

Eco-efficient services as a route towards sustainable development

Between the traditional and the radical

Markku Anttonen



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Eco-efficient services as a route towards sustainable development: Between the traditional and the radical

Publisher School of Business**Unit** Department of Management and International Business**Series** Aalto University publication series DOCTORAL DISSERTATIONS 181/2012**Field of research** Organization and Management**Abstract**

The dissertation addresses eco-efficient services as a potential solution to environmental problems such as the ever-increasing use of natural resources. In short, eco-efficient services refer to service solutions that are based on fulfilling customers' needs instead of product ownership. Customer, whether a company or private household obtains services that solve his/her needs. Eco-efficiency refers to the analysis of an economic value of a product or production activity in relation to its environmental impacts. The aim of eco-efficiency is to optimize this relation.

The dissertation consists of four journal articles and an introduction that draws the articles together. It studies what kinds of services with a potential to enhance eco-efficiency have emerged, which issues influence the supply and demand of these services and what kind of business models pertain to such services.

One of the articles studies services directed to households and three of them analyze material efficiency services in the business-to-business sector. The findings indicate that these services have a strong connection to customers' everyday life and business. At the household sector ecological sustainability as such is not sufficient; the service in question needs to increase the everyday wellbeing of the customer. Likewise, at the business-to-business sector, the eco-efficient service needs to solve both ecological and economic efficiency issues of operative, everyday business.

The origins of business-to-business services are varied, such as new logistics and ICT-services in chemical management service industry. The business models of these services are contextual and depend, among other things, on the service provider's position in the supply chain.

Keywords eco-efficient services, eco-efficiency, material efficiency services, sustainable development, sustainable homeservices, customer needs, business models

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Tekijä

Markku Anttonen

Väitöskirjan nimi

Ekotehokkailla palvelumalleilla kohti kestävää kehitystä: radikaalin ja perinteisen liiketoiminnan välimaastossa

Julkaisija Kauppakorkeakoulu**Yksikkö** Johtamisen ja kansainvälisen liiketoiminnan laitos**Sarja** Aalto University publication series DOCTORAL DISSERTATIONS 181/2012**Tutkimusala** Organisaatiot ja johtaminen**Tiivistelmä**

Väitöskirja tarkastelee ekotehokkaita palveluita yhtenä ratkaisuna ympäristöongelmiin ja kestävään kehitykseen liittyvissä kysymyksissä. Ekotehokkailla palveluilla tarkoitetaan palveluratkaisuja, joiden tavoitteena on asiakkaan tarpeiden tyydyttäminen tuotteiden omistamisen sijaan. Asiakas ostaa ratkaisuja, jotka kuormittavat vähemmän ympäristöä ja käyttävät resursseja tehokkaammin. Ekotehokkuudella tarkoitetaan saman materiaalisen hyvinvoinnin tuottamista huomattavasti pienemmällä energian ja luonnonvarojen kulutuksella.

Tutkimus koostuu neljästä tieteellisissä lehdissä julkaistusta artikkelista ja johdannosta, joka kokoa artikkelien tulokset yhteen. Työ käsittelee minkälaisia potentiaalisesti ekotehokkuutta ja siten kestävää kehitystä tukevia palveluita on markkinoilla, mitkä tekijät vaikuttavat näiden palveluiden kysyntään ja tarjontaan sekä millaisia niiden liiketoimintamallit ovat.

Tutkimus osoittaa, että kotitaloudet voivat siirtyä tuotteiden omistamisesta palveluiden käyttöön, jos ne helpottavat arkea. Yrityksille tarjottavien palveluiden osalta korostuu kustannustehokkuus, ympäristön hallinta ja palveluiden rooli päivittäisen operatiivisen liiketoiminnan tehostamisessa. Yrityksille tarjottavat materiaalitehokkuuden palvelut ovat kehittyneet usein muista kuin ekotehokkuusmotiveista. Esimerkiksi tutkimuksessa tarkasteltujen kemikaalien hallinnan palveluiden taustalla on niin uusia ICT-pohjaisia palveluita kuin logistiikkapalveluita. Näiden palveluiden liiketoimintamallit ovat kontekstisidonnaisia ja niihin vaikuttaa mm. toimiala ja se mille kohtaa toimitusketjua ne kohdentavat liiketoimintansa.

Markkinoille päässeiden palveluiden edellytys on, että palveluntarjoaja ymmärtää hyvin asiakkaiden tarpeet ja toiminnan, oli kyseessä kotitalouksille tai yrityksille suunnatut palvelut. Tutkimuksen tulosten perusteella voidaan päätellä, että kehitettäessä uusia ekotehokkuutta ja kestävää kehitystä edistäviä palveluita on tärkeää, että lähtökohdiltaan ekotehokkaita tuotteita tai teknologiaa kehittävät toimijat työskentelisivät järjestelmällisemmin liiketoimintainnovaatioiden kehittäjiä kanssa yhteistyössä.

Avainsanat ekotehokkaat palvelut, ekotehokkuus, materiaalitehokkuuden palvelut, kestävä kehitys, kestävät kotipalvelut, asiakastarpeet, liiketoimintamalli

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Helsinki, 6 December 2012

Markku Anttonen

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Part II: Articles

Halme, M., Anttonen, M., Hrauda, G. and Kortman, J., 2006. Sustainability evaluation of European household services. *Journal of Cleaner Production* 14:1529-1540

Halme, M., Anttonen, M., Kuisma, M., Kontoniemi, N. and Heino, E., 2007. Business models for material efficiency services: Conceptualization and application. *Ecological Economics*, 63(1): 126-137

Anttonen, M., 2010. Greening from the front to the back door? A typology of chemical and resource management services, *Business Strategy and the Environment* 19 (3), 199–215

Anttonen, M., Halme, M., Houtbeckers, E. and Nurkka, J., 2012. The other side of sustainable innovation: Is there a demand for innovative services? *Journal of Cleaner Production*, in press, corrected proof, available online 23 December 2011

1. Introduction

This dissertation deals with environmental problems such as the ever-increasing use of natural resources, and eco-efficient services as a potential solution to them. Since the 1970s business has responded to these increasing problems in varying ways; from installing end-of-pipe technologies for reducing direct emissions to integrating corporate environmental management systems (EMS) in order to integrate environmental concerns into business processes, manage them and diminish adverse environmental impacts. They are also a way to comply with tightening environmental regulation and societal pressures. EMS can be said to be common across different industries. Less common are incentives and companies that look to innovative approaches as a means to changing their manufacturing, product design and business logics towards a more sustainable direction. A well-known example of this is the outdoor clothing company Patagonia, who has narrowed its product offerings, uses recycled fabrics and asks their customer if s/he truly needs new outdoor gear. At the radical end of this continuum are the ideas of eco-effectiveness and the cradle-to-cradle design (Braungart, McDonough and Bollinger 2007) in which it is seen that manufacturing and economy should increase environmental quality and sustainability instead of doing less harm with increased efficiencies.

This dissertation investigates existing eco-efficient services directed for household and business markets and analyzes them as a potential solution. Eco-efficient services here refer to all kinds of commercial or non-profit market offerings which aim to fulfill customers' needs through services instead of products. This is expected to reduce material consumption and energy use. These services can be eco-efficient by design or they can be 'normal' services creating eco-efficiency gains as a by-product. The dissertation is based on four articles which study eco-efficient services in relation to 1) ecological and social sustainability 2) business models and 3) demand for these services. This introductory chapter gives an overview of the research by

1. Introduction

first outlining briefly the background for eco-efficient service discussions and presenting gaps in the research. After this, the chapter presents the general objectives of the dissertation, introduces the research questions and gives an overview of the main findings.

1.1 Background

Problems such as climate change, loss of biodiversity and the exhaustion of natural resources are increasing steadily, while the limits of resource use are becoming clearer. From the year 1900 till 2005 the extraction of natural resources grew eight fold on average although Individual resource use varies considerably. For example, the extraction of construction minerals has grown by factor 34, ores and industrial minerals by factor 27 and fossil energy carriers such as oil and uranium by factor 12. Biomass is extracted 3.6 times more than at the beginning of the last century (UNEP 2011, 10). Altogether 55 billion tons of materials are extracted annually. This has had severe environmental and societal impacts and presented a threat to our human existence. Some researchers (Rockström et al. 2009) estimate that we have already passed a safe operating space for us regarding some of the global planetary systems.

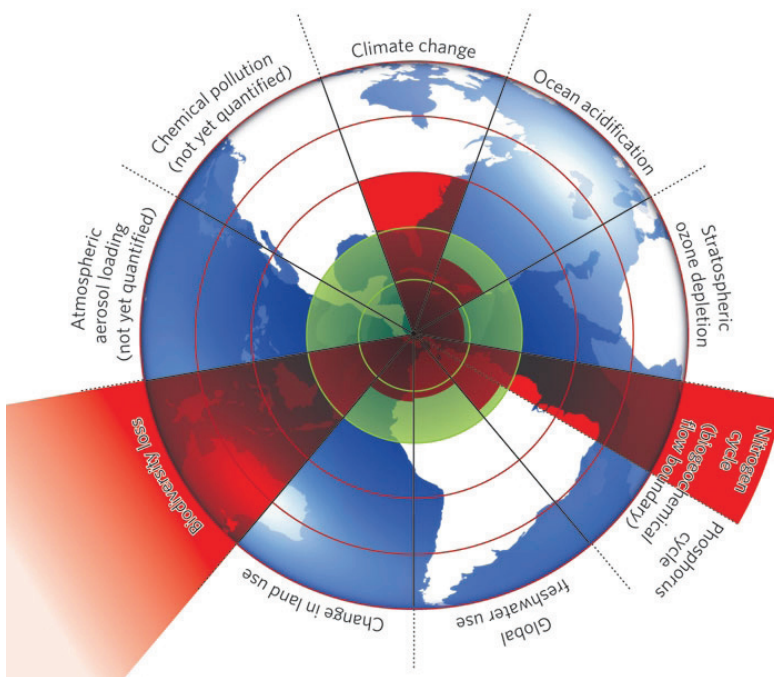


Figure 1: The inner shading represents the proposed safe operating space for nine planetary systems. The wedges represent an estimate of the current position for each variable (Rockström et al. 2009)

Rockström and colleagues (2009) argue that with biodiversity loss, climate change and human interference with the nitrogen cycle we have trespassed furthest away from the safe operating space. The rate for biodiversity loss is now on a level with last mass-extinction event. These adverse changes considerably weaken the conditions for human existence in general and the conditions for a prospering economy in particular. There is also a clear connection between intense industrial resource use and inequality (Jackson 2009). At the heart of these questions are consumption and the role and activities of business and the idea of economic growth, with the intensifying energy use and material through-put, which have been seen and are still seen as a precondition of human well-being.

Researchers (Allwood, Ashby and Gutowski 2004, Rockström et al. 2009), political institutions, NGOs and business practitioners (Hawken 1993, Stahel 1982 & 1997) alike have argued that this level of natural resources extraction and our socio-economic structures cannot stay as it is for long. If we want to maintain our (Western) standard of living as well as enable the socio-economic development of the poor globally, the use of energy and natural resources for production has to be downscaled by factor four or even down to factor 10, though even this is not considered considerable enough chance. The downscaling calls for the decoupling of economic growth and development (measured by GDP) from the use of natural resources (UNEP 2011). This means the dematerialization of economy (Herman, Ardekani and Ausubel 1989, Schmidt-Bleek 1998).

Within the factor and decoupling framework this study concentrates in particular on eco-efficiency and eco-efficient service models. Eco-efficiency can be seen as a strategy and a tool to achieve the above-mentioned decoupling or dematerialization, especially in the business context. The basic idea of eco-efficiency is understood as an analysis of the economic value of a product or production activity in relation to its environmental impacts (Ehrenfeld 2005, Gabriel and Braune 2005). The aim is to optimize this relation (Huppes and Ishikawa 2005). Eco-efficiency includes both the material and energy efficiency dimension (Hoffrén and Apajalahti 2009). The idea of eco-efficient services is that the above-mentioned dematerialization and/or deduction in material and energy usage is expected to be achieved by fulfilling the needs of customers with the help of services instead of them having to own

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products (e.g., a car-sharing service instead of a private car or service for managing chemicals in customers manufacturing line).

One of the main ideas of eco-efficiency and solving environmental issues is that it should not be considered merely a practical or financial burden. It embraces the idea that increasing eco-efficiency creates economic benefits while diminishing the environmental burden of companies and provides households with more choices for needs satisfaction. (DeSimone and Popoff 1997).

The service approach has not been realized as widely as researchers from the 1980's (Stahel 1982, Hawken 1993) to present day (Tukker 2004; Mont, Dalhammar and Jacobson 2006, Mont, Singhal and Fadeeva 2006, Halme et al. 2007) have hoped. Different household services enhancing ecological sustainability remain quite rare, except for car sharing which has had considerable growth in North-America, Asia, Australia (Shaheen and Cohen 2007) after an earlier growth in continental Europe (Shaheen, Sperling and Wagner 1998). It is also the most studied eco-efficient consumer service. In the business-to-business sector, strategies for outsourcing and purchasing services have long been mainstream operations. Another exception is the ESCO (Energy Service Company) business model that was developed after the first oil crisis in the 1970's in the United States (World Energy Council 2008) and is currently offered globally. As car sharing in the consumer sector the ESCO concept is a frequent object of academic research (Vine 2005, Bertoldi, Rezessy and Vine 2006, Da-li 2009, Lindgren Soroye and Nilson 2010, Okay and Akman 2010). The markets for ESCO services have also been studied broadly (Hopper et al. 2007, Word Energy Council 2008, Satchwell et al. 2010, and Marino et al. 2011) compared to other eco-efficient services.

