for each of the three phases can also be able to meter depending on the meter configuration: voltage and current variations, active power, apparent power, total reactive power, fundamental frequency reactive power, voltage dips and swells, total distortion of the supply voltage, some harmonic voltages, DC-voltage component, frequency of the supply voltage, voltage unbalance between the three phases. [6, 7]

All the measurement data (i.e. even over several years) can be stored in the open relational Power Quality Database (PQDB). The measurement data of the PQDB can be studied using the Web–based application, PQNet system, in addition to DMS and network planning systems. Integration of the PQNet QMS systems with DMS and Customer Information System in the pilot project are key elements in meeting the business process requirements. Power quality data can also be offered to the customers (e.g. industrial customers) with their energy consumption and billing data through the PQNet.

Factors that increase the need and possibilities of monitoring power quality also on low voltage level are e.g.:

- need for better customer service
- reasonable priced meters
- telecommunication development
- applications which can use the power quality data in network planning and operation
- regulation requirements

In this pilot project at Koillis-Satakunnan Sähkö Power Quality monitoring is done with several meter types integrated into PQNet to provide large scale power quality monitoring. Quality module integrated with AMR provides information from quality of supply in low voltage level. Measurements are also placed on each primary substation and in some secondary substations to monitor different voltage levels and locations in distribution network and to support network planning and operation. Addition to continuous metering integration of PQNet system with network operation and customer service systems provide tools for fully utilizing power quality information.

CONCLUSION

AMR can provide additional values for DNO´s business processes. Low voltage network management is one option. It is made possible by developing advanced and modular AMR meter with e. g. OPC type of smart integration possibilities to operational information systems. In pilot project in Koillis-Satakunnan Sähkö in central Finland this type of solution is in operational use.
Developing the working solution required development and testing to introduce new type of AMR solution. Still some development needs in selectivity but on general level the project has achieved it´s requirements and partners in project have illustrated possibility to develop this type of new functionality.

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Publication 8

Hyvärinen, M., Pettissalo, S., Trygg, P., Malmberg, K., Holmlund, J., Kumpulainen, L., ”A comprehensive secondary substation monitoring system”, Proceedings of the 20th International Conference on Electricity Distribution (Cired 2009) conference. 8-11 June, 2009, Prague, Czech Republic.

A COMPREHENSIVE SECONDARY SUBSTATION MONITORING SYSTEM

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ABSTRACT

This paper introduces a comprehensive monitoring system for urban MV/LV substations. The system has been specified by Helen Electricity Network Ltd, a subsidiary of Helsinki Energy. The pilot system has been developed by a group of companies specialized in SCADA, power system protection, and power quality issues. The system includes e.g. power quality measurements & database, disturbance recordings, fault location, transformer monitoring, and remote control of the MV switches at the substation. The paper reports the experience of the pilot project consisting of five secondary substations.

INTRODUCTION

The development of the first generation secondary substation monitoring system started at Vamp Ltd in 2002. This system measured all electrical quantities on the LV side of the transformer, calculated the loading of the transformer and registered the abnormalities in power quality. SMS technology was used for communication.

The second generation system was developed during 2007 according to customer feedback. The new monitoring unit was based on the technology used in protection relays manufactured by Vamp Ltd. This technology had been used in all relays developed after year 2000. One of the most important customer requirements was the indication of MV earth faults and short circuit faults. Another important issue was the development of the communication between the monitoring unit and the SCADA and DMS systems in the control room. The SMS technology was replaced by IEC-104 protocol and GPRS.

The invitation to submit tenders of a comprehensive substation monitoring system by Helen Electricity Network Ltd (Helen) included functions that required co-operation of several partners. Co-operation of Netcontrol Oy, PowerQ Oy, and Vamp Ltd was created to fulfil the requirements of the specified pilot system. The delivery of the pilot system was started in June 2008 and it was completed by October.

THE MAIN FEATURES OF THE MONITORING SYSTEM

The system consists of four functional areas:

- Secondary substation level functions
- Communication between secondary substations and the control centre
- SCADA interface to critical functions
- Power quality database and reporting

Figure 1 presents the system diagram of the developed system.

