Business Model Design for Strategic Sustainable Development

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Doctoral Dissertation in Strategic Sustainable Development

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Karlskrona, Sweden, January 2017,

César-Levy França
Abstract

Humanity confronts an existential threat without historic precedent. Environmental pressures have reached such intensity and pace of change that the earth system may be irreversibly tipped into a new and unpredictable state. The emerging global reality is, in turn, redefining overall conditions for business success. Addressing these challenges both demands and brings great opportunities for innovation. An important and sometimes neglected aspect of innovation is the design or redesign of business models, which has been identified as a greater source of lasting competitive advantage than new products and services per se. The business model has also been suggested as a new unit of analysis when discussing sustainability. However, this is still a relatively underexplored area. The aim of this work was therefore to develop an approach to business model design that supports strategic sustainable development, i.e., supports organizations to contribute to society’s transition towards sustainability in a way that strengthens the organization.

To be able to design a business model that supports strategic sustainable development, it is necessary to know what sustainability is and how to develop sustainability-promoting, economically viable strategies. Therefore, the Framework for Strategic Sustainable Development, which includes, e.g., an operational definition of sustainability and strategic guidelines for how to approach it, was used as an overarching framework. Specific research methods and techniques included, e.g., literature reviews, questionnaires, interviews, work with focus groups, participatory action research with partner organizations, creative problem solving techniques, modeling, and simulation.

The literature reviews revealed potential sustainability benefits of developing business models in conjunction with product-service systems (PSS). However, a knowledge gap exists regarding how to effectively connect these fields. Arguably, PSS strategies can best contribute to sustainability when business models support their implementation and when both the business models and the PSS strategies are guided by an understanding of strategic sustainable development. Therefore, an integrated approach to Business Model Design for Strategic Sustainable Development was co-developed and tested in PSS innovation work with partners, e.g., companies within the energy and lighting sectors. The tests indicated that the new approach helped to clarify strengths and weaknesses of current business models from a strategic sustainability perspective; to transform an organization’s vision and strategy into a sustainability-framed vision and a sustainability-promoting strategy; and to communicate the new vision and strategy to the value network as a basis for
engaging important stakeholders in the change. For example, the approach supported one of the partner companies in its transformation towards providing sustainable PSS solutions in the form of light as a service.

Examples of business benefits of the new approach include improved scalability and risk avoidance, which provide a foundation for better investment strategies. Benefits also include improved differentiability and a broadened view on, and a more solid foundation for, collaboration with stakeholders that are increasingly important to sustainable business success.

**Keywords:** Business Model Innovation and Design, Strategic Sustainable Development, Sustainability, Sustainable Development, Sustainable Product-Service Systems, Value Network.
Thesis Disposition

This thesis includes an introductory part and the following papers. The papers have been reformatted from their original publication to fit the format of this thesis but the content is unchanged.

Paper A

Paper B

Paper C

Paper D

Paper E
Related Work

The following work has been developed during the PhD research but is not appended to this thesis.


### Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<tbody>
<tr>
<td>BMC</td>
<td>Business Model Canvas</td>
</tr>
<tr>
<td>BTH</td>
<td>Blekinge Institute of Technology (Blekinge Tekniska Högskola)</td>
</tr>
<tr>
<td>CFC</td>
<td>Chlorofluorocarbons</td>
</tr>
<tr>
<td>CHP</td>
<td>Combined Heat and Power</td>
</tr>
<tr>
<td>CO2</td>
<td>Carbon Dioxide</td>
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<tr>
<td>CSR</td>
<td>Corporate Social Responsibility</td>
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<tr>
<td>D4S</td>
<td>Design for Sustainability</td>
</tr>
<tr>
<td>DH</td>
<td>District Heating</td>
</tr>
<tr>
<td>FSSD</td>
<td>Framework for Strategic Sustainable Development</td>
</tr>
<tr>
<td>ICT</td>
<td>Information and Communication Technology</td>
</tr>
<tr>
<td>IPCC</td>
<td>Intergovernmental Panel on Climate Change</td>
</tr>
<tr>
<td>LaaS</td>
<td>Light as a Service</td>
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<tr>
<td>LCA</td>
<td>Life Cycle Assessment</td>
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<tr>
<td>LED</td>
<td>Light-emitting diode</td>
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<tr>
<td>MD</td>
<td>Maturity Degree</td>
</tr>
<tr>
<td>MWh</td>
<td>Megawatt hour</td>
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<tr>
<td>NOx</td>
<td>Nitrogen Oxides</td>
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<tr>
<td>PSS</td>
<td>Product-Service Systems</td>
</tr>
<tr>
<td>SCA</td>
<td>Strategic Capability Assessment</td>
</tr>
<tr>
<td>SLR</td>
<td>Systematic Literature Review</td>
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Appended Papers

**Paper A:** Exploring the Nexus of Product-Service Systems, Business Models and Sustainability - a need for strategic and practical approaches.