In addition, recent years have witnessed the development of the chemical management services (CMS) (Stoughton and Votta 2003) or chemicals leasing services (Jakl and Schwager 2008) in such fields as automotive and aeronautics industries (CSP 2004, 2009). They are industries that use considerable quantities of diverse chemicals. In recent years the ideas of physical limits of human (economic) activity have gained renewed momentum through the *décroissance* (in French) (Latouche 2006 and 2010) or the degrowth movement (Schneider et al. 2010). Yet eco-efficient services or services that clearly aim to improve customers' eco- and economic efficiencies are not common.

Decoupling, eco-efficiency and degrowth embrace the idea that we live and perform economic activities on a single planet, which sets the

limits for our activities. The fundamental difference between the decoupling and efficiency approaches compared to degrowth is that the latter embraces abandoning of the pursuit of economic growth as well as substantial and equitable downscaling of production and consumption, while aiming at increased wellbeing and enhanced ecological conditions, both short and long term (Hueting 2010, Schneider, Kallis and Martinez-Alier 2010). Decoupling and eco-efficiency ideas, on the contrary, approach sustainability from the perspective that substantial efficiency increases and technological innovation enable the continued economic growth (or in other words sustainable growth).

Whether analyzing production, consumption and sustainability from a degrowth or an efficiency perspective, the production of needed and desired goods and services needs to be organized in some way. Services have long been seen as one potential and alternative way to achieve this. Yet their ecological potential and role, whether in the market economy or in some other type of social context, has been studied relatively little. Therefore, eco-efficient services and the eco-efficiency potential of services in general needs to be studied both extensively and intensively. This thesis provides new knowledge on this topic.

1.2 The research questions

At the beginning of this research project very little empirical research had been done on the eco-efficient services and services enhancing sustainable development regarding to their demand, supply and business models. The situation remains unaltered even today. The main body of the research has focused on analyzing and presenting single service cases (Stoughton and Votta 2003) or developing business models based on a small number of business cases for chemical management services (Bierma and Waterstraat 2000) or for the energy sector (Wüstenhagen and Boehnke 2006). A body of research has also focused on the problems and limits of eco-efficiency thinking (Hukkinen 2001) and the slim chances of the eco-efficiency approach and eco-efficient services to provide a radical enough change towards more sustainable direction (Heiskanen and Jalas 2003, Christensen 2007).

The development of eco-efficiency strategies and tools has focused more either on the analysis of product or process eco-efficiency or looked at the systems level aspects of eco-efficiency through industrial

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ecology research¹. Both approaches fail to address the financial aspects (investments, funding, and profit), organizational challenges and business models of enterprises (who provides services and what logistics, supplier relations, profit models, etc. are involved) and what makes the services usable or even desirable for business and household customers alike.

Why is it important to pursue filling these research gaps? If eco-efficient services are considered important in bringing ecological innovations to the markets, it is important to acknowledge that services need producers and customers, they do not happen automatically in the industrial or economic system. In order to be feasible, these services need to generate value for the company and for the customers by solving customer needs. The service provider also has to have competencies to carry it out - fulfill the service promise to the customer and it needs to create sufficient income flow to maintain itself.

The aim of this dissertation is to understand why and how existing eco-efficient services have developed, what types of services there are and what reasons there might be for their success. For services directed to households the unit of analysis is a service and for the business-to-business sector the units of analysis are the services and their business models. Thus the research questions are as follows:

1. *What kinds of services with potential to enhance eco-efficiency have emerged (articles I, II and III)?*
2. *Which issues influence the supply and demand of these services (articles I and IV)?*
3. *What kind of business models pertain to such services (articles II and III)?*

¹ Industrial ecology includes different ideas and sources (Garner and Keoleian 1995, Ehrenfeld 1997 and 2004) for changing our industrial systems to more sustainable or ecologically balanced direction. It is argued (Garner and Keoleian 1995, 4) that these definitions of industrial ecology share. It holds 1) a systemic view on ecological and industrial systems and their interactions, 2) energy and material flows and their transformations are in the center, 3) it is a multidisciplinary approach, and 4) it is an effort to reduce harmful impacts on ecological systems caused by industrial systems. It emphasizes 5) harmonious integration of industrial and ecological systems, 6) it concentrates on the system level analysis of industrial production. 7) It aims to create industrial systems that better emulate natural systems and their efficiency and sustainability and it also aims 8) to identify and compare natural and industrial systems hierarchies.

The first question is answered both from the consumer and business services sectors perspective, as is question two. The third question is answered from the viewpoint of business-to-business services, and from the material efficiency services perspective.

1.3 Structure of the study

The study is organized in two parts. This introduction (part I) gives an overview of the whole research and the second part (part II) presents the four articles that form the empirical basis of the research findings and conclusions.

The structure of the introduction is as follows: chapter 2 sets the framework for the study and covers discussion on the role of services as a means towards a more environmentally and socially sustainable economy. The third chapter describes the methodological approach and explains the choice of research methods. Chapter four discusses the main findings of the articles in the order they have been written and published. Chapter five sums up the conclusions drawn based on these findings and elaborates on their practical implications and future directions for research.

2. Setting the theoretical framework for the research

The next chapters focus on the concepts and academic discussions on eco-efficiency, eco-efficient services and service orientation. These discussions form the framework for this study as shown in figure two. Eco-efficiency is a widely accepted yet controversial concept for operationalization of sustainable development. It is both an approach to and a tool for analyzing and developing ecological sustainability mainly in private sector industrial organizations (Huppel and Ishikawa 2005). The World Business Council for Sustainable Development (WBCSD) has promoted it as a means to direct businesses towards sustainable development and as a way to diminish their ecological burden without endangering economic growth (WBCSD 2000a and b, DeSimone and Popoff 1997).

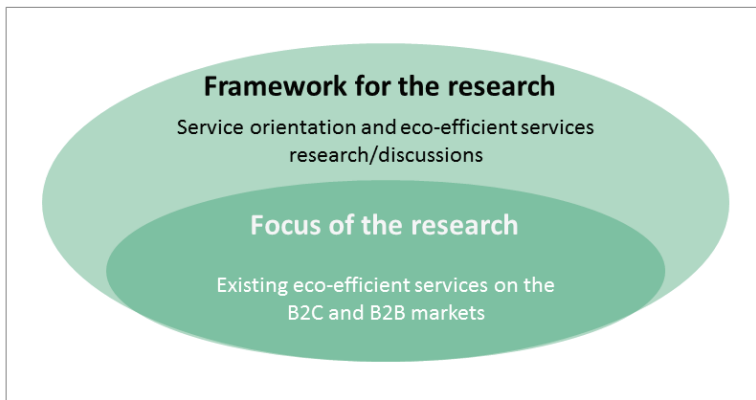


Figure 2: The framework for the research done in this dissertation

2.1 Eco-efficiency as a potential solution for sustainable development

The concept and idea of eco-efficiency has been used in the context of corporate environmental sustainability and public environmental policy since the early 1990's (Pogutz, Micale and Winn 2011). Originally it was introduced by two Swiss researchers, Andreas Strum and Stefan Schaltegger (1989). The concept gained larger international visibility a few years later, when WBCSD published a book titled *Changing the Course* (Schmidheiny 1992) where eco-efficiency was introduced as a way for business to change its practices more sustainable.

Eco-efficiency as a concept has very tight connection to the ideas of Sustainable Development (SD) (Pogutz et al. 2011), a concept which was first introduced in 1987 in Our Common Future report (WCED 1987). In short it can be defined as an economic and social development that meets the needs of current generation without endangering the possibilities of future generations to do so (WCED 1987) i.e. development has to happen within the environmental limits of earth. SD soon became a buzz word for socio-economic development that also protects natural environment. The basic idea is that it is possible to solve socio-economic issues such as poverty with economic growth which remains within the ecological boundaries. Critics (Bartelmus 2003) have argued that it is an opaque definition which does neither specify the aim or characteristics of the socio-economic development, time span, nor the environment. It is also argued that there are fundamental contradictions between the idea of economic growth and enhanced level of ecological conservation (Sneddon, Howarth and Norgaard 2006).

An approach to achieve, at least ecologically more sustainable direction for socio-economic development would be the reduction material throughput below the so called ecological carrying capacity. This could be done by decoupling economic growth from natural resource use with eco-efficient production and consumption.

In this dissertation eco-efficiency is defined as a way for companies to use (natural) resources in a more efficient way and to reduce waste (waste equals process inefficiency). This is achieved through technological innovation, which in turn enhances the competitive advantage and profit of the organization in question. Eco-efficiency is

2. Setting the theoretical framework for the research

defined as a way for companies to operate in an ecologically sustainable way. Since then the WBCSD has promoted and operationalized the eco-efficiency concept with an active publication policy and support material for private enterprises (DeSimone and Popoff 1997, WBCSD 1996, 1998, 2000a, 2000b and 2006).

At the general level eco-efficiency and its analysis can be understood as the relationship between the economic value (service aspect and functionality) of a single product or manufacturing process and the ecological impact of that product or process (Ehrenfeld 2005, Gabriel and Braune 2005). The aim is to maximize this relation (Huppes and Ishikawa 2005), i.e. to achieve an economically viable product or manufacturing with the least possible resource input and environmental damage. The smaller the ecological damage and material and energy inputs, the more eco-efficient the product or manufacturing process is.

According to DeSimone and Popoff (1997) eco-efficiency increases can be achieved through 1) reducing material and energy intensity of goods and services, 2) using less toxic materials 3) improved recyclability, 4) by maximizing use of renewable resources and 5) by greatly increasing the durability of products and 6) increasing the service intensity of goods and services. This last objective is the focus of this research: I address different types of eco-efficient services and the ways in which they may help to achieve more sustainable economy.

2.2. The service approach to eco-efficiency

Part of the eco-efficiency discussion and research is the idea that services can contribute substantially to achieving eco-efficiency and direct Western industrial societies in particular towards a more sustainable direction (Meijkamp 1998, Hockerts 1999, Bartolomeo and Scholl 2001, Bartolomeo et al. 2003). The ideas for eco-efficient service thinking come from many sources. As mentioned in the previous chapter, its roots are in the so-called factor and decoupling concepts, which means producing the same wealth with considerably smaller resource use and thus aiming at decoupling the economic growth from the natural resource use (Jänicke et al. 1989, Schmidt-Bleek 1998). The idea of this approach is that the above-mentioned dematerialization and/or deduction in material and energy usage is to be achieved by fulfilling the needs of customers with the help of services instead of owning products (e.g., a car-sharing service instead of a private car or chemical management services instead of chemicals).

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Products are seen only as means, not ends as Paul Hawken (1993) states in his seminal work: “*what we want from these products is not ownership per se, but the service*”. An economy where derived from products rather than the products themselves are a key element, has been termed as a functional or service economy (Stahel 1982 and 1997, Hawken 1993). In this context services replace products to a greater or lesser degree, solve customer needs (those of consumers or companies), and thus reduce the material and energy needed to perform an economic activity (e.g. manufacturing, moving, travelling, housing etc.), are called eco-efficient services.

2.2.1 The definitions of eco-efficient services

In general eco-efficient services can be defined as product-service systems that provide the greatest value added for the customer with a considerably smaller environmental harm compared to situation where the service has not been implemented (Roy 2000, Bartolomeo and Scholl 2001, Brezet, Bijma, Ehrenfeld and Silvester 2001, Mont 2001, Bartolomeo et al. 2003). This general idea of eco-efficient services can be divided into three types of services concepts, which all have a different relation between a tangible product and the intangible service component. These conceptual approaches are *product-based*, *use-oriented*, and *result-oriented* services, of which the result-oriented ones are considered to have the highest eco-efficiency potential (Tukker and Tischner 2006).

In the first category, product-based services, the product is still a focal part of the product-service system. Services are additional to the product and they can include repair, maintenance, upgrading or take-back of the product. This concept can be seen as an example of extended producer responsibility even after the point of sale (extended such as tires or SER take back and recycling schemes) but the product ownership remains with customer whether they are consumers or business organizations.

Another approach to eco-efficient services is offered by use-oriented services, which provide value for the customer by allowing access to the product and to the function it provides (USEPA 2009). The customer only pays for the access and the use. The ownership of the product may be transferred to the customer or the service provider can retain it. This latter alternative involves renting or leasing a product to the user and it goes a step further: the ownership remains with the producer. The earlier car-sharing, as described earlier, is an archetype of a use-oriented service.

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Both of these above-mentioned service approaches involve a product around which the service is developed. The third, result-oriented, group of services takes a step further and aims to solve customers' specific and current needs by providing the function of a product (Heiskanen and Jalas 2003, Halme et al. 2007, USEPA 2009) i.e. a painted car instead of paint (BASF Coatings and Success service²). This type of service may include various forms of contracting, for instance least-cost planning in the energy sector, facility or material flow management, or waste minimization services. Result-oriented service may be offered by the manufacturer, e.g., an energy provider. It may be profitable for the provider to promote energy-saving equipment. ESCO-services and some of the most advanced chemical management services such as above mentioned BASF Success or Kemira Operon³ can be defined as result-oriented services.