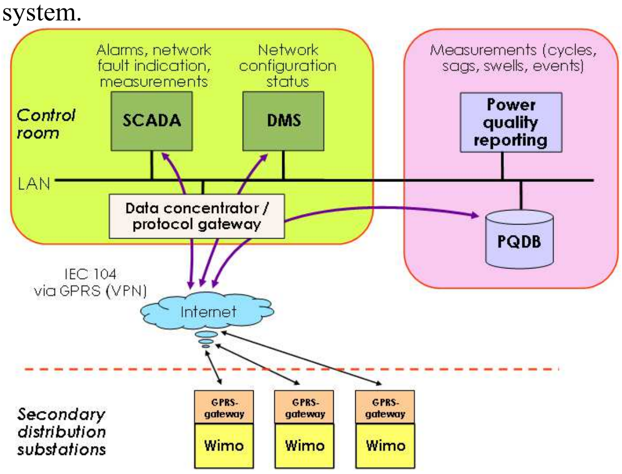

Figure 1. System diagram of the monitoring system.

In addition to technical issues, the most important feature of the system is cost effectiveness, including investment costs and annual operation and maintenance costs. This requirement is essential due to the low fault frequency level characteristic of urban cable networks and the large number of the secondary substations, in Helen's case 2.400. This is a very high number compared to the number of primary substations, only 20. Although the pilot project consists of only five secondary substations, the technical requirements have been specified so that the system can be expanded to cover hundreds of substations. Part of the substations will be equipped with remote control.

THE FUNCTIONS AT SECONDARY SUBSTATIONS

In the pilot system there are two types of secondary substations: remote monitored and remote controlled. Four of the substations are remote monitored and one is remote controlled and equipped with two transformers.

The main instrumentation of the system in a remote monitored secondary substation with one transformer is simple, consisting of two units: measurement and control unit WIMO 6CP10 and communication unit Netcon GW325. Figure 2 presents an example of the monitoring equipment at a secondary substation.

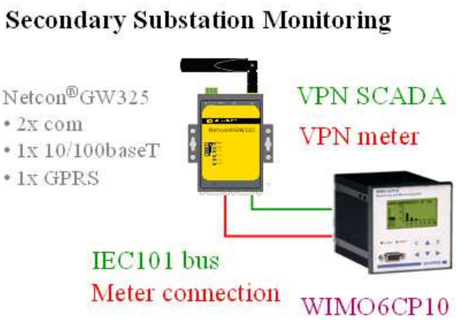

Figure 2. The main instrumentation of a remote monitored secondary substation.

One of the pilot secondary substations was equipped with remote control, because in the future Helen will apply this technology in a part of its substations. The chosen substation includes two transformers, both of which are monitored. The monitoring and control of this kind of substation is possible using the equipment illustrated in Figure 3.

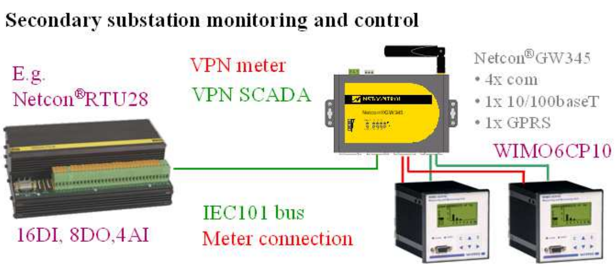

Figure 3. Monitoring and communication devices of a remote controlled secondary substation.

The measurements and associated control and alarm functions are carried out by measurement and monitoring unit WIMO 6CP10. The device can be characterized as a simplified protection relay, including only one trip relay. On the other hand, the measuring properties of the unit are versatile and it can be equipped with several types of sensors. This is illustrated in Figure 4.