**Paper B:** Systematic Guidance for How to Integrate a Strategic Sustainability Perspective in Core Business Decision Systems.

**Paper C:** Sustainability-Self-Assessment and Business Model Design.

**Paper D:** District Heating and CHP – A Vital Role for the Development towards a Sustainable Society?

**Paper E:** Business Model Innovation and Design for Strategic Sustainable Development.
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1 Introduction

This chapter briefly introduces the research territory investigated and specifies the aim and scope of the thesis.

1.1 Sustainability Challenges and Opportunities

Negative impacts of socio-economic trends on the earth system are accelerating (Figure 1). As a consequence humanity is confronting an existential threat without historic precedent. Environmental pressures have reached such intensity and pace of change that the earth system may be irreversibly tipped into a new and unpredictable state (Rockström 2015).

![Image of socio-economic and earth system trends]

**Figure 1.** The great acceleration (Steffen et al. 2015). Image credit: SRC/IGBP/F Pharand Deschenes.

For example, Hansen et al. (2016) conclude that should greenhouse gas emissions continue to grow, there will be an interrelated series of devastating consequences, likely including, e.g., a multi-meter sea level rise within 50-150 years, a full shut-down of the North Atlantic Overturning Circulation within the next decades, and significant increases in weather extremes. Moreover, resulting social disruption is anticipated, including, e.g., conflicts arising from
forced migration and economic collapses that might threaten the social fabric of civilization.

Current sustainability problems are due to systemic errors in the basic societal design and operation, causing a weakening of both the social and ecological fabric on which humanity depends (e.g. Broman and Robèrt 2016). These and other authors also assert that the risk of being hit financially by such systematic degradation, and related changes in market conditions including policy changes, will become increasingly relatively higher for those organizations whose contribution to the global problem is relatively large (e.g. Holmberg and Robèrt 2000, Robèrt and Broman 2016). It also follows that there is business opportunity for those organizations that develop products and services that align with the inevitably and sometimes abruptly changing conditions in global markets, e.g., changes regarding resource availability and costs, customer demands, and political decisions that can be foreseen in principle (e.g. Holmberg and Robèrt 2000, McNall et al. 2011, Willard 2012, Robèrt and Broman 2016).

1.2 Business and Sustainability

Generally, overall conditions for business success are being redefined in the twenty-first century (e.g. McNall et al. 2011, Willard 2012, Robèrt and Broman 2016). Addressing sustainability challenges both demands and brings great opportunity for innovation (e.g. Porter and van der Linde 1995, Basile et al. 2011). However, so far only a small percentage of all organizations have developed the business case of sustainability (Unruh et al. 2016).

An important but historically neglected aspect of business innovation is the design or redesign of business models (Boons and Lüdeke-Freund 2013, Schaltegger et al. 2015). However, the role of business model innovation is becoming increasingly clear (Wirtz et al. 2016). A growing number of business executives are identifying the design of new business models as a greater source of competitive advantage than new products and services per se (Unit 2005). Furthermore, an increasing number of companies are changing their business models to be more service oriented (Rifkin 2014). The competitive edge likely shifts to actors capable of applying modern information and communication technology and utilizing supply webs to provide easily accessible and highly contextualized high-performance services with fewer intermediates. However, integration of sustainability considerations is not inherent to most of the ongoing business model innovation (Schaltegger et al. 2012). A product-service systems (PSS) approach has been proposed as an opportunity for promoting sustainability, but in that field, while sustainability is
often mentioned, there is little concrete support to actually promote integration of sustainability aspects (Vasantha et al. 2012, Tukker 2015).