Earlier discussion (Jänicke et al. 1989) considered non-material services as yet another category that should be discussed in connection with services that can lead to a decreased environmental burden in society. These traditional services, such as medical or personal care, legal services, banking etc., do not necessarily replace products directly. Their potential ecological contribution is realized through

² As an advanced chemical management service provider BASF Success is advanced and differentiates itself from other companies by providing tools to analyze both social sustainability and eco-efficiency and services that enhance these goals. Success co-operates closely with other BASF business units and utilizes their capabilities. An example of the eco-efficiency analysis and new business that Success has created for itself and other BASF business units is the management of Mercedes Benz A -series coating. Success has analyzed the eco-efficiency potential of this process, which the coatings unit realizes by operating and managing the coating of the vehicles instead of selling paints for the customer (Anttonen & Apajalahti 2009). The analysis tool is based on the ISO 14032 standard and is well recorded. Of course it can be asked if the eco-efficiency analysis is neutral towards all chemicals manufactures or not. In general this potential service provider bias and dependency on one provider has been identified as one of the barriers for using chemical management services by potential customers (Singhal 2003, Mont, Singhal and Fadeeva 2006 and Kortman et al. 2008)

³ Kemira Operon is a subsidiary of the global chemical company Kemira. It provides solutions for operating and managing of industrial and municipal wastewater and sludge treatment processes. The company recovers acids, bases and metal hydroxides, primarily aluminum and iron from the sludge. These recovered resources can be recycled as raw material in chemicals production. Another interesting feature of the service concept of the Kemira Operon is that it aims at reusing the recovered materials within a geographical proximity of the original industrial site. The company estimates that metal recycling reduces the disposed waste sludge volume around 2 000 t annually and for acids and bases recycling, the reduced volume constitutes up to 3 000 t/a. The estimated avoidance of solid landfill is up to 50 000 tons a year. (FORA and COWI 2010; personal information from Kemira Operon CEO Tapio Korttilalli, Feb. 11th 2011)

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another kind of mechanism. From a macroeconomic perspective, the shift towards services and the resulting increase in the service intensity of the economic production is hypothesized to benefit ecological sustainability through the decline of traditional smokestack and extractive industries as opposed to less materials-intensive and more knowledge- and labor-intensive service industries. Contrary to these ideas, it seems that the transition towards service economy increases high energy use, at least a study (Horio and Watanabe 2008) analyzing developed Asian economies indicates this. The considerable increase in energy use is caused by the intensified and broadening use of IT and its over-dependency on energy (Horio and Watanabe 2008). Services, as such, are not eco-efficient. For developing the eco-efficiency of services, each service in question must be assessed individually, examining each of them in context (cf. Salzman 2000).

Parallel to sustainable or eco-efficient product-service discussion, there is an analogous and longer academic discussion on servitization in strategy; supply-chain and general management literature is the sustainable product-service system discussion in eco-efficient services. The discussion dates back to 1988, when Vandermerwe and Rada introduced the concept of servitization. They emphasized the importance of services in the formation of corporate strategies and success. Vandermerwe and Rada (1988) defined servitization as a movement in which *“corporations are increasingly offering fuller market packages or ‘bundles’ of customer-focused combinations of goods, services, support, self-service, and knowledge”*. Services thus become an integrated part of core business activities and shift the core activity from manufacturing into different types of product-service bundles, which can be any combinations of goods services, (customer) support, self-service and knowledge.

These product-service combinations then create better customer value propositions (Alvizos and Angelis 2010). Product Service Systems are seen as a specific case of servitization, which can be seen as a market proposition that extends the traditional functionality of a product by incorporating additional services. Here the emphasis is on selling use not the product. This means that the customer pays for using rather than purchasing an asset. The aim is to avoid the risks, responsibilities, and costs associated with ownership (Baines et al. 2007).

This and the eco-efficient service concepts seem to share only some common ground evaluated by the articles used in this thesis. It might

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be worth studying why these two streams of product-service research do not interact more or ask what they could learn from each other.

Further recent areas of research include the concepts of service-dominant logic or SDL (Grönroos 2008, Vargo and Lush 2004 and 2008) and new service development (Matthing, Sandén and Edvardsson 2004) in marketing research. Firstly, these approaches or lenses (Vargo and Lusch 2004) emphasize the role of skills, information and knowledge. Secondly, the customers are active in value creation or are co-producers of the value. Understanding and fulfilling dynamic customer needs is the focus of services developed with these concepts in mind. Consequently, the value created is value-in-use, i.e. customers buy neither products nor services but activities that fulfill the needs in question. Value is not a predefined outcome or embedded in goods (Vargo and Lusch 2004, Matthing et al. 2004). These concepts of value-in-use and service dominant logic have similarities to the concept of result-oriented services as described earlier and the ideas of functional economy (Hawken 1993).

2.2.2 The contribution of services to eco-efficiency

Why would the services outlined above contribute to eco-efficiency, i.e., to a reduction in materials and energy consumption? Firstly, if the ownership of the product remains with the manufacturer, there is an incentive to produce more durable goods. This is because income is created by selling the use of the product, not the one-time sale of the product itself. Secondly, a lower stock of products is needed if consumers use the same product in sequence. The lower the stock of products, the less material is needed to produce them. In other words, more intensive use increases the probability of higher service yield before the product becomes obsolete due to outdated technology or changing fashions. For instance, cars or personal computers are often exchanged for newer ones not due to breaking down, but for reasons that lie somewhere in the midway between changes in technology and fashion. Thirdly, in result-based services where the operator takes responsibility for product use, the service may facilitate more professional usage. Thus, services may create substantial eco-efficiency impacts if they change the way in which products are designed, how they are disposed of and even replaced altogether (White et al. 1999).

The eco-efficiency benefits of services have been studied surprisingly little. Again, in the consumer sector, car sharing stands above other services (Meijkamp 1998 and 2000, Mont 2004). This research has

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shown that car sharing has clear eco-efficiency benefits that are related to the more intensive use of the vehicle and the slower growth of the fleet. Other consumer services and their eco-efficiency potential have been studied far less. The main body of the research has focused on describing and analyzing individual service cases. In addition, different products and the kinds of services that could be attached to them have been studied (Schrader 1999, Behrent et al. 2003, Hirschl et al. 2003, Scholl and Konrad 2004).

These studies include rental skies and textile washing (Hirschl et al. 2003; Scholl and Konrad 2004). They estimated that rental skies increase resource efficiency by factor 1.6 - 1.7 depending on the boundaries of the estimated system. Textile washing increases resource productivity from factor 1.4 to factor 2.4. Both of these examples are still far away from productivity shifts of factor 4 or 10, which are considered to be the necessary bottom line for achieving sustainable levels of material and energy use. Scholl and Konrad (2004) consider high enough efficiency improvements unlikely without significant changes in technical and organizational settings. The first article (Halme et al. 2006) of this dissertation is one of the broadest studies on eco-efficient services and their sustainability impacts, although the evaluation of the impacts was qualitative in nature.

In the business-to-business areas most covered by the research are the ESCO (Energy Service Company) business model and a few other energy efficiency services (Newcomb 1994, Vine 2006, Wüstenhagen and Boehnke 2006, Hanley et al. 2009). From the material efficiency service perspective, chemical management services have been studied to some extent from a very pragmatic point of view. For example, Chemical Strategies Partnership (CSP), a USA-based organization has drawn up industry reports (CSP 2000, 2004 and 2009) which list the customer benefits accrued by using chemical management services (Figure 3).

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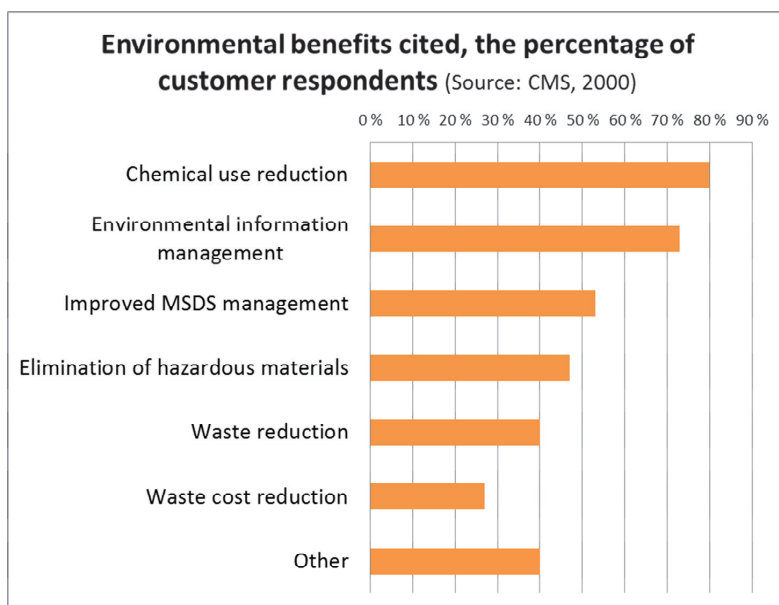


Figure 3: The experienced environmental benefits of the chemical management services

CSP (2000, 2004) finds that the greatest benefits of eco-efficiency have been the reduction of chemical waste and more efficient use and recycling of chemicals. A third of the customers have also been able to replace chemicals and chemical compounds with less hazardous ones, as shown in Figure 3 above. In addition to the industry reports (2000, 2004, and 2009) there have been numerous studies on individual chemical management services (White et al. 1999, Bierma and Waterstraat 1999 & 2000, Singhal 2003, Stoughton and Votta 2003, Oldham and Votta 2003, Mont 2004) and chemicals leasing examples (Jakl et al. 2004 & Jakl and Schwager 2008, Perthen-Palmisano and Jakl 2005).

Eco-efficient service research is mostly based on describing case studies of individual services. Only a few reports present the results of more systematic and larger data sets (Singhal 2003, Mont, Singhal and Fadeeva 2006, Kortman et al. 2008). Of course, the number of companies providing eco-efficient services is quite limited and for example, the CSP (2004 and 2009) data on the environmental and economic benefits of chemical management services in the USA is based on roughly 30 customer companies ranging from automotive industries to metalworking.

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Individual service providers such as German BASF Success and Swedish AGA Sisource have demonstrated the positive effects of the services, as have the case examples from Chemical Strategies Partnership (www.chemicalstrategies.org/). In these company accounts, as in most of the analyzed case studies, like the ones on the Chemical Strategies Partnership website, or in Bierma and Waterstraat (2000), the environmental and economic benefits are presented as relative improvements, e.g. in chemical waste reduction, etc. This is quite understandable from an individual company's perspective, but it creates difficulties for evaluating the energy and material-efficiency potentials of chemical management services in greater detail and on a larger, environmental and economic scale.

Unfortunately, as Heiskanen and Jalas (2003) pointed out already a decade ago, the systematic and quantified evaluation of the impacts of eco-efficient services was not done back then and it remains undone. This is something that should be urgently addressed. Even though the eco-efficiency potential is not clearly quantified, the case examples illustrate several ways in which companies can change their business models and business logics and operate a feasible and successful new business. They also show that customers can benefit from using these services and that there should be market potential for them.

The environmental impacts of servitizing have also been studied in the context of ICT and server based computing (SBC) services. The results show that outsourced SBC services at least double the life span of end-user hardware. Assessing the precise environmental implications of a SBC service system compared to product analysis can prove difficult because of the ambiguity of the system boundaries and the measurements for delivered functionality. (Plepys 2004)

2.2.3 Limits of efficiency – critique towards eco-efficiency and the service approach

One of the major critiques against the eco-efficiency concept and its use as a tool for promoting environmental policies is that it, by definition, focuses on economic and ecological efficiency and does not take into account social sustainability, even though ecological, economic and social sustainability are strongly intertwined (Welford 1997, Hukkinen 2001, Dyllick and Hockerts 2002, Ehrenfeld 2005). Thus eco-efficiency in itself is not a sufficient means of achieving change towards a sustainable enough direction (Dyllick and Hockerts 2002, Figge and Hahn 2004).

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The second critique towards eco-efficiency concept is that it is seen as a universal solution for improving sustainability (Hukkinen 2001) i.e. that eco-efficiency is a general and systematic way to enhance sustainable development regardless of context and culture. For example, Hukkinen (2001) argues that there are local, culturally embedded ways of using natural resources which are both ecologically and socially sustainable although they do not fit under the idea of eco-efficiency umbrella. In a similar fashion, ecological economist Mario Gogoy (1995) has criticized the penetration of market sector ideas and practices into personal or previously non-market areas of life such as families and communities. According to Gogoy (1995) this leads to 1) an increased use of technology which consequently intensifies the use of energy and resources. This in turn 2) causes centralization of local and decentralized processes and diminishes the capabilities of individuals and communities to manage different resource processes.

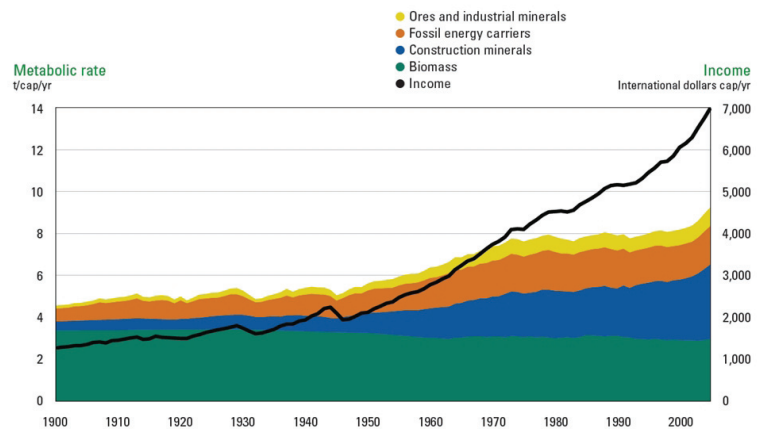
On the other hand, Lebel and Lorek (2008) point out that locally adapted eco-efficient ways of dealing with sustainability issues seem to be quite similar regardless of whether they have emerged from the industrialized or developing markets. These new (eco-efficiency) solutions also seem to challenge the previous local practices that are perhaps focused more on the economic side of the resource management. Eco-efficiency as a concept and means towards sustainability can also be seen as a pragmatic and comprehensible way for organizations to initiate sustainability improvements instead of having to tackle climate change or other planetary threats directly in the context of the everyday business. Analogically, it can be argued, the same applies to households and the organization of everyday life. Short environmental campaigns have no lasting effect in changing the behavior of individual people or households. Campaigns can fail because individual people cannot perceive the connection between global environmental problems and their everyday behavior, or global issues are seen too complex for consumers to have an effect on through their own actions (Hobson 2002).

The third critique focuses on the relativity of the eco-efficiency concept (Huesemann 2004, Hoffrén and Apajalahti 2009): with eco-efficiency it is impossible to reduce resource use enough, because its goal is a relative improvement of resource efficiency - product A, is produced in a more efficient way, but eco-efficiency does not question whether it is desirable or even necessary to produce the product in the first place.