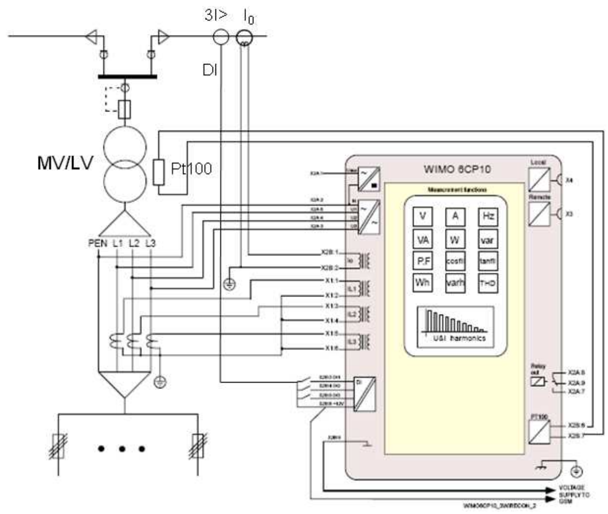

Figure 4. Connection diagram of WIMO6CP10.

SENSORS

Normally secondary substations are equipped with current transformers on the LV side in each of the three phases. The nominal current is typically 5A. The phase voltages can be directly connected to the measurement and monitoring unit. The power is supplied by one phase voltage.

In addition to traditional phase current and voltage measurements WIMO unit measures the temperature of the transformer using a Pt100 sensor.

Short-circuit fault indicators on the MV side can be connected to the digital inputs of the measurement and monitoring unit. To be able to indicate earth faults, WIMO unit measures the earth-fault current on the MV side using a zero sequence current sensor.

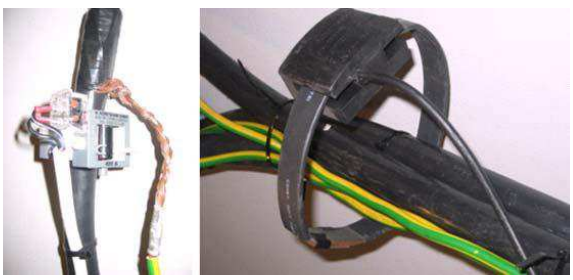

Figure 5. Examples of short-circuit and earth-fault sensors that can be connected to WIMO measurement and monitoring unit.

THE FUNCTIONS OF THE MEASUREMENT AND MONITORING UNIT

The measurement and monitoring unit records the measurements and state indications with time stamps. Most of the measurement data is used for customer power quality monitoring. The following quantities can be measured and calculated:

- Disturbance recording files
- Voltages, 10 min average
  - voltage sags, depth, duration and time stamp
  - voltage spikes, height, duration and time stamp
  - voltage 10 min average alarm level (max, min) monitoring and alarm
- Hourly averages of active power
- Hourly averages of reactive power
- Phase currents, 10 min averages
- THD (2..15 harmonic) in each phase

The quantities are recorded in permanent memory during the last month. However, the normal procedure is to remote read the recorded data once a day and store it in the measurement data base in the control centre.

Other functions, not related to power quality, are the following:

- Measurement of the earth-fault current (MV side) and earth-fault indication
- Indication of MV short circuit by s-c indicators
- Measurement of the temperature of the transformer using Pt100 sensor

Three general purpose digital inputs can be used for e.g. various state indications or contact alarms.

Monitoring of transformer load and temperature is expected to decrease the probability of transformer fires, which can be very hazardous especially in urban networks. Especially because the increase of cooling load in Helsinki has transferred the transformer peak load in many cases from winter to summer time, temperature monitoring is a useful feature.

At the control room level the critical data, such as earth fault and short-circuit fault indications, transformer temperature alarms, and alarms of nonconformities in power quality data are directed to SCADA system. The less critical data related to power quality, and disturbance recordings, is stored in the power quality data base.

LOCATION OF EARTH FAULTS AND SHORT CIRCUIT FAULTS

The location of faults in the MV network can be based on the indication of short circuit and earth fault at secondary substations. In short-circuit faults, the short circuit indicators activate and send alarm signal if the fault current has passed the secondary substation. Indication of earth fault is based on the measurement and analysis of the earth-fault current. In earth isolated network, selective indication is easily achieved.