Many tools, methods and concepts are available to support sustainability-oriented innovation. A list with many examples is provided by, e.g., Adams et al. (2012). In particular three research fields are gaining attention in the academic literature as important for companies to contribute to sustainable development of society, namely PSS, Business Models and Sustainability. These fields are further described in Chapter 2.

1.3 Aim and Scope

The overall aim of this work was to develop an approach to business model design that supports strategic sustainable development, i.e., supports organizations to contribute to society’s transition towards sustainability in a way that strengthens the organization.

Specifically, the following main research question was formulated:

*How can business model design support strategic sustainable development?*

As initial literature reviews revealed potential sustainability benefits of developing PSS in conjunction with business models, this became a focus of interest, especially since a knowledge gap was identified regarding how to effectively connect these fields. There is currently no cohesive support for developing PSS in conjunction with business models for the realization of sustainability-informed strategies.

The research in this thesis is focused mainly on the early phases of the innovation process (Figure 2), since the greatest opportunities to create solutions that contribute to sustainable development of society and business success are linked to these phases (e.g. Charter and Chick 1997, McAlloone and Tan 2005). The other phases of the innovation process are considered mainly from an overall theoretical perspective and deeper studies are deferred to future research.

This introduction (Chapter 1) is followed by a deeper description of the key fields PSS, Business Models and Sustainability and preliminary ideas of their integration (Chapter 2). Thereafter, the research design and methods are described and justified (Chapter 3). Then follows brief summaries of the appended papers (Chapter 4) and the main synthesized result is given (Chapter
5). Finally, the results are discussed and some concluding remarks and directions for future work are given (Chapter 6).

**Figure 2.** A model of the innovation process, recreated from (Roozenburg and Eekels 1995, p. 13).
2 Background of the Fields

This chapter presents a background of the fields Product-Service Systems, Business Models and Sustainability, and of their integration.

2.1 Product-Service Systems

Research in the field of product-service systems (PSS) has grown significantly. The number of papers published annually has more than quadrupled in the last decade, while the number of scientific publications in general has doubled (Tukker 2015).

The concept is becoming more common in our societies and transforms our relationship with products, from one based on ownership to one based on access of a system of products and services. There is also a growing awareness of the potential sustainability benefits of the concept, including, e.g., increased efficiency, reduced waste, and possibilities for upgrading during the use phase.

In spite of the growing research, there is no consensus on a definition of the concept (Mont 2002). A description of various definitions by authors in the field is provided in Table 1.

Table 1. PSS definitions.

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Frambach et al. (1997)</td>
<td>The set of all potential additional services a supplier can supplement his product offering with, in order to differentiate his offering relative to the competitors’ as perceived by (potential) customers and distributors.</td>
</tr>
<tr>
<td>Goedkoop et al. (1999)</td>
<td>A PSS (or combination of products and services) is a set of marketable products and services jointly capable of fulfilling a need for a client. [...] The PSS may lead to a benefit for the environment in connection with the creation of a (new) business.</td>
</tr>
<tr>
<td>Manzini et al. (2001)</td>
<td>A business innovation strategy offering a marketable mix of products and services jointly capable of fulfilling a client’s needs and/or wants - with higher added value and a smaller environmental impact as compared to an existing system or product.</td>
</tr>
<tr>
<td>Brezet et al. (2001)</td>
<td>Eco-efficient services are systems of products and services which are developed to cause a minimum environmental impact with a maximum added value.</td>
</tr>
</tbody>
</table>
An eco-efficient service is one which reduces the environmental impact of customer activities per unit of output. This can be done directly (by replacing an alternative product-service mix) or indirectly (by influencing customer activities to become more eco-efficient.

A PSS is a pre-designed system of products, supporting infrastructure and necessary networks that fulfil users’ needs on the market, have a smaller environmental impact than separate product and services with the same function fulfilment and are self-learning.

Comprehensive bundles of products and/or services, that fully satisfy the needs and wants of a customer related to a specific event or problem.

The result of an innovative strategy that shifts the centre of business from the design and sale of (physical) products alone, to the offer of product and service systems that are together able to satisfy a particular demand.

Integrated combinations of products and/or services that are unusually tailored to create outcomes desired by specific clients or types of clients.

PSS is a system of products, services, supporting networks and infrastructure that is designed to be competitive, satisfy customers’ needs and have a lower environmental impact than traditional business models.