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These analyses focus on the relation between inputs and final products, i.e. how to manufacture something as efficiently as possible, while forgetting the ecological effectiveness of the particular process or product. In other words, from an ecological or social perspective we may manufacture the wrong kind of products that, in an absolute sense, worsen the environmental problems through increased production and consumption. For critics such as Braungart, McDonagh and Bollinger (2007) eco-efficiency is merely a way to do less harm compared to business-as-usual and that can be far from sufficient (Pogutz et al. 2011). Instead of eco-efficiency they (Braungart et al. 2007) propose eco-effectiveness and a cradle-to-cradle design approaches which changes the aim of industrial processes and design from doing less harm to doing more good; purifying air, water, and soil; retaining valuable materials for perpetual, productive reuse, etc.

When analyzing the current situation, it seems that eco-efficiency, technological innovation (Schneider et al. 2010) and the factor 10 or decoupling ideas haven't had enough leverage to change the direction of resource use (UNEP 2011). A report by the United Nations international resource panel (UNEP 2011) clearly illustrates that, at the global level the absolute use of resources has increased even though income levels have risen faster than resource use (Figure 4) i.e. relative decoupling has taken place but achieving absolute and sufficient decoupling still seems unattainable goal.



Source: Krausmann *et al.*, 2009; based on Sec Database "Growth in global materials use, GDP and population during the 20th century", Version 1.0 (June 2009); <http://uni-klu.ac.at/socec/inhalt/3133.htm>

Figure 4: The Relative decoupling of the economic development and natural resource use

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Because eco-efficiency does not address the underlying questions of economic growth, the development of technology may give us temporary improvements and maybe more time before the ecological and social conditions get considerably worse (Huesemann 2004). This criticism is at least partially based on so-called Jevons's paradox (Huesemann 2004, Huppel and Ishikawa 2005) that any efficiency increase (Bartolomeo et al. 2003) of resource use will only lead to increased use of that resource. This increased resource use happens because the savings are directed at other economic activity and thus the absolute use of the resource in question will eventually increase (Huesemann 2004, Hoffrén and Apajalahti 2009). Energy-efficiency, for example, has been criticized on this account (Herring 2006).

The rebound effect is a particular form of this criticism in the household context - eco-efficient services can lead to increased use of resources when households have more time or money to spend on unsustainable practices (Heiskanen and Jalas 2003). Part of the increased demand for products and natural resources is seen to result from diminished production costs (Bartolomeo et al. 2003). Apart from money, technological development can equally cause a rebound effect by making products more affordable to households or by stimulating population growth (Ehrenfeld 2004, Alcott 2010), which in turn leads to increased environmental damage. On the other hand, Gabriel and Braune (2005) have argued that while criticism directed at the eco-efficiency analysis of a product or manufacturing line may be valid, the situation would be worse if eco-efficiency was not assessed and developed in business organizations at all.

As with the eco-efficiency impacts of services, it is difficult to demonstrate in general what kinds of eco-efficiency results companies have achieved. Two studies on environmental reports produced by Finnish companies (Erkko, Melanen and Mickwitz 2005, Hoffrén and Apajalahti 2009) do not indicate to what extent the companies analyzed are striving for eco-efficiency in their production processes. This in turn makes the assessment of eco-efficiency potential difficult at the industry and economy level.

2.3 Business models and eco-efficient services research

In previous research it has been argued that a lack of feasible business models and business model research is one of the main obstacles for the development of eco-efficient services (Halme et al. 2007). Any

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service, whether profit or non-profit oriented, that wants to maintain its existence and to develop towards a desired organizational direction needs to stay feasible. In order to be feasible, they have to generate income and create benefits for their customers, i.e. value that customers gain by using the service in question (Chesbrough and Rosenbloom 2002, Andersson, Narus and van Rossum 2006). A business model is a concrete concept that postulates the ways in which an organization connects to its customers, competitors and suppliers. In the next paragraphs, the development of the business model concept is presented along with current academic research. Then the use of the concept in eco-efficient and in broader sustainability research is presented together with the definition of the concept used in this study.

2.3.1 The development of the business model concept and research

The concept of the business model is not new to practitioners. Ghaziani and Ventresca (2005) date the concept to 1970's but it was only the 1990's ICT boom that brought it into prominence. As a concept it has been and still is loosely defined and with varying meanings. Briefly, a good business model can be argued to be a model that combines the capabilities and other resources of the firm to create value for the customer with products and services (Fielt 2011). Moreover, the aim of the business model is also to provide a competitive advantage for the service provider compared to other service offerings on the target market, i.e. a means to capture value for the company itself. This should be done in an economically profitable way, or if the organization operates on a non-profit principle, the model should help the organization to operate in an economically sound manner.

The research focusing on business models has expanded greatly both in scope and depth in recent years, even though the concept is still defined broadly and lacks a commonly accepted general definition (Chesbrough and Rosenbloom 2002, Morris, Schindehutte and Allen 2005, George and Bock 2009, Zott, Amit and Massa 2010, Fielt 2011). One plausible reason for this could be that the research on business models has been and is carried out from very different research angles in several academic subject areas that do not mix or discuss with each other (Zott et al. 2010).

From an academic perspective, the business model is a relatively new concept. The business model concept becoming a commonly used concept in research is closely related to the 1990's dotcom boom and the rapid growth of ICT and internet (Timmers 1998, Morris et al.

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2005, Zott et al. 2010). This growth created demand and possibilities for unconventional exchange and transaction mechanisms (Amitt ja Zott, 2010). The research and development of the concept has focused on generic business model typologies (Timmers 1998 & 1999) or classification of business model components such as value and income flow (first order components) and pricing mechanisms (second order component) (Afuah and Tucci 2001). In addition, the reorganization of the supply-chain caused by e-commerce, internet and ICT was one of the first focus areas of the business model research, i.e. the changing role of distributors in pc-markets and the effects of this changing role (Magretta 2002).

Business models have also been studied from the strategic management point of view. This research has broadened the concept with ideas of value creation as a complex set of actions and transactions between suppliers, customers and partners instead of simple linear thinking and seeing the business model as a kind of standalone model (Zott et al. 2010). A business model cannot be studied as merely internal to the organization in question (for example control and incentive systems, processes such as production or distribution). A strategic perspective on business models in fact makes the borders of an organization somewhat fuzzier; even if the analysis concentrates on the internal aspects of the model.

Such concepts as value creation and value capture, competition and competitive advantage and profit creation are concepts the strategic perspective has incorporated into business models research. When business models are studied from a strategic point of view, cooperation, partnerships and joint value creation are issues that are looked at more closely. Then again, business model thinking and studies have brought the customer and customer needs more to the fore compared to traditional strategy literature (Magretta 2002, Zott et al. 2010, 18).

Another major strand of research is the role of business models in innovation and technology management (Zott et al. 2010). This research has focused on two types of studies. The first one asks how companies commercialize new technology by using their business models (Chesbrough and Rosenbloom 2002, Chesbrough 2010). Studies such as Chesbrough and Rosenbloom (2002) and Chesbrough (2010) analyze how companies can 'capture value' with new technology and whether the existing business models fit with the technology or not

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(Chesbrough 2010). This line of research has shown that (Chesbrough 2007a and b) even though the technological innovations are important, the technology as such has no value. The value is created only when the technology and the business model (solving customer needs) are compatible (Chesbrough 2010).

The other strand of research sees business models as innovations (Mitchell and Coles 2003, Johnsson, Christensen and Kagermann 2008). From this perspective, business models are innovations that differ from traditional organizational, process and product innovations (Zott et al. 2010). The focal idea of this research approach is that business model innovation creates new forms of cooperation, collaborative networks of different actors (Chesbrough 2007b). Through these new ways of doing business, companies can surprise their competitors and gain a competitive advantage on new markets (Zott et al. 2010). However, changing the business model requires, as innovation in general, systematic processes and methods and knowledge (Johnsson et al. 2008). This research has broadened the scope of the business model concept by showing that actors such as customers and competitors and external processes such as new markets can be a valuable source of innovation (Chesbrough 2010). Business model innovation can also be seen as a collaborative network in which the different actors participate in business model creation (Chesbrough 2007b) or even a collaborative entrepreneurship (Miles et al. 2006).

Recently, business models have also been analyzed from variety of viewpoints outside of mainstream business studies. Some researchers (Doganova and Eyquem-Renault 2009) have analyzed them the actor network theory (ANT), describing business models as narratives and market devices that help enterprises to study and create markets for their products and services. Others see them as textual, verbal and graphic representations of business enterprise (Cascadesus-Masanell and Ricart 2010). A third non-mainstream approach could be defined as a Business Model Ontology (BMO) perspective (Gordijn and Akkermans 2001, Osterwalder and Pigneur 2002, Osterwalder 2004). This approach means that essential parts of a generic business model are conceptualized as elements, relations, vocabularies and semantics. Osterwalder and colleagues have formed a widely used package (Business Model Canvas) for business model development (Osterwalder and Pigneur 2002, Osterwalder 2004)

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Despite the different perspectives on business model research, there are more and more shared themes within the research community (Zott et al. 2010). First, the business model itself is the focus of the research and the unit of analysis alongside the product, company, industry or network. The focus may be the organization in question, but the boundaries are broader than a single organization since no single company can operate separately from its clients, competitors or suppliers. Secondly, the business model approach emphasizes systemic analysis. Thirdly, business model approach highlights organizational action and fourth, the researchers seek to explain value creation and capture by using business model concept.

2.3.2 Business models in eco-efficient service research

The business model as a concept has been used to a lesser degree in the context of sustainable and eco-efficient services than in mainstream management and business studies. The business model concept lacks a coherent definition in the eco-efficient service research, as is the case in business model research in general (Timmers 1999, Morris et al. 2005, George and Bock 2009, Zott et al. 2010). In the eco-efficient services and sustainable product-service discussion it has been used synonymously with terms such as business plan or revenue model (Vercalsteren and Gerken 2004) or conceived as a flow chart describing service logistics (Tempelman 2004).

One of the studies using the business model was Wüstenhagen and Boehnke (2006), which proved that the technology involved has an effect on the business model and on how 'traditional' (manufacturer, distributor, installer and customer chain) or 'innovative' (i.e. whether it creates new networks and shared contracts) it is (Wüstenhagen and Boehnke 2006; Boehnke and Wüstenhagen 2007). Some researchers in industrial ecology have used the concepts of customer value and business model in studies focusing on the automotive industry (Wells and Orsato 2005, Wells and Seitz 2005, Wells 2006) and local eco-industrial economies (Wells and Bristow 2007). They argue that industrial ecology has methodologically and conceptually focused on the macro level analysis while neglecting micro (company, facility) level analysis and that this has hampered the eco-industrial ideas becoming reality (Wells and Orsato 2005, Wells and Seitz 2005, Wells 2006). They see the business model as a concept that could link individual organizations at the local or micro level with macro level analysis. This is similar to the ideas presented in the strategy approach, which argues that the business model as a concept stretches the

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boundaries of a company or single organization towards a network and system (Zott et al. 2010). The business model could be a concept that makes the ideas and methodology of industrial ecology easier to understand for professionals (Wells and Orsato 2005, Wells and Seitz 2005, Wells 2006).

Sometimes the business model as concept has been used in an unusual way seeing it some kind of a combination of life cycle analysis, leasing and maintenance services in the industrial manufacturing context (Meier and Massberg 2004). For example revenue models or customer value are not mentioned in this study.

The mainstream business model literature has largely neglected eco-efficiency, sustainable development and eco-efficient services. In general management journals, sustainability and servicitizing (Rothenberg 2007) and chemical management services have been mentioned as an example of an innovative business model (Anderson et al. 2006). It has also been used as an example of product-service systems and service orientation in industrial management (Lay et al. 2009).

2.3.3 The definition of the business model concept for eco-efficient service research and development

In three of the articles (II, III and IV) the concept of the business model has been used as a unit of analysis. We define it through four dimensions, which are 1) the value for the customer (value proposal). Value means the benefits that customer receives from using the service. It can be relieving or enabling: relieving value means the labor savings for the customer, i.e. reducing costs, working hours, etc.; enabling value includes all output of an offering that enables the customer to operate more efficiently and effectively, for example to produce the same output with fewer resources. The model 2) includes the competitive advantage for the service provider in relation to other actors at the market. It 3) analyzes the internal competences for creating the customer value, and 4) it looks the value capturing i.e. how the service provider creates profit and covers the costs of the investments (Halme et al. 2007). The concept is based on the ideas of value constellations and offerings (Normann and Ramirez 1994) and business model literature of the time (Räsänen 2001, Magretta 2002). This business model concept remains valid. One thing that could strengthen it if the research were done now, would be an expanded analysis of the organization of the service and the way in which the value is created. This means asking whether the company offers the

2. Setting the theoretical framework for the research

service and creates the value by itself, or whether some of the services are outsourced or co-created with other service providers or together with customers. This model could include more new and different forms of cooperation, collaborative networks with, perhaps less traditional, actors such as customers and competitors. Both of these groups can be co-producers of value and they could be also considered with other groups and organizations, such third sector volunteer organizations as a valuable source of innovation for the service provider (Chesbrough 2007b and 2010).

3. Empirical work

This dissertation examines the empirical phenomenon of eco-efficient services. It aims to increase our understanding of the ways in which eco-efficient services would be a feasible route towards sustainable development. This chapter presents the methods applied and the empirical data collected in four different research projects and used for the analysis. It also illustrates the bindings between the empirical research and pragmatist mixed method research.

3.1 Data and the methods in the articles

This thesis consists of four articles that represent the empirical research done in four projects between 2002 and 2008. The research projects and the corresponding articles are presented in the following table (Table 1). The empirical research that article I is based on was carried out in the project called '*Homeservices: Benchmarking Sustainable Services for the City of Tomorrow*' and it was funded by the European Commission⁴. Articles II, III and IV are based on a series of so-called MASCO -projects (MAterial Service COmpany MASCO 1-3). All the projects were funded by the Finnish Funding Agency for Technology and Innovation TEKES and participating companies.