Depending on the fault location, several secondary substations can send the indication simultaneously. The indication is immediately transferred to the control centre where it can be shown graphically by SCADA or DMS system. Figure 6 illustrates the principle of the fault location.

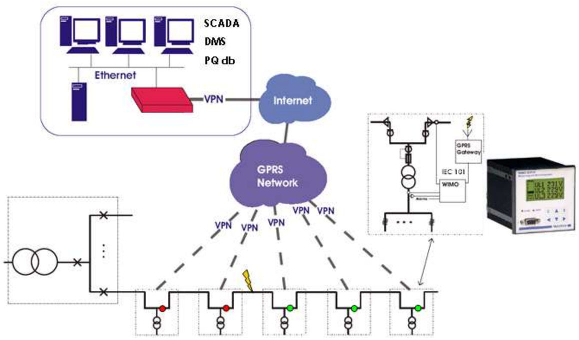

Figure 6. The principle of the fault location.

COMMUNICATION

Normally there is no wired communication to secondary substations. Thus it is reasonable to apply wireless communication, already existing for other purposes, and completely covering the distribution networks in urban areas. The public wireless GSM/GPRS telephone network satisfies the needs of secondary substation monitoring system. The speed of data transfer is adequate and the costs are low since the size of the transferred data is limited.

Every secondary substation is equipped with GPRS gateway, and a data concentrator is installed in the control room. Virtual Private Network (VPN) connections are established between the control room and the secondary substations. Figure 7 illustrates the communication system.

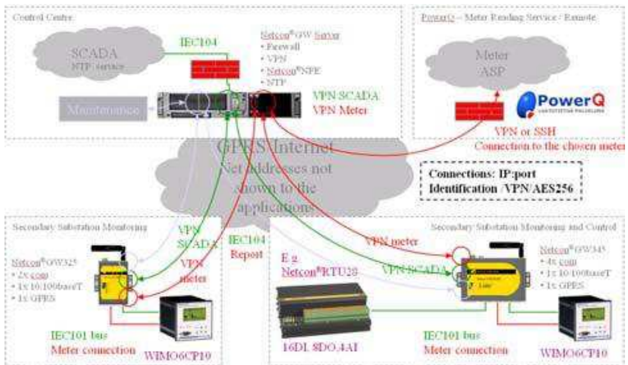

Figure 7. Overview of the communication of the secondary substation monitoring system.

Inside the secondary substations, Netcontrol Oy´s GPRS gateway is used, and the communication between WIMO units and Netcon units is polling and IEC-101 based. The communication between secondary substations and the control centre is arranged using IEC-104 protocol, and it is tunneled over the GPRS using VPN.

In the control centre the data concentrator links the information between the secondary substations and the SCADA system, and it also links the requests of the power quality management system to the secondary substations. In the communication between the PowerQ Oy's power quality database and WIMO units GETSET protocol by Vamp Ltd is used. The use of two different protocols is possible, because each protocol has its own serial port in the WIMO.

To avoid overloading of the SCADA system, the data concentrator groups 50 secondary substations into one virtual substation. This enables the monitoring of hundreds of secondary substations in the future.

The status of the communication equipment is monitored by the data concentrator in real time. In case of communication failure the concentrator rebuilds the connection or gives an alarm, if the fault is permanent. In the future it is possible to expand the communication capabilities of the system with other wireless solutions.

NOT JUST POWER QUALITY

Power quality information system is delivered as Application Service Provisioning (ASP) by PowerQ Oy. This means that implementation is easier and utility's own resources are not needed in system management.

The necessary measurement information is regularly or on demand transferred to the database of the PQNet system. PQNet has various advanced reports and automatic monitoring of user set limits. System provides users easy and sophisticated tools for crushing data and making conclusions needed by different utility processes. Examples of monitoring reports are given in Figures 8, 9 and 10.