A pure product system is one in which all property rights are transferred from the product provider to the client on the point of sale […]. A pure service system is one in which all property rights remain with the service provider, and the clients obtain no other right besides consuming the service. A product-service system is a mixture […] of the above. It requires that property rights remain distributed between client and provider, requiring more or less interaction over the life time of the PSS.

PSS is a product of material and intangible services designed and combined so that both jointly are able to satisfy a specific need of a user. In addition a PSS may reach sustainability targets.

Products that comprise combinations of ‘hard’ and ‘soft’ elements. Typically, they are described as comprising hardware combined with a service support system.

A Product-Service System consists of tangible products and intangible services designed and combined so that they are jointly capable of fulfilling specific needs of customers.

A set of customer-supplier relational processes comprising (1) customer requirements definition, (2) customization and integration of goods and/or services and (3) their deployment, and (4) post-deployment customer support, all of which are aimed at meeting customers’ business needs.

An ordered set of products and services, developed and manufactured as solution of a problem and can be a subset of a superior socio-technical system.

PSS is an integrated offering of a product and a service that provides a value. Using a PSS offers the opportunity to decouple economic success from material consumption and thus reduce the environmental impact of
economic activity.

<table>
<thead>
<tr>
<th>Source</th>
<th>Definition</th>
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<tbody>
<tr>
<td><em>Sakao et al.</em> (2008)</td>
<td>A functional solution that fulfills a defined customer need. The focus is, with reference to the customer value, to optimize the functional solution from a life-cycle perspective.</td>
</tr>
<tr>
<td><em>Leimeister and Glauner</em> (2008)</td>
<td>The intelligent interlocking of physical products and services that are already in the design and development phase closely linked. Their individual components can be decoupled from each other only with difficulty.</td>
</tr>
<tr>
<td><em>Müller et al.</em> (2009)</td>
<td>A concept that integrates products and services in one scope for planning, development and delivery, thus for the whole life-cycle.</td>
</tr>
<tr>
<td><em>Tischner et al.</em> (UNEP 2009)</td>
<td>A PSS is a system of products and services (and infrastructure), to jointly cope with the needs and demands of customers in a more efficient way with better value for both businesses and customers, compared to only offering products [...]. PSS can decouple the creation of value from the consumption of materials and energy and thus significantly reduce the environmental impact in the life cycle of traditional product systems.</td>
</tr>
<tr>
<td><em>(Schrödl and Turowski 2011)</em></td>
<td>Offerings that provide both tangible goods as well as services and intangible assets in an integrated manner.</td>
</tr>
<tr>
<td><em>Boehm and Thomas</em> (2013)</td>
<td>An integrated bundle of products and services which aims at creating customer utility and generating value.</td>
</tr>
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</table>

If a single definition is to be chosen among the above, the definition by *Tischner et al.* (UNEP 2009) is closest to the perception of the present author.

In addition to the wide array of definitions, various classifications of PSS have been proposed. Most authors make a distinction between three main categories of PSS (Tukker 2004) as described below and in Figure 3.

With *Product-oriented PSS*, the business model is mainly geared towards sales of physical products, but some extra services are added. The provider not only sells a product, but also offers services that are needed or desired during the use of the product or at end of life of the product. This can be, e.g., a maintenance contract, a financing scheme, supply of consumables, a take-back agreement, advice and consultancy.

With *Use-oriented PSS*, physical products play a central role, but the business model is not geared towards selling products. The product ownership stays with the provider, and the product is made available to the user in some way, and is sometimes shared by a number of users. Examples include product lease, product renting or sharing, and product pooling. *Product lease* implies that the provider has ownership, and is also often responsible for
maintenance, repair and control. The lessee pays a regular fee for the use of the product and usually has unlimited and individual access to the leased product. **Product renting or sharing** is similar to product lease but with the main difference that the user does not have unlimited and individual access as others can use the product at other times. **Product pooling** is similar to product renting or sharing but with simultaneous use of the product.