Each of the articles has a slightly different perspective on and contribution to eco-efficient services research (see table 1 and figure 5). Article I studies services directed to households (consumers) and investigates their ecological, social and economic sustainability effects. Article II addresses material efficiency services offered to business customers and conceptualizes business models for them. The article also studies the market potential of these business models.

Article III studies material efficiency services and their business models, focusing on chemical management and resource management services. It analyses existing services and their business models. The fourth article (IV) turns the focus to the demand side of material efficiency services. The data and methodologies used in the articles and the research projects are described in detail in the succeeding chapters.

⁴ The funding came from the Research Directorate-General (H), within the framework program '*The City of Tomorrow and Cultural heritage*'.

3. Empirical work

Table 1: The articles of the thesis and the corresponding projects

Projects	Article
Sustainable Homeservices, 2002 - 2004	Article I: Halme, M., Anttonen, M., Hrauda, G. and Kortman, J. 2006. Sustainability Evaluation of European Household Services. <i>Journal of Cleaner Production</i> 14:1529-1540
Masco 1, 2005	Article II: Halme, M., Anttonen, M., Kuisma, M., Kontoniemi, N. & Heino, E. 2007. Business models for material efficiency services: Conceptualization and application. <i>Ecological Economics</i> , 63(1): 126-137
Masco 2, 2006 - 2007	Article III: Anttonen, M. 2010. Greening from the front to the back door? A typology of chemical and resource management services, <i>Business Strategy and the Environment</i> 19 (3), 199–215
Masco 3, 2008 - early 2009	Article IV: Anttonen, M., Halme, M. Houtbeckers, E. & Nurkka, J., 2012. The other side of sustainable innovation: Is there a demand for innovative services? <i>Journal of Cleaner Production</i> , corrected proof, available online 23 December 2011

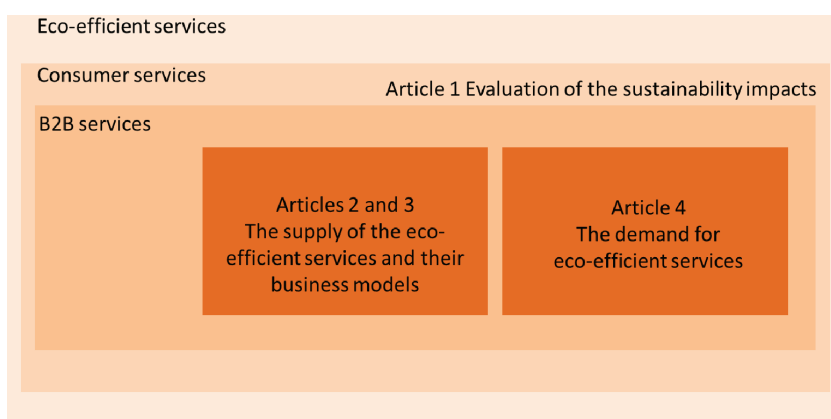


Figure 5: The perspectives of the articles on eco-efficient services

3.1.1 Article I

Article I is based on the analysis of 215 (provided by 67 different organizations) existing services targeted at households in six European countries (Austria, Germany, Finland, The Netherlands, Portugal and Spain). The data was collected during the *Sustainable Homeservices* project (Halme et al. 2004 and 2005) and the services were analyzed by using a qualitative framework developed in the course of the same project. The primary data for the analysis consist of over hundred interviews of representatives of service providers, such as private companies, public authorities and non-profit organizations and housing organizations. Housing organizations and public authorities also represented the customer side of purchasing services from the private and non-profit sectors. Naturally occurring, complementary data, i.e. data that was not created for research purposes (Silverman 2006, p. 201), was collected from the available sources such as websites, company reports and promotional materials, newspapers and magazines. In order to understand the customer needs for household services, a survey based on the findings of the interviews and the analysis of the service data was carried out. Altogether the number of respondents was 333 in six European countries.

3.1.2 Article II

The main source of the data for article II was a set of semi-structured interviews with 61 service providers, financial representatives of potential customer companies for material efficiency services. Representatives from Environmental ministry and the ministry of Trade and Industry were also among the interviewees for two reasons; first the Finnish defense forces participated in the research project and secondly the role of legislation and public governance as barrier and facilitator of eco-efficient services was studied during the project. Parallel to the interviews, two focus group discussions with employees representing companies from the food and beverage industry were organized to understand how the MASCO business model concept was perceived in potential customer companies and whether would it be understandable and feasible for efficiency improvements. In addition, naturally occurring data such articles and internet documents on ESCO and MASCO-services were used as data.

All the data (interviews, focus groups and naturally occurring data) was analyzed by using content analysis, which is a “research technique for replicable and valid inferences from the text or from other meaningful material to the context of their use” (Krippendorff 2004).

3.1.3 Article III

Article III focuses on the business models of the chemical management services (including chemicals leasing services mentioned in chapter two, the actual services and their position in the supply chain). The data for the article

3. *Empirical work*

consists of document data (websites, promotional material, and newspaper and magazine articles) that deals with 38 companies offering chemical or resource management services. The main source for finding the company data was the US based Chemical Strategies Partnership (www.chemicalstrategies.org), a non-profit organization focusing on the development and promotion of chemical management services as an environmentally sound and a good business model.

The method used analysis was thematic analysis, which is a tool for encoding and interpreting qualitative data (Boyatzis 1998, 161). The analysis combined coding driven by previous research and inductive coding derived from researcher's reading of data. Previous research and literature formed the basis for the analysis (the types of services included in chemical management, the basic business model used and the benefits for the customers). The data was read and grouped in themes presented in the material.

3.1.4 Article IV

Article IV reports the findings of the last a MASCO -project, which focused on customer needs and the demand for innovative material efficiency services. This article combines directly different data and data collection methods in a conventional manner following a stepwise approach from face-to-face interviews to a survey and to focus groups as follows. The first step comprised semi-structured interviews of 30 practitioners from potential customer companies of material efficiency services from the following industries: the manufacturing industry (metal working, technology, etc.), construction, wholesale and retail and logistics and forwarding. The official statistical nomenclature for classifying industries was used for defining the industry sectors.

The interviews were envisaged to help us further develop and fine-tune the questionnaire, as well as to assist us in gaining a deeper understanding of the motives behind accepting or declining eco-efficient services provided by external service providers. The interviews were analyzed (Attride-Stirling 2001) in a fashion similar the one used in article III. As a technical tool for analyzing the interviews NVivo 8 software was used. The second step was a survey of potential customer companies (294 respondents), The survey data was analyzed with statistical software PASW 18.

Finally, after the data gathering phases above, two focus group discussions were held in order to give the interviewees/participants a possibility to reflect upon the findings and to help us to determine what kind of material efficiency services they would like to procure and how these services should be offered to them.

3.2 Studying eco-efficient services with mixed methods

First, this part of the text presents the interest of knowledge and the methodological foundations that guided the methodological choices made in this research and different articles. This research contributes to the previous research on eco-efficient services from an empirical research perspective with wide-ranging data with the aim of increasing understanding of eco-efficient services and the way in which these services could function as a route towards sustainable development. As mentioned earlier, the previous research had been more conceptual than empirical.

3.2.1 Mixed methods approach in this research

The research includes much more data and a greater variety of methods than are directly used in the articles. The articles focus on the most important findings of the research and the data and methods behind them. Part of the data collection methods mentioned in table 2 were reported only in the context of the research projects and their reports (Halme et al. 2004, Halme et al. 2005 and Anttonen et al. 2008). All the applied data collection methods are illustrated in table 2. It presents the article in question and the corresponding research project and the different data collection methods applied.

There are several reasons for using wide-ranging data collection and analysis methods. As exemplified in earlier chapters the eco-efficient services had been relatively little studied empirically. Consequently, understanding existing eco-efficient services, their market (needs), and eco-efficiency potential, necessitated collecting data from service providers and customers alike. The analysis also required data from various levels, ranging from the actual services to the customer's operations to the presence or absence of these services on the market. This need for varied empirical data and different perspectives on eco-efficient services called for diverse data sets and data collection methods. This comprehensive data set is also the strength of this study because such a wide-ranging empirical data set on eco-efficient services does not exist elsewhere.

Table 2: The data collected in the four research projects

Source of data for the projects and articles					
Primary focus of the analysis	Surveys	Semi structured interviews	Observation/Participatory observation	Focus groups	Naturally occurring data
Article I	Reports the sustainability effects of 215 existing homeservices in six European countries by using the service analysis framework developed in the Sustainable Homeservices project.	Survey for residents and tenants in owner occupied and rental housing. Questions related on a) the housing and family situation, b) the residents interest in sustainable homeservices and c) what homeservices they would like to use? Altogether the number of respondents was 333 in six European countries	25 service provider, housing organization and local government representatives in Finland, altogether X interviews in six countries.	In order to better understand how ordinary residents can operate as energy experts (one good sustainable household service example from Finland) the energy expert training in Helsinki was observed.	Topic: What services ideas would be most desirable and acceptable for the residents? The group had five participants from both rental and owner occupied housing.
Article II	Studies material efficiency services as an eco-efficient solution at the B-to-B markets. It introduces a conceptual framework for the analysis of business models for eco-efficient services and applies the framework to material efficiency services. In conclusion four business models are outlined and their feasibility is studied.	N/A	Interviews focusing on the acceptability, feasibility and market potential of MASCO business model. Interviews included 17 service providers, 33 customer organizations, 3 financing and 7 government organizations' representatives.	Topic: How the MASCO - model would work in paper and pulp, beverage and food processing industries. Participants from these industries.	Included local government, national and EU statistical material on environmental, social issues, housing and the service sector development. Data also included web sites, brochures, annual reports, etc. provided by companies offering household services.
Article III	Examines chemical and resource management services as one of the few successful business concepts for material efficiency services. In it a typology of five service approaches in to material efficiency services is constructed.	Survey for both member companies of The Association of Environmental Enterprises and The Association of Chemical Traders. Number of respondents was 18.	Interviews focusing on a) the ways chemicals are used in the heavy duty vehicles maintenance and repairs, b) in what way the chemicals waste management operates and c) what could be improved and in what way chemical management services could be used. All together 38 interviews were carried out with representatives from the Finnish State Railways, Finnish Defence Forces and chemical service companies in Finland and internationally, including staff members of the Chemical Strategies Partnership.	Two day observation period at the Finnish Defence Forces, Parola depot. Topic: How chemicals are used in maintenance and repair shops for heavy duty vehicles, what types of services are used. Four day participatory observation period at Finnish State Railway, Helsinki Depot together with the aWärth Finland Oy Safety@Work business unit team. Topic: How chemicals audit is performed and how maintenance and repair chemicals are used in rail transportation?	Public material provided via internet, annual reports, and newspaper and magazine articles concerning 39 chemical management service companies. Data included also confidential material on service contracts of a waste management company.
Article IV	Investigates what kinds of eco-efficient services customers need and under what conditions (barriers and incentives) would use them.	Survey was carried out to broaden the understanding of service needs and incentives and barriers for using them. The industries surveyed represented the same industries that the interview respondents represented. All together the survey had 294 respondents.	Interviews focusing the service needs and incentives and barriers for using advanced material efficiency services. 31 interviewees representing companies from industry, wholesale and retail, construction, logistics and forwarding.	Topic: How to organize the service throughout the wholesale-retail supply chain. Six participants from packing industry, wholesale and retail and waste management. Seven representatives from technology industry. Topic: The use of services in Technology industry.	N/A

The data collection methods included surveys, semi-structured interviews, focus groups, and participatory observation. Surveys were used to acquire a broader understanding of eco-efficient services in the context of the project: In the Sustainable Homeservice project and in Masco 3 the surveys were used to obtain information on the service needs. Secondly in the Masco 2 project the survey aimed at finding out how common or uncommon the chemical and resource management services were on markets at the industry level (environmental management and technical trading and wholesale) and what future expectations the respondents had. The surveys were analyzed with mainly by means of descriptive statistical analysis for understanding the temporal patterns (Langley 1999), i.e. the presence or the absence of service offer (articles II and III) and customer needs (articles I and IV) on the market.

In all these projects, the research, interview and the focus group themes were guided by the previous literature and research findings. Both interviews and focus groups were semi-structured in that they sought to find answers to questions and to fill in research gaps defined by the researchers. However, during the interviews and focus-group discussions there was room for interviewees and participants to voice their own thoughts, ideas and experiences concerning services, eco-efficiency and sustainability. Both content analysis and thematic analysis (Attride-Stirling 2001, Thomas 2003) was used to analyze the interview, focus group and naturally occurring data. Meanings in the data (text) are constructed in a particular context (in this research in the context of eco-efficient or material efficiency services) and the categories created through the analysis emerge from the text though previous empirical research and existing theory provides ideas for research questions. Analysis is seen as an interactive, back and forth, process and it has to locate the meaning of data in the context and other texts concerning the studied subject. (Hardy, Harley and Phillips 2004)

More participatory and engaging (van den Ven 2007) methods were applied to understand the services better from the service providers' and customers' perspective and to give room for their own experience on the subject. Engagement here refers to ideas that 1) scientific and practical knowledge can benefit each other and 2) that researchers and practitioners negotiate and collaborate as a learning community (van den Ven 2007). Figure 6 illustrates the wide-ranging use of the method

3. Empirical work

for obtaining diverse and complementing knowledge during the research.

In this study the applied methods were understood as complimentary, providing a more thorough picture of the phenomenon from a diverse set of perspectives (Sale et al. 2002, Greene 2006, Denscombe 2008). Each method provides data on particular aspects of the eco-efficient and sustainable services and in this way, adds to a more comprehensive understanding of the subject. Compared to more traditional views of triangulation, the qualitative and quantitative methods were not used only for methodological triangulation, i.e. results accrued with one type of method were not used to validate results obtained with the use of another method (Tashakkori and Teddlie 2003, Cresswell 2008). Interview findings were nevertheless used as a way to develop questions for survey in article IV.