Measurement information can be processed to serve following utility processes:

- Fault details and fault effect to power quality
- Reporting for customer complaints for quality of supply
- Transformer condition monitoring using load and temperature analysis
- Optimizing network assets according to actual load
- Recording and detecting any exceptions in electricity supply close to the end customer
- Determining reason and responsible for these exceptions

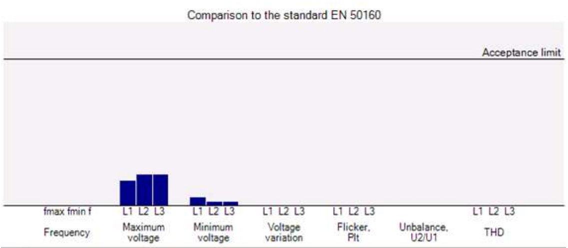

Figure 8. An example of power quality monitoring reports.

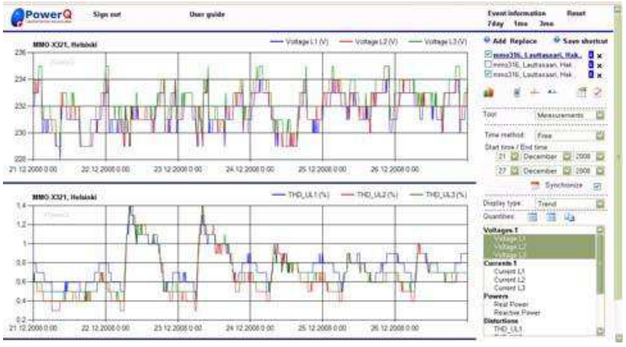

Figure 9. An example of detailed power quality monitoring reports including voltage and THD data.

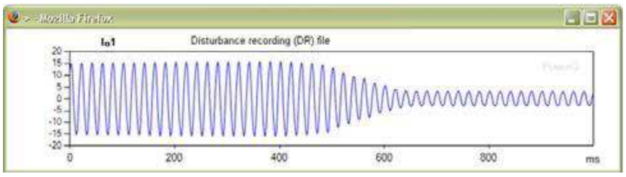

Figure 10. An example of a DR file recorded by WIMO.

EXPERIENCE OF THE PILOT SYSTEM

The technical efficiency of the pilot system has met all expectations. The reliability of the communication has proven to be high compared with corresponding systems in other countries.

The primary goal of the system is to shorten outage times. This emphasizes the importance of fault location. During the pilot phase the system has demonstrated its effectiveness. Two earth faults have occurred, and in both cases the indication has been correct, which verifies the usefulness of the method at least in earth isolated network. In the future, earth-fault location for compensated networks will be tested as well.

CONCLUSIONS

A unique secondary substation monitoring system has been introduced. A successful pilot project has been carried out. The technical performance has fulfilled the expectations regarding e.g. communication, fault location, and power quality monitoring, and the costs are reasonable.

The utilization of public wireless networks and standard IEC communication, allowing flexible connection of distributed RTUs to the utility SCADA system, assure easy system expansion and future technology development of the separate components of the distribution network monitoring and control system.

By implementing secondary substation monitoring as described, the distribution network operator will achieve improvements in supply performance and asset management with good cost efficiency.

Publication 9

Trygg, P., Repo, S., Järventausta, P., Seppänen, M., "Cost – benefit analysis of load control aggregation service using home automation", Proceedings of the Tenth Nordic conference on electricity distribution system management and development (Nordac 2012). 10-11 September, 2012, Espoo, Finland.

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.

<table>
<tr>
<td rowspan="2">Key partners
• Who are our Key Partners?
• Who are our key suppliers?
• Which Key Resources are we acquiring from partners?
• Which Key Activities do partners perform?

Motivations for partnerships:
• Optimization and economy
• Reduction of risk and uncertainty
• Acquisition of particular resources and activities:</td>
<td>Key activities
• What Key Activities do our Value Propositions require?
• Our Distribution Channels?
• Customer Relationships?
• Revenue streams?</td>
<td rowspan="2">Value propositions
• What value do we deliver to the customer?
• Which one of our customer's problems are we helping to solve?
• What bundles of products and services are we offering to each Customer Segment?
• Which customer needs are we satisfying?