With **Result-oriented PSS**, the client and the provider agree in principle on a result, and there is no pre-determined product involved. Examples include activity management/outsourcing, pay per service unit, and functional result. **Activity management/outsourcing** implies that a part of an activity of a company is outsourced to another party. Since most of the outsourcing contracts include performance indicators to control the quality of the outsourced service, they are grouped under result-oriented services in this thesis. However, in many cases the way in which the activity is performed does not shift dramatically. This is reflected by typical examples such as outsourcing of catering and office cleaning that is now common in most companies. **Pay per service unit** implies that the PSS might still have a fairly common product as a basis, but the user no longer buys the product, but instead the output of the product. Well-known examples include the pay-per-print formulas now adopted by most copier producers. Following this formula, the copier producer takes over all activities that are needed to keep a copying function in an office available (i.e. paper and toner supply, maintenance, repair and replacement of the copier when appropriate). **Functional result** implies that the provider agrees with the client about the delivery of a result, and the provider is, in principle, completely free as to how to deliver the result. Typical examples include delivery of a specified ‘pleasant climate’ in offices rather than heating or cooling equipment and delivery of a specified scheme of light in schools rather than light sources.
2.2 PSS and Sustainability

PSS research has in the past ten years mainly focused on improving competitiveness in a traditional sense, lacking an explicit attention to sustainability (Tukker 2015). Sustainable PSS is mentioned in the literature, but there is not much support to achieve it (Vasantha et al. 2012). At the same time, a PSS approach has been proposed as one of the potentially most effective instruments for moving society towards a resource-efficient, circular economy (Tukker 2015).

Also Roy (2000) suggests that the provision of results or functions through eco-efficient products could reduce environmental impacts by a factor of four to twenty. He also pointed to shared utilization, product life extension and demand side management as ways to support sustainability. However, sustainability was mainly related to efficient use of energy, materials, less waste and clean tech, while the economic and social dimensions were not given equal attention.

The concept of eco-efficiency and services has also been part of the thinking around PSS and sustainability. Meijkamp (1998) looked at innovation as a strategy to influence consumers through eco-efficient services and to achieve less environmentally damaging consumption behavior.
A description of the ecological and economic basics of the PSS concept was presented by Goedkoop et al. (1999). The authors used life cycle approaches aligned with support from experts in specific fields of knowledge to operationalize the concept.

Ehrenfeld (2001) concluded that the underlying concept of sustainable development is inadequate as a design foundation. Moreover, he claimed that conventional understanding of products and services fails to account for absolute limits of the global ecosystem and overlooks the humanistic dimension, which prevents efforts to design sustainable systems. The author pointed to the need for a coherent strategy foundation for sustainability.

Manzini and Vezzoli (2002) pointed to the need to shift business focus from designing and selling physical products only, to designing and selling a system of products and services capable of fulfilling specific demands, while re-orienting current unsustainable trends in production and consumption. Manzini (2002) points to the need for companies to become “system organizers” and “solution providers”, and defines a sustainable system as “an integrated network of people, products, services and infrastructures that, as a whole, is consistent with the fundamental principles and characterized by a low material-energy intensity and by a high degree of context quality”. “Fundamental principles” here refers to ethical principles related to people and society (such as international justice), principles related to the environment (such as conservation of biodiversity, zero hazardous wastes, etc.) and principles related to social and economic issues (such as wealth distribution, power balance, democracy enhancing, quality and quantity of job creation, community promotion, and people involvement).

Mont (2004) refers to the increasing complexity of life-cycle thinking at the supply chain level and argues to include management of stakeholders to help develop innovative products and services for customers. The author also describes systems of joint use as a solution for reducing life-cycle environmental impacts.

Tan et al. (2010) mapped a range of design strategies related to different types of services, including: Product-oriented approaches (e.g. design for maintainability/serviceability, design for supportability and design for service) and Customer-oriented approaches (e.g. service design, service engineering, integrated product and service development). Thompson et al. (2011) explored how a framework for strategic sustainable development (FSSD) could guide understanding of sustainability issues and provide insights into how incremental and radical approaches could be aligned within PSS innovation.
Ceschin (2014) wrote about the strategic design research frontier for sustainability. The author investigated, through the use of case studies, the role of strategic design in supporting the introduction and scaling up of sustainable PSS innovations. A new strategic design role was described in which the development of sustainable PSS concepts is coupled with the designing of appropriate transition paths to gradually introduce and diffuse these concepts. The author suggested designers to become the link between the world of production and that of the user and the social/societal surroundings in which these processes take place. Designers are seen as enablers of more sustainable lifestyles for users.

Tukker (2015) points out that PSS will not by definition be more resource-efficient or “circular” than any other product system and that result oriented PSS offer the greatest potential for radical resource efficiency gains. The author also concluded that companies need structure, culture and capabilities to achieve success with PSS.