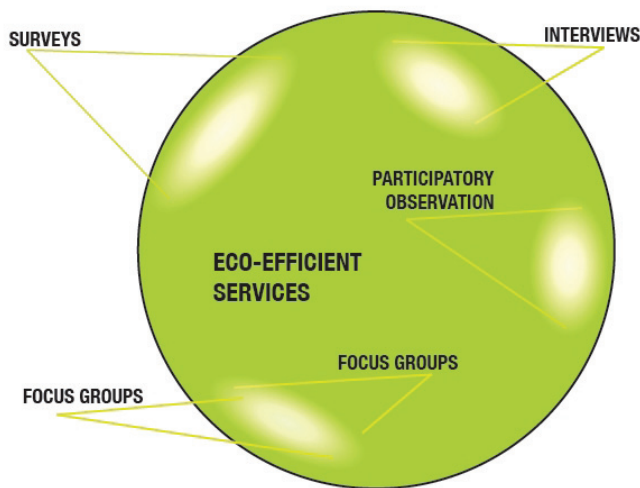


Figure 6: The use of qualitative and quantitative methods aimed at producing diverse sets of perspectives on the eco-efficient services

In the following data vignette one of these more engaging and participatory research experiences is described in some detail to demonstrate how this part of the research contributed to articles through wider understanding of the material efficiency services in practice.

Data Vignette:

The example is a chemical audit carried out during the material flow management project reported in article II. During the project we applied both qualitative (interviews, focus groups and observation) and quantitative (survey) methods in order to study and understand chemical management and other material flow management services in their practical context.

After this desk oriented literature review phase and interviews a more participatory chemicals audit was organized at the Finnish State Railway Helsinki Depot. In the context of chemicals management services the aim of an audit is to find out how chemicals are used in the customer company, in what way the chemicals usage could consolidate and make it more efficient. One important task was also to find out what chemicals could be substituted with more safe ones from the occupational and environmental safety perspective. The main focus of the audit is to make both safety and cost benefits concrete.

The Helsinki depot is by any standards a sizeable operation. It maintains the majority of the long distance trains and the electric engines. At the time of the analysis the personnel were around 800, 250 of whom worked in the maintenance and repairs. The company doing the actual audit was Safety@Work -unit of Würth Finland Ltd. This unit specializes in chemical management services. The aim of the audit was to study the chemicals usage the depot and in same time to analyze the CM service by Safety@Work in order to understand better these types of services in practice.

Organizing the audit included several stages with interviews and planning meetings together with the Safety@Work -unit and the managers of the different production lines (engine halls, coach maintenance, etc.). Before the audit for example, me and my colleague along with the Safety@work staff had to participate in safety training organized by the occupational safety unit of the depot.

The audit lasted two days; during this time we followed the auditors and observed them in a *go-along* (Kusenbach, 2003) fashion their work (picture 1). We also interviewed and talked informally with the staff about the practices of using chemicals and the practices of providing the audit and other CM services. We asked the staff what they thought functioned well in terms of chemical management and what could and should be done differently, and what the role of chemical management services was and ought to be. We put the same questions to the auditors in relation to their work and practices.

3. Empirical work

Afterwards two workshops were held; one with the safety@work staff and another one with the Helsinki depot personnel. The purpose of these workshops was to reflect on what insights and practical improvement potential were observed during the audit

The audit was a threefold learning-by-doing process. Looking at eco-efficient services and particularly chemical management services from the researcher's perspective, we learned a lot about the audits and chemicals usage from the professionals who were interested in developing their own work. We tried to learn from the participants in order to be able to give feedback based on our knowledge gained through conducting more conventional studies (interviews, group discussions and surveys) and in the previous MASCO 1 project.

An essential feature of the audit was that it gave us practical knowledge about chemical management services and their potential for environmental and economic benefits compared to merely reading about them from the literature. Although the focus of the project was studying the business models, it was useful to understand a tad more about the use of support chemicals in metals working and vehicles maintenance.

Academic dissertations are also about learning to be a scholar and of learning to do research. This part of the project gave me a large amount of knowledge on participant observation, writing field notes and how to approach participants in an appreciative way: The participants knew their work best: consequently they were able to contribute substantially to the MASCO 2. Working together with a senior colleague also enabled me to reflect on my work and skills. Participants helped us to improve our own approach and the quality of the fieldwork.

3.2.2 Pragmatic approach to research

The previous paragraphs on research design and methods together with the research questions presented in chapter 1 show that the interest of knowledge has been pragmatic and thus focused on solving the research problems by using pluralistic approaches to deriving knowledge of the problem at hand (Patton 1990, Creswell 2008): in all the articles, we have studied eco-efficient services as a potential route to sustainable development. One aim of the studies has also been to facilitate the development of eco-efficient services. In other words, this research aims to increase knowledge of eco-efficient services in order to facilitate action: empirical, scientific knowledge on eco-efficient services that could help promote understanding and develop of both

existing and new services and to advance academic research in the field of sustainable development.

The practical and open theoretical discussions on the topics of eco-efficiency, decoupling and service orientation facilitated this pragmatic approach. Sustainable development and eco-efficient services can be defined as a theoretical lens or perspective (Cresswell 2008, 62), which provided the overall direction for the study.



Picture: My colleague Mika Kuisma observing Petri Koskenniemi from Würth's Safety@Work unit doing the chemicals audit at the VR Helsinki Depot (September 19th 2007)

Also the project research context in which the articles were written steered the research towards a more pragmatic orientation. All four articles are based on research done in pragmatic research projects aiming to foster understanding of the development and potential of eco-efficient services. The project context directed the research themes towards applied research, which traditionally has been defined as research that produces results applicable to the practitioners such as public or private organizations or political decision making. Despite this perspective, the research was not limited by this point of view and was able to formulate interesting research themes for researchers and practitioners alike. In conclusion, the project framework still enabled us to do engaged academic research (van den Ven 2007).

4. Key findings and contribution of articles

This dissertation studies why and how existing eco-efficient services have developed, what types of services they are and what reasons there might be for their success. It consists of four articles, each of which examines the phenomenon from a different perspective. Article I analyzes at 215 existing eco-efficient or sustainability enhancing services in six European countries and analyzes their ecological, social and economic sustainability aspects. Article two develops and identifies four potential business models for material efficient services. These services are less studied compared to energy efficiency services such as ESCO. Article three studies in detail one of the business models identified in article one, namely the material flow management model through empirical analysis of 33 existing business-to-business (B-to-B) services within the chemical management services (CMS) industries and advanced waste avoidance services or resource management services. Article four asks whether there is demand for different types of material efficiency services and examines what issues have an effect on the demand of these material efficiency services as a barrier or driver.

Article I is based on empirical research carried out in the project called '*Home services: Benchmarking Sustainable Services for the City of Tomorrow*', funded by the European Commission Research Directorate-General (H). The project aimed to study the existence of sustainable home services, their market and sustainability potential in six European countries (Austria, Finland, Germany, The Netherlands, Portugal and Spain). The basic idea behind the Sustainable Homeservices project was the notion that the environmental burden of households could be reduced and their quality of life enhanced by services that cater directly to them and are conveniently located (Behrent et al. 2001). The main goal of the project was to stimulate the introduction of sustainable Homeservices on European housing markets.

4. Key findings and contribution of articles

Articles II and III and IV are based on a series of MASCO -projects (**MA**terial **S**ervice **CO**mpany MASCO 1-3). These projects were funded by the Finnish Funding Agency for Technology and Innovation TEKES and participating companies. First one of the projects, MASCO 1 aimed to analyze the possibilities and potential of contextualizing the ESCO (Energy Service Company) - energy efficiency business model into materials efficiency business model as well from both the organizational and financial perspectives alike. It was carried out jointly with the University of Helsinki, department of biosciences.

4.1 Article I: Sustainable services in the household context

The analyzed services in this article are defined as sustainable homeservices indicating that they are delivered directly to the customers' homes, and that they enhance sustainable development. Previous research (Behrent et al. 2003) had shown that people were more willing to use services that are available relatively close to their homes; for that reason, this study focused on services that were offered either directly to homes or in their immediate surroundings.

Another starting point for this study was that the social dimension of sustainable development had been somewhat neglected in eco-efficient service research. Most of the research had concentrated on the ecological dimension of sustainable development. Previous research also had focused more on analyzing the service concepts at system level than studying actual services in their operational context (Halme et al. 2006). The analysis covered seven areas of services directed to households, these categories were:

1. Consulting and information (variety of services that provide counseling or information on environmental and social issues, energy use, waste, financial issue, etc.)
2. Care and supervision (services directed to care of people, building or apartment maintenance, etc.)
3. Leisure services (facilitating social interaction, culture, sports, etc.)
4. Maintenance and repairs (tool rental, workshop space for DIY repairs, repair services, etc.)
5. Mobility and delivery (vehicle rental and sharing, delivery, etc.)
6. Safety and security (apartment, building or personal safety, etc.)

4. Key findings and contribution of articles

- 7. Supply and disposal (services pertaining to energy and water supply and waste management, recycling, etc.)

4.1.1 Findings

The services were evaluated with a simple yet systematic qualitative indicator framework, with which the ecological, social and economic aspects of sustainable development could be taken equally into account. The framework contributes to eco-efficient service research by offering a tentative means to assess the sustainability effects of services offered to households. It enables us to compare the no-service alternative with a situation in which an eco-efficient service is available. When the research was conducted there were no tools for measuring sustainability effects of the services, so defining a set of such criteria was an important contribution to the research. Tables 3 and 4 illustrate the structure and scaling of the sustainability indicator framework.

Table 3: Indicator set for the evaluation of the sustainable homeservices

Environmental aspects	Social aspects	Economic aspects
1 Material use	1 Equity	1 Employment
2 Energy use	2 Health	2 Financial situation of the residents
3 Water use	3 Safety and security	3 Regional product and service use
4 Waste	4 Comfort	4 Profitability to the company
5 Space use	5 Social contacts	5 Profitability to the region/community
6 Emissions	6 Empowerment	
	7 Information and awareness	

Table 4: Scaling of the indicators for the evaluation of the sustainable homeservices

Operationalization of sustainability indicators						
Energy use (environmental)						
The effect of the service on material use compared to the status quo (= situation without the service)						
Increases energy use	-2	-1	0	1	2	Decreases energy use
Empowerment (social)						
The effect of the service on residents' ability to influence decision making that affects them						
Decreases ability to influence	-2	-1	0	1	2	Increases ability to influence
Employment (economic)						
The effect of the service on employment						
Less jobs/job opportunities lost	-2	-1	0	1	2	More jobs are created
Example of one indicator in each sustainability dimension. 2: A major positive change, 1: a substantial positive change; 0: the service does not change the status quo; -1: substantial negative change; -2: a major negative change.						

The findings show that the overall social impacts of the assessed services are higher than their environmental and economic benefits. It can be argued that sustainable homeservices improve the quality of life of the customers (households) in general. This is presumably partly due to the fact that in order to survive on the market, household services must first and foremost be socially beneficial to the customers and to improve their quality of life. An interesting finding was that the analyzed services with an ecological sustainability starting point also seem to fulfill needs on a social sustainability dimension (e.g. car sharing, repair & recycling services for household appliances, etc.).

Since the analyzed services were real-life examples instead of prototypes or hypothetical service concepts, the findings strongly suggest that if services are to be successful on the markets they need to contribute to the quality of life of the customers.

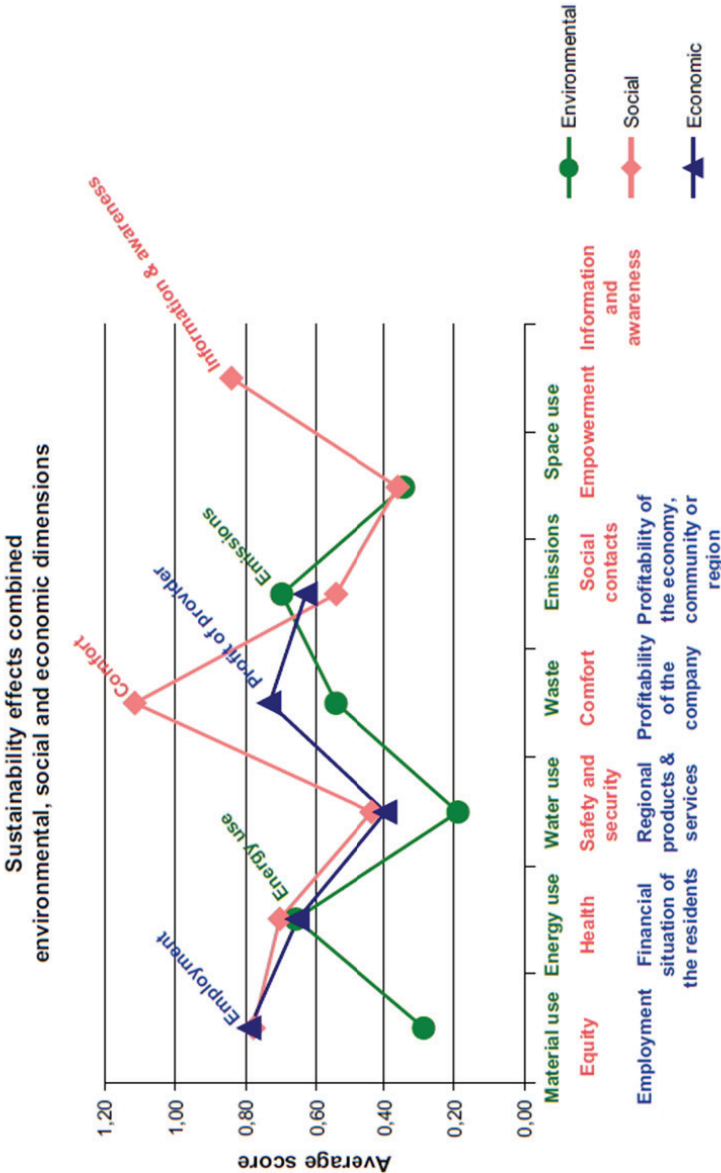


Figure 7: The relative sustainability scores of the evaluated homeservices

The study also shows that service providers, such as housing organizations, can achieve long-term profits and better sustainability outcomes from eco-efficient services if they focus on the system level optimization instead of looking for short-term profit of a single service. The empirical data illustrates that some (rental) housing organizations had realized that home services increase housing satisfaction and perhaps attachment to the surroundings and through that reduces negligence, vandalism and volatility of the tenants.