Characteristics:
• Newness
• Performance
• Customization
• "Getting the Job Done"
• Design
• Brand/Status
• Price
• Cost Reduction
• Risk Reduction
• Accessibility
• Convenience/Usability</td>
<td>Customer relationships
• What type of relationship does each of our Customer
• Segments expect us to establish and maintain with them?
• Which ones have we established?
• How are they integrated with the rest of our business model?
• How costly are they?</td>
<td rowspan="2">Customer segments
• For whom are we creating value?
• Who are our most important customers?

Examples:
• Mass Market
• Niche Market
• Segmented
• Diversified
• Multi-sided Platform</td>
</tr>
<tr>
<td>Key resources
• What Key Resources do our Value Propositions require?
• Our Distribution Channels? Customer Relationships?
• Revenue Streams?</td>
<td>Channels
• Through which Channels do our Customer Segments want to be reached?
• How are our Channels integrated?
• Which ones work best?
• Which ones are most cost-efficient?</td>
</tr>
<tr>
<td colspan="3">Cost structure

• What are the most important costs inherent in our business model?
• Which Key Resources are most expensive?
• Which Key Activities are most expensive?</td>
<td colspan="2">Revenue streams

• For what value are our customers really willing to pay?
• For what do they currently pay?
• How are they currently paying?
• How would they prefer to pay?
• How much does each Revenue Stream contribute to overall revenues?</td>
</tr>
</table>

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.

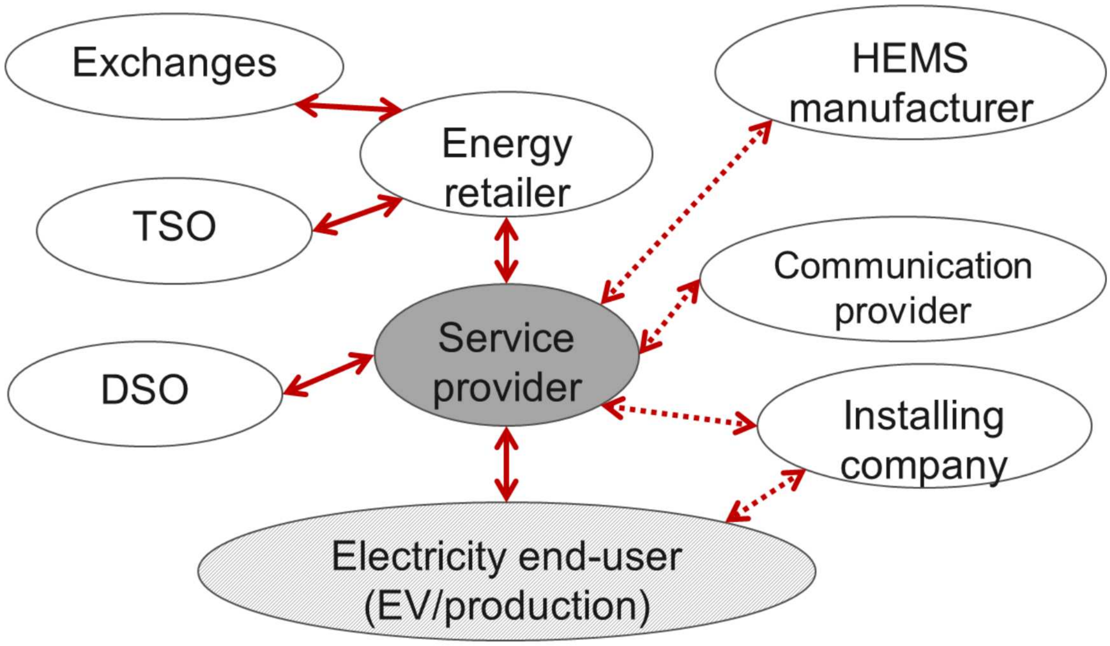

Figure 2. Value network of Demand Response (DR) carried out by independent service provider.

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 buy 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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