PSS thinking are at the core of many business models nowadays (Gassman et al. 2014). Examples include: performance based contracts, where the price of a product is based not on its physical value but on the performance or valuable outcome it delivers in the form of a service and the ownership is retained by contractors (e.g. Xerox); Pay Per Use, where the use of a service or product is metered and the customer pays on the basis of what is effectively consumed (e.g. Car2GO and Google pay per click adds); Digitization, where the ability to turn existing products or services into digital versions and achieve rapid distribution with zero marginal cost (e.g. Wikipedia, Dropbox and Survey Monkey); Subscription, where the customer pays a regular fee, on a monthly or annual basis to gain access to a product or service (e.g. Spotify, Netflix); Rent, where instead of buying a product the customer rents it (e.g. Xerox, Blockbuster, Rent a bike).

What is obvious from the above, though, and from the systematic literature review presented in Paper A, is that that the potential for PSS to promote sustainability is not fully utilized, and a lack of practical approaches to the design of business models capable of supporting implementation of such PSS has been proposed as a partial reason (Vasantha et al. 2012, Tukker 2015).
### 2.3 Business Models

An important but sometimes neglected aspect of innovation is the design or redesign of business models. The concept of business models has reached global impact (Wirtz et al. 2016). However, there is a heterogeneous comprehension of the concept. A description of various definitions by authors in the field is provided in Table 2.

**Table 2. Business model definitions.**

<table>
<thead>
<tr>
<th>Author(s)</th>
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<tr>
<td>Treacy and Wiersema (1997)</td>
<td>A business model describes the interaction of operating processes, management systems, organizational structures and corporate culture, which enables a company to keep its promise of service.</td>
</tr>
<tr>
<td>Timmers (1998)</td>
<td>An architecture for the product, service and information flows, including a description of the various business actors and their roles; and a description of the potential benefits for the various business actors; and a description of the sources of revenues.</td>
</tr>
<tr>
<td>Wirtz (2000)</td>
<td>Here, the term business model refers to the depiction of a company's internal production and incentive system. A business model shows in a highly simplified and aggregate form which resources play a role in the company and how the internal process of creating goods and services transforms these resources into marketable information, products and/or services. A business model therefore reveals the combination of production factors which should be used to implement the corporate strategy and the functions of the actors involved.</td>
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<tr>
<td>Hamel (2000)</td>
<td>A business model is simply a business model that has been put into practice. A business concept compromises four major components: Core Strategy, Strategic Resources, Customer Interface, Value Network.</td>
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<td>Linder and Cantrell (2000)</td>
<td>Operating business models are the real thing. An operating business model is the organization’s core logic for creating value. The business model of a profit oriented enterprise explains how it makes money. Since organizations compete for customers and resources, a good business model highlights the distinctive activities and approaches that enable the firm to succeed – to attract customers, employees, and investors, and to deliver products and services profitably.</td>
</tr>
<tr>
<td>Eriksson and Penker (2000)</td>
<td>A business model is an abstraction of how a business functions. [...] What the business model will do is provide a simplified view of the business structure that will act as the basis for communication improvements, or innovations, and define for the information system requirements that are necessary to support the business. It isn’t necessary for a business model to capture an absolute picture of the business or to describe every business detail. [...] The evolving models also help the developers structure and focus their thinking. Working with the models increases their understanding of the business and, hopefully, their awareness of new opportunities for improving business.</td>
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A business model is a unique blend of three streams that are critical to the business. These include the value stream for the business partners and the buyers, the revenue stream, and the logistical stream.

In the most basic sense, a business model is the method of doing business by which a company can sustain itself - that is, generate revenue. The business model spells-out how a company makes money by specifying where it is positioned in the value chain.

A business model depicts the content, structure, and governance of transactions designed so as to create value through the exploitation of business opportunities.

A business model is comprised of four parts: a value proposition or “cluster” of value propositions, a marketspace offering, a unique and defendable resource system, and a financial model. The value proposition defines the choice of target segment, the choice of focal customer benefits, and a rationale for why the firm can deliver the benefit package significantly better than competitors. The offering entails a precise articulation of the products, services, and information that is provided by the firm. The resource system supports the specific set of capabilities and resources that will be engaged in by the firm to uniquely deliver the offering. The financial model is the various ways that the firm is proposing to generate revenue, enhance value, and grow.