As stated above, the homeservices contributed most to social sustainability. From an ecological perspective, the largest contributions were created through energy efficiency improvements and emissions reduction. Contrary to general assumption, this study implies that eco-efficient household services do not decrease material use, i.e. they do not increase the material efficiency of the consumption. This indicates that in order to enhance material efficiency through services, those who are responsible for designing them should consider eco-efficiency even at the earliest stages of service development.

4.1.2 Contribution

This article contributes to the discussion on eco-efficient service by providing a tentative framework and a starting point for evaluating and analyzing the sustainability impacts of services directed to the households. The framework for analyzing the sustainability effects is also simple enough for practitioners to use for evaluating both existing and new services. The simplicity of the framework remains important because a vast majority of the companies providing services for households are small or medium size companies, if not micro companies. For example, in the year 2008 in the EU-27 area, 91.1 per cent of service providers in the accommodation and food services were micro enterprises and 8.7 percent were in the category “small” (EUSTAT 2011). It remains to be seen how this or a similar type of framework could be applied to business-to-business services and which industries would benefit most for using it.

The findings, then, strongly suggest that in order to be successful in the market place the service (whether concentrating on ecological sustainability or not) needs to take social sustainability into account. From an ecological sustainability perspective, the sustainable homeservices may enhance energy efficiency, but their impact of the sustainable household on material use seems controversial.

4.2 Article II: Conceptualizing business models for material efficiency services

This article examines result-oriented material efficiency services provided by outsourced suppliers and develops a business model framework for analyzing them. Based on the framework the article outlines four business models for material efficiency services and explores their market feasibility.

When this article was written, systematic analysis of eco-efficient services from a business perspective was scarce. The previous research had focused mainly on the technical design of the eco-efficient services (Bleischwitz, 2003) and this seems to remain the present day situation. The business model concept is widely used in eco-efficient service discussions, but its definition has frequently been insufficient. This article proposes a simple conceptual framework for analyzing the business models of the eco-efficient services. The model is based on the works of Normann and Ramirez (1994), Räsänen (2001) and Magretta (2002). The framework looks at the market viability of the services from the following perspectives:

- What benefits can users or customers derive from the service in question, compared to more traditional ways and means of fulfilling their needs i.e. added value to the customer?
- What kind of competitive advantage does the sustainable or eco-efficient service offer (for the customer), i.e. what are the strengths of service in relation to competitive alternatives?
- What capabilities and other resources does the provider or a network of providers have?
- How the service is financed and the income flow created?

4.2.1 Findings

The four business models outlined for the material- efficiency services are:

- The Masco model
- Material efficiency as additional service
- Material flow management service
- Material consultancy service.

Three out of the four above-outlined business models are new and different from business-as-usual models. The fourth - the consultancy service - does not differ from most consultancy business; therefore the findings concentrate on the first three models. The Masco model and

4. Key findings and contribution of articles

material efficiency as additional service are investment-based models, in which the enterprise specializing in material efficiency makes a material saving investment in the customer company and is compensated according to savings achieved. The provider manages the project from the financing to implementation throughout the investment period. In the Masco model, the service provider focuses its business operations solely on Masco-projects similar to ESCO projects. The additional service model is essentially the same, but the service supplier has an existing relationship with the customer to whom they offer the Masco service in addition to the existing services. Typically, they can be providers of industrial equipment, maintenance services or waste management. The following table 5 summarizes the four aspects of the framework for each of the three new business models.

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Table 5: Summary of business models for material efficiency services

Summary of business models for material efficiency services (the consultancy model is excluded, because it represents an ordinary consulting model)

	MASCO	Material efficiency as additional service	Management service for material flows
How does the customer benefit from the service?	Does not tie up client's funds or [operational] resources (e.g. time of personnel)	Does not tie up client's funds or [operational] resources	Outsourcing non-core-operations to a specialist firm
What is the competitive advantage of the service?	Financing model: customer pays only for results, cost efficiency	Existing contact between provider and customer trust and low transaction costs	More efficient organization of operations
What capabilities does the service provider need?	Arranging financing, finding suitable know-how (subcontractors), finding customers on regular basis	Knowledge of client's processes or part of them, e.g. waste management or maintenance of machinery	Profound knowledge of a material/s and its processing
How the service is financed (income flow)?	From the savings gained from the material efficiency investment	From the savings gained from the investment, but client simultaneously pays fees for other services	Charges are based on results instead of paying for material amounts
What kinds of instances is the model suited for?	Large, turn-key projects	Material efficiency improvements that complement the provider's service (equipment provider, waste mgmt. company, maintenance provider)	Long-term strategic partnerships, e.g. chemical management service

4.2.2 Contribution

Firstly, this article contributes to the eco-efficient service discussion by defining a simple yet systematic concept for analyzing the business models of existing eco-efficient services. This approach enables both researchers and practitioners to study and develop business models for new eco-efficient services.

Secondly, the article contributes to the eco-efficient service discussion by analyzing the market feasibility of the outlined business models. One of the most important prerequisites for economic feasibility of the services is their scalability to a large group of customers, i.e. they have to be technically easy enough to provide with little variation across multiple customers and facilities. The willingness of potential clients to use these types of services seems to depend on their size and solidity.

4.3 Article III: Real-life material efficiency services in detail

This third article focuses on existing services using the material flow management business model, namely chemical management services and resource management services. The material flow management model is one of the four business models for material efficiency services outlined in the previous article II. Although services and product-service systems have been promoted as a promising means towards a more eco-efficient and sustainable society, they have not become reality as expected. Chemical and resource management services are among the few exceptions. Generally, they aim to align the service provider's and customer's actions to a) reduce chemical usage and waste, b) improve supply chain management and c) increase resource efficiency. This in turn creates cost savings for the customer. Arguably, these types of services also create new business opportunities and higher profit margins for the service providers, compared to merely selling chemicals or handling industrial waste.

4.3.1 Findings

The chemical and resource management services have been viewed more or less as a single business model with a new type of shared savings business logic. As identified in the previous research (White et al. 1999, Bierma and Waterstraat 2000, Mont 2004, Mont, Singhal and Fadeeva 2006) the focal change of business logic is the move from selling products into selling solutions, i.e. changing the business operations to result-oriented services. The compensation of the service provider is based on how well it fulfills the promised results and savings.

This study argues that chemical and resource management services operate with contextualized, yet overlapping business models. These models can be presented as five ideal types:

1. Streamlining supply-chain from *upstream*
2. *In-house*: managing chemicals in customer's manufacturing processes
3. *IT-focused*: includes services based solely on different ICT solutions
4. *Integral* or full service approach
5. *Entering from the downstream* - improved waste avoidance and recycling services

4. Key findings and contribution of articles

Starting from the upstream supply chain, the first service profile concentrates on the customer's inbound supply management. Services in this group include such tasks as sourcing, centralized procurement of chemicals and other materials, warehousing and inventory management and JIT (Just In Time) deliveries, which include varied supply-chain management services. The second, in-house profile focuses on managing support chemicals such as coolants or cutting fluids in the customers manufacturing processes.

The third, integral or full service model combines chemical management and waste management in order to streamline the customers' processes starting from downstream or by wrapping the customer with inbound and outbound supply management. It seems to be a profile for large companies that are able to offer all the services either by themselves or through subsidiaries and different business units.

The third, IT-focused profile, is structured around safety and supply of chemicals usage via technological and software applications, just like any similar enterprise resource planning and management or environment, health and safety (EH&S) solutions. In this profile, the services seem to concentrate more on M/SDS (material/safety data sheets) management, legal compliance issues and reporting than on the inbound supply management or other profiles.

The fifth, resource management entering from downstream model differs from chemical management in terms of the industry applying it. In this profile, the basis of this is the changing business logic of the waste management companies from waste hauling, disposal, incineration or recycling to the avoidance of waste. This is done by consulting and offering solutions for customers' manufacturing and purchasing processes in order to avoid hazardous and other waste.

Each model has its particular organizational features and competences, which can concentrate on vendor and relationship management, for example, or on the management of the manufacturing process or parts of it. Central to the findings is that all these business models combine aspects of technological and organizational innovation as defined by Rennings (2000). From a technological perspective, they include both process and product innovations such as the use of new information technologies, such as radio frequency identification (RFID). Third party logistics services and new type of shared savings/benefits

4. Key findings and contribution of articles

contracts represent process and organizational and management innovations in chemical and resource management services.

The findings also show that most of the services were not originally designed with eco-efficiency in mind. They are based on new supply-chain management development, such as third party logistics and ICT. Interesting exceptions are the BASF Success, SafeChem and AGA Sisource. Their emphasis on sustainable development seems to present a marked contrast to their North American competitors.

Even though certain services can be bundled under a profile forming a logical category of its own, there are services that are common throughout the five service profiles. These are services without which the service providers cannot carry out their promises to customers. One category includes enabling and specifying services such as audits, which aim to find out what chemicals or materials are used, in what quantities and in which ways. This is a prerequisite for the service provider to understand the cost structure of the material in question. Similar kinds of enabling service are consultative and training services.

The second type of service could be called content services. For example, due to the nature of chemicals, EH&S is something of a core element in all chemical and hazardous material use. The aim of CMS and RMS is to reduce the risks related to chemicals and the hazardous waste created by their use. Thus, a crucial element in these services is the establishment and management of usable and accurate MSDS (material safety data sheet) databases as part of the overall environmental health and safety issue management. Advanced ICT solutions (software, monitoring, logistics control, etc.) are a key elements in all chemical and material efficiency service models analyzed. The following table (Table 6) summarizes these common service elements.

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Table 6: Common elements for analyzed material efficiency services

Service Element	Individual Services
Enabling and specifying services	Chemical/material audits, consultation and training
Content services	Organization of waste anagement, environmental, health and Safety (EH&S) management, various reporting services
Technological support	ICT solutions for MSDS, ordering, purchasing, etc.

4.3.2 Contribution

This article contributes to eco-efficient service literature by showing that

- Business innovations that do not derive from eco-efficiency thinking can create eco-efficiency and turn into eco-efficient services.
- Chemical management services stem from business innovations such as supply-chain management or ICT.
- Chemical and resource management services do not constitute a single result-oriented service model even though both have undergone similar changes in business logic, e.g. from selling products to selling results and shared savings/benefits.
- Each model concentrates on services at different phase in the supply-chain or value network. This in turn has an effect on the customer value creation, revenue model, technological and organizational competences in the particular business model.
- These services also have common elements, that enable the service provision such as (for example EH&S, ICT-solutions and data management)
- The article also shows that these services are combinations of technological (ICT) and organizational or management innovations. New technology has an important role as an enabler of the new services, but even more essential is the reorganization of service production, liabilities and goals of the service.

The results indicate that business innovations and existing service models could be a viable source for eco-efficient service development and eco-innovation in many ways. New, radical technological

innovations could be integrated in existing business models or models or another way round.

4.4 Article IV: Is there demand for material efficiency services?

As suggested in Article I, there may be a mismatch between the supply and demand of business-to-business material-efficient or more broadly eco-efficient services. While the focus of articles II and III was the supply side and the business models of eco-efficient B2B services, they also hinted at the significance of the demand side. This fourth article in turn focuses on examining the demand side of the material efficiency services in the business-to-business context, whilst the two previous articles concentrated more on the supply side and the business models. This article discusses the issues that affect the demand for innovative material efficiency services. Previous literature has identified the following four major factors involved in the demand of the material efficiency services:

- The size of the potential customer has a strong impact on the demand. Larger companies tend to have a better understanding of eco-efficiency and compliance issues and they may also have a better understanding of the possibilities of using innovative services (Halme et al. 2007).
- Expected cost savings strongly affect the success of the eco-efficient services in B2B context (Halme et al. 2007).
- Trust between the customer and supplier is vital because these types of advanced services require a closer relationship between the client and the supplier (Kortman et al. 2008, Mont, Singhal and Fadeeva 2006)
- The customer's outsourcing strategies define also the use of innovative material efficiency services (Kortman et al. 2008)

4.4.1 Findings

This study confirms the above-mentioned prerequisites for successful eco-efficient service business. More importantly, it contributes to the eco-efficient service discussion by demonstrating empirically that the customer industry has a strong effect on the perceived potential of eco-efficient or particularly material efficient services. At the company or even facility/outlet level, the customer organizations' understanding of material efficiency is a key element in determining demand for material efficiency services. This understanding varies greatly between the industries analyzed. Manufacturing industries have a relatively good understanding concerning material efficiency. And the companies

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in these industries also feel that they are better equipped to improve material efficiency in their manufacturing processes than outside service providers. Instead they believe that outside service providers can best develop side stream management and through that reuse and recycling of side stream materials.

Previous experience and knowledge about outsourcing also have an effect on willingness to use innovative services. According to the study, companies that had more knowledge and more positive experiences of outsourcing had a more positive attitude towards purchasing material-efficiency services. From the service provider's perspective, selling and operating innovative material-efficient services calls for industry-specific competences (materials, manufacturing processes, supply-chain management, technology, etc.). This in turn limits the range of the industries within which one company can feasibly operate in.

Another hindrance for the growth and development of these types of services on the markets seems to be the lack of active marketing and sales. Only very few interviewees and survey respondents reported, that they had been actively approached by providers offering material efficiency services. Successful offering of material efficiency services requires not only active marketing and selling but service providers also have to be able to demonstrate clearly the benefits their services create and the processes that generate the benefits. The following figure (Figure 8) shows the contribution of this study to the eco-efficient service discussion and research.