A business model refers to the core architecture of a firm, specifically how it deploys all relevant resources (not just those within its corporate boundaries) to create differentiated value for customers.

Based on the review of existing literature, we would define a business model as consisting of the following causally related components, starting at the product market level: 1) customers, 2) competitors, 3) offering, 4) activities and organization, 5) resources and 6) factor and production input suppliers. The components are all cross-sectional and can be studied at a given point in time. To make this model complete, we also include 7) the managerial and organizational, longitudinal process component, which covers the dynamics of the business model and highlights the cognitive, cultural, learning and political constraints on purely rational changes of the model.

A good business model remains essential to every successful organization, whether it’s a new venture or an established player. [...] Business models, though, are anything but arcane. They are, at heart, stories – stories that explain how enterprises work. A good business model answers Peter Ducker’s age-old questions: Who is the customer? And what does the customer value? It also answers the fundamental questions every manager must ask: How do we make money in this business? What is the underlying economic logic that explains how we can deliver value to customers at an appropriate cost?

The business model provides a coherent framework that takes technological characteristics and potentials as inputs, and converts them through customers and markets into economic inputs. The business model is thus conceived as a focusing device that mediates between technology development and economic value creation. It “spells out how a company...
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<th>Reference</th>
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<tr>
<td><strong>Rentmeister and Klein (2003)</strong></td>
<td>A business model is a model on a high abstraction level which illustrates the essential, relevant aspects of the company in an aggregate, clear form. Ideas and concepts for businesses can be identified, discussed and/or evaluated.</td>
</tr>
<tr>
<td><strong>Afuah and Tucci (2003)</strong></td>
<td>A business model is a framework for making money. It is the set of activities which a firm performs, how it performs them, and when it performs them so as to offer its customers benefits they want to earn a profit.</td>
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<tr>
<td><strong>Afuah (2004)</strong></td>
<td>A business model is the set of which activities a firm performs, how it performs them, and when it performs them as it uses its resources to perform activities, given its industry, to create superior customer value (low-cost or differentiated products) and put itself in a position to appropriate the value.</td>
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<td><strong>Osterwalder et al. (2005)</strong></td>
<td>A business model is a conceptual tool containing a set of objects, concepts and their relationships with the objective to express the business logic of a specific firm. Therefore, we must consider which concepts and relationships allow a simplified description and representation of what value is provided to customers, how this is done and with which financial consequences.</td>
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<td><strong>Morris et al. (2005)</strong></td>
<td>A business model is a concise representation of how an interrelated set of decision variables in the areas of venture strategy, architecture, and economics are addressed to create sustainable competitive advantage in defined markets.</td>
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<td><strong>Shafer et al. (2005)</strong></td>
<td>We define a business model as a representation of a firm’s underlying core logic and strategic choices for creating and capturing value within a value network.</td>
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<td><strong>Zollenkop (2006)</strong></td>
<td>The business model serves as a strategic instrument for a comprehensive, cross-company description, analysis and constitution of the business activity.</td>
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<tr>
<td><strong>Chesbrough (2006)</strong></td>
<td>At its heart, a business model performs two important functions: value creation and value capture. First, it defines a series of activities that will yield a new product or service in such a way that there is net value created throughout the various activities. Second, it captures value from a portion of those activities for the firm developing the model.</td>
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<tr>
<td><strong>Al-Debei et al. (2008)</strong></td>
<td>The business model is an abstract representation of an organization, be it conceptual, textual, and/or graphical, of all core interrelated architectural, and financial arrangements designed and developed by an organization presently and in future, as well as all core products and/or services the organization offers, or will offer, based on these arrangements that are needed to achieve its strategic goals and objectives.</td>
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<tr>
<td><strong>Johnson, Christensen, Kagermann (2008)</strong></td>
<td>A business model, from our point of view, consists of four interlocking elements that, taken together, create and deliver value. The most important to get right, by far, is the first. Customer value proposition, profit formula, key resources and key processes.</td>
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<tr>
<td><strong>Osterwalder and Pigneur (2010)</strong></td>
<td>A business model describes the rationale of how an organization creates, delivers, and captures value. Four pillars and nine building blocks. Product: value proposition; Customer interface: customer segments, channels, relationship; Infrastructure management: key resources, key activities and...</td>
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key partners; Financial aspects: revenue streams, cost structure.

Demil and Lecocq (2010) Generally speaking, the concept refers to the description of the articulation between different BM components or ‘building blocks’ to produce a proposition that can generate value for consumers and thus for the organization.

Teece (2010) In short, a business model defines how the enterprise creates and delivers value to customers, and then converts payments received to profits.

Zott and Amit (2010) A business model can be viewed as a template of how a firm conducts business, how it delivers value to stakeholders (e.g., the focal firms, customers, partners, etc.), and how it links factor and product markets. The activity systems perspective addresses all these vital issues.

George and Bock (2011) A business model is the design of organizational structures to enact a commercial opportunity. [...] three dimensions to the organizational structures noted in our definition: resource structure, transactive structure, and value structure.

If a single definition is to be chosen among the above, the definition by Osterwalder and Pigneur (2010) is closest to the perception of the present author.

In addition to the wide array of definitions, various other aspects are also debated. For example, Zott and Amit (2008) pointed to a need for new research in the field of business models to understand the relationship between strategy, structure and the boundaries of firms. The authors concluded that competitive advantage can emerge from superior strategic positioning in the market, as well as from the firm’s business model. Teece (2010) argued that coupling strategy analysis with business model analysis is a way to protect whatever competitive advantage results from the design and implementation of new business models.

Magretta (2002) see business modeling as the “managerial equivalent of the scientific method – you start with a hypothesis, which you then test in action and revise when necessary.” Business models describe as a system; how the pieces of a business fit together. When a new model changes the economics of an industry and is difficult to replicate, it can create a strong competitive advantage. Baden-Fuller and Morgan (2010) refer to business models as laboratories where academics explore how they work and managers experiment with their firms.

Casadesus-Masanell and Ricart (2010) proposed a structure linking strategy to business models and onto tactics (i.e. plans of action, which take place within
the bounds drawn by the firm’s business model), concluding that business models are reflections of the realized strategy but not strategies themselves.

Wirtz et al. (2016) propose a converging business models model view based on an analysis of definitions, perspectives and components in the literature (Figure 4). The authors claim that research in the business model field has been dominated by three basic theoretical perspectives or research silos: technology, organization and strategy.

*Technology-oriented:* The origins of publications within this theoretical perspective are primarily between 1970 and 2002. Until 1999 they had an emphasis on systems modeling. Between 2000 and 2002 publications were dominated by e-business (internet-based business concepts), and since then more strategy-oriented articles have been published (Wirtz et al. 2016).

*Organization-oriented:* This perspective is characterized by an abstract representation of the company architecture, including overriding corporate design, capabilities, innovation linkage structures and decision making. This perspective include definitions of business models as representations and stories that explain how enterprises work; the architectural design of organization structures, and descriptions of the business activity. Authors taking the strategic perspective described this perspective as a support for the creation and execution of competitive strategic objectives related to governance, corporate culture, products and services, and for capturing value within the value network (Wirtz et al. 2016).

*Strategy-oriented:* This perspective is characterized by an integrated description of entrepreneurial activities that relate to vision and mission of a company’s business models, competitive strategy, innovation, capabilities and value creation logic. This perspective has been considered to have an essential influence on and guidance for the development of business models (Wirtz et al. 2016).
The definitions and perspectives provided above point to certain key components. According to Wirtz et al. (2016) the component-oriented view is part of many peoples’ understanding of the business model concept. The components and partial models of an integrated business model that are listed in Table 3 are presented by the authors.

An investigation of the existing business model literature (Wirtz et al. 2016) allocates the reviewed articles into specific research categories as illustrated in Figure 5, and Gassmann et al. (2014) describe 55 business model patterns responsible for 90 % of the world’s most successful companies, namely: Add-on, affiliation, aikido, auction, barter, cash machine, cross selling, crowdfunding, crowdsourcing, customer loyalty, digitalization, direct selling, e-commerce, experience selling, flat rate, fractional ownership, franchising, freemium, from push to pull, guaranteed availability, hidden revenue, ingredient branding, integrator, layer player, leverage customer data, licensing, lock-in, make more of it, mass customization, no frills, open business, open source, orchestrator, pay per use, pay what you want, peer to peer, performance-