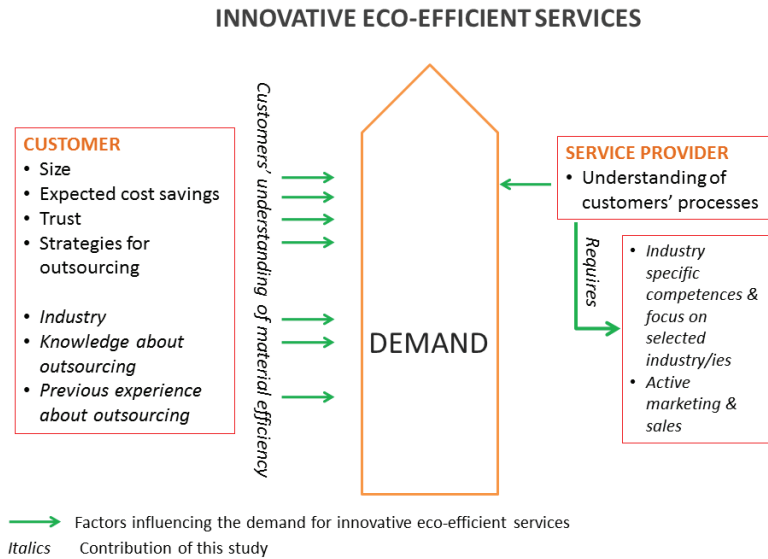


Figure 8: A comprehensive set of factors influencing the demand of innovative B2B eco-efficient services

4.4.2 Contribution

The findings of this article contribute to the eco-efficient service research by providing deeper understanding of the issues that influence the demand of advanced material-efficiency or eco-efficient services. The study shows that the industry involved, the customer's knowledge and previous experiences of outsourcing have a clear impact on the demand. The way in which the customer organization understands the concept of material efficiency also affects demand as indicated in the above figure 8.

The service providers could increase demand and the market success of their services by focusing on a few core industries whose specific customer needs and still be able to scale up their services for market feasibility. The service providers could also be more active in their marketing and sales operations and provide more concrete reference cases and examples of the material-efficiency and economic gains that their services may accrue for the customer.

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This part draws together the key themes through the articles. Though each article investigates eco-efficient services from a different perspective, the findings form several common themes that contribute to the theoretical discussion and the development of eco-efficient services. This part starts by outlining the contribution of the articles to the eco-efficient services research. It then discusses their contributions for practitioners developing eco-efficient services. Thereafter, it reflects the market development and the future of service development. Finally, the epilogue reflects on the research process and presents some directions for future research.

5.1 Services need strong connection to customers' everyday life and business

Perhaps the most important conclusion of this study is that, for an eco-efficient service to be successful, it needs to be able to solve problems that customers face in their everyday environment, whether in the sphere of private households (article I) or the day-to-day operations of a business organization (article IV). For the service provider this calls for a proper understanding of the customers' needs and challenges to be overcome by using eco-efficient services or services that enhance social sustainability in conjunction with the ecological one. An important characteristic of successful eco-efficient services offered to households seems to be that they enhance comfort of everyday life. The concept of comfort here means that the customers are able to live well and for example overcome difficulties of organizing everyday life, such as the burden of mobility or poor indoor climate. Besides car sharing, different carpooling services, such as Greenriders⁵ enable households and companies flexible travel. Another example of combining ecological and social sustainability is household appliances repair and recycling organization R.U.Z.T. from Austria. It offers employment on

⁵ Greenriders is a web-based solution for consumers and companies alike to organize carpooling for work and leisure travel. (www.greenriders.fi/)

social grounds, repairs household appliances and sells them to customers at a considerably lower price compared to the cost of new ones (Halme et al. 2004 and 2005). Together with adding to the comfort of everyday life, another important characteristic of successful services was that they enhanced customers' skills or empowered them in their everyday life by giving them a chance to participate in decision-making concerning their housing, for example.

In the B2B sector the expressed customer needs (article IV) include concerns such as acquiring relevant knowledge about material flows and their management (inbound and return logistics) of resources and finding ways of increasing recycling and waste avoidance. Resource management services seek to meet these concerns through enhanced recycling or with zero waste approaches. Judging by these findings, there seems to be quite a gap between practical needs and the suggestions made by radical eco- and sustainable innovation researchers. Another obvious challenge for future research is to find ways to combine practical business needs with radical innovations that reduce material and energy consumption at least by factor four or more.

It is worth noting that the topic of social sustainability rarely came up in the B2B interviews carried out during the MASCO projects even though the question was put to the interviewees. Perhaps the B2B markets and especially the manufacturing industries see social sustainability as a separate domain from manufacturing and other core processes. Social sustainability may well be seen as something that belongs to the domain of corporate social responsibility whereas material and eco-efficiency are perceived as an integral part of production or manufacturing processes. It would be interesting to look at whether eco-efficient services and social aspects of sustainable development are possible and even desirable to integrate both from sustainable development and feasible business perspectives. BASF Success and SafeChem service examples suggest that it might be possible and even viable from a business point of view. However, this needs to be studied systematically in order to say something conclusive about it.

5.2 Varied sources for eco-efficient service models

Article III clearly shows that the thinking behind existing chemical management services has not arisen from eco-efficiency or eco-innovation ideas or from purely ecological concerns. Rather, they are based on other business innovations such as new logistics services and ICT. Therefore, it seems that eco-efficient services, eco- and

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sustainable service innovation researchers and practitioners alike could benefit from dialogue with other areas of business innovations such as the supply-chain and operations management. The development ICT has played and continues to play a central role in chemical and resource management services and their development. Recent international environmental legislation such as REACH (Registration, Evaluation and Assessment of Chemicals) in the European Union and similar chemical legislation around the globe increases demand for reliable and usable data on chemicals in products and industrial processes.

It is important to keep in mind that all these service companies have also changed their business logic and, through that, their business models. They are not merely selling products or hauling waste, but offering results such as the smooth running of the manufacturing process in terms of chemicals management wise or waste reduction. The logic, then, has changed from selling more and more products or hauling and handling more waste. Chemical management services are clearly result-oriented even though products remain at the heart of the service model, resource management aiming at waste avoidance and reduction is clearly a result-oriented service. In addition to technological innovation, chemical and resource management services also involve organizational innovations and changes - value creation is in many cases a co-creation process (Norman and Ramirez 1994) as is value capturing through shared savings contracts, in which the service provider and customer share the cost savings or profits in a way defined in the contract (Bierma and Waterstraat 2000, Corbett and DeCroix 2001, Stoughton and Votta 2003). Shared savings or profits are not the most common form of business contracting. This could change, however, if the wishes expressed by the respondents in article IV become reality: according to the survey and the interviews, the shared savings contracts were considered the most appealing alternative in the future.

ICT also played an important role in providing market access and use of the services in the household sector. Intermediary internet platforms offer a channel for small service companies to market their services and to cooperate with other service providers. Similarly, organizational innovations or changes have an important role to play in the household sector through the co-production of services, i.e. the ways in which housing organizations, commercial and non-profit

service providers form new service offerings in the context of housing and households.

5.3 Contextualized business models

Previous research on eco-efficient services discusses product-service systems as a single (conceptual) business model. The rhetoric of chemical and resource management services has also tended to frame these services more or less as a single business model. The findings of the present articles demonstrate, however, that existing eco-efficient services vary according to their place and role in the supply chain or networks and this in turn has an effect on the revenue logic. This means that there is no single business model for existing material efficiency services. Instead, their business models are contextualized and should not be viewed as a single service or business model.

Chemical management services (Article III) operate in several industries and count even local governments and national defense forces among their customers. Service providers also offer their services at different stages of the supply chain. Some companies focus more on inbound chemical purchasing and delivery, whereas others operate at the level of customers, manufacturing process or provide ICT solutions. Some of the largest companies, such as BASF, provide services throughout the supply-chain. The service provider's place in the supply chain also has an effect on the business model (its competitive advantage for the customer, the capabilities, technologies and the revenue models needed).

Although the sustainable homeservices project did not study the business models as such, the findings indicate that the context of providing sustainable household services (services directly offered to households, in partnership with other companies or public organizations, by commercial or social enterprises, etc.) has a clear impact on the revenue logic, the skills and the investments needed and the way in which value for the customers is realized. This is something that calls for further research, however.

It is essential to ask how social and ecological sustainability should be more closely interlinked within the same service or group of services in the household and consumer sector. As with the B2B services, it might prove useful to analyze how eco-efficiency or other ecological sustainability aspects could be incorporated into existing and new services with a strong social sustainability dimension (e.g. BASF

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Success services) and whether new eco-efficiency innovations and eco-efficient services could contribute to social sustainability.

5.4 The market development and the future of the eco-efficient services

When our first study on eco-efficient services (Sustainable homeservices) was started in 2002, the idea of material efficiency services and eco-efficient services was in a nascent phase. Empirical research was scarce compared to conceptual studies. In the business world the idea was new and not well understood. Unfortunately, the situation has not changed dramatically since then. On the Finnish markets the same service providers who were operational during the research process are still the main operators. Kemira Industrial Environmental Services (KIES) has been changed into a subsidiary of Kemira and renamed Kemira Operon. At the moment, its market focus is at the moment in Finland, with services targeted at municipal and industrial waste water and sludge management. According a recent Nordic study (FORA and COWI 2010), services offered by Operon have clear positive eco-efficiency impacts. One Finnish chemicals supplier offers chemical management services concentrating on inbound chemical logistics, but there are few other examples of chemical management services with eco-efficiency or environmental aspects on the market. One of the international chemical management service providers has withdrawn from the Finnish markets, although it seems to offer its services successfully in other Nordic countries.

One reason for this slow market development in Finland might be the relatively small size of the industrial market in Finland. Earlier studies on chemical management services have revealed that chemical purchasing should be about a million euros or more for the services to be profitable for the customer organization (Bierma and Waterstraat 2004, CSP 2004, Kortman 2008). The development of services for SME markets and provided by SME-companies needs to be designed differently compared to the services offered by and targeted at large industries (Bierma and Waterstraat 2004). One possibility to find markets would be service exports, which requires resources that smaller companies seldom have.

Since the majority of the existing B2B services seem to originate from business services and innovations other than eco-efficiency, it is worth analyzing different industrial services in order to find viable ways to combine eco-efficiency improvements with these business innovations.

Another path worth pursuing might be research on how to export material efficiency service concepts to industries in which they do not yet exist. One interesting approach could be combining energy and material efficiency services, just as BASF Success or Finnish Construction and building Maintenance Company YIT (ESCO and MASCO) have done.

A further direction for future research might be investigating how radical sustainable or eco-innovation can be integrated into existing, moderately eco-efficient and other business-as-usual services, such as industrial services or operations management, etc. Also finding out how viable service models can be combined with radical innovation that has limited business potential as such, at least in the short term. Addressing current pragmatic customer needs efficiently might open a door for introducing more radical eco-innovation to customer organizations.

Yet another interesting and relevant research topic would be the role of eco-efficient services in a future where material and energy degrowth or absolute decoupling would have become true. In this situation services could have a significant role to play. Degrowth also demands profound changes and innovations for business models and product-service systems – what would be feasible, or how they could be produced (technological, management and technological innovation) what types of income flows there could be in a situation where the success of a company is defined differently than that it is now.

Stepping outside of the focus of this study, the eco-efficient services, Cleantech and radical eco-innovation research could benefit from research that analysis business model as an innovation and studies them a way to commercialize new technology (Chesbrough 2007a and b). This research has analyzed how existing business models may need to be modified or completely new ones invented so that they fit in with the technology in question (Chesbrough and Rosenbloom 2002, Chesbrough 2010). Technological innovations are important but the technology as such has little value (Chesbrough 2007a and 2007b). Value is created only when the technology and the business model are in line, solving the customer's needs (Chesbrough 2010) i.e. the technology is useful. Different clean technologies may need different business models which are more traditional or innovative according to the technology and market in question (Wüstenhagen and Boehnke 2006). Understanding the business model as an innovation itself might

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also prove to be useful for sustainable product-service systems research and development. The business model may operate as a unit of analysis which enables researchers to better combine services with radical eco-innovation or cleaner technologies.

In the introduction to this dissertation, environmental management systems and the innovative approach of Patagonia were given as examples of corporate responses to sustainable development. Environmental management systems are commonplace in business and they are a means to manage environmental impacts. At the other end of the continuum are innovative approaches that challenge, to some extent, traditional ideas of doing good business, which are understood as growth orientation and the creation of profits by selling more products.

Compared to e.g. environmental management systems approach eco-efficient services are radical. In the business-to-business sector the studied services go beyond managing environmental aspects by using EMS, and change the business models of the companies from selling products to, and to enhancing eco-efficiency in, their customers' supply-chain and manufacturing processes. In the household sector some services enhance social sustainability at the household sector by providing services that empower them through knowledge and skills, helping them to organize everyday life.

The analyzed chemical management services are also at the more innovative end of traditional – radical continuum from the perspective that they create new business, value, and enhance eco-efficiency for the customer by utilizing new technologies (ICT) and business innovations in logistics and supply-chain management.

However, eco-efficient service models are not single solution towards solving the challenges of sustainable development. The eco-efficiency and other environmental sustainability impacts are not always clear. As stated earlier, this still demands further research. Especially in the B2B market, these services still operate within the (green) growth idea, seeing increasing environmental and economic efficiencies as the solution. They do not question whether we need to maintain current manufacturing structures or whether we need some other types of approaches, such as cradle-to-cradle design and eco-effectiveness (Braungart et al. 2007), instead of eco-efficiency. Neither do they question the necessity of current consumer cultures and needs; do we need all that we want and are manufacturing? In this sense eco-

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efficient services are less than radical. Thus, it can be said that eco-efficient service models are between traditional and radical, and a part of the route towards more sustainable society.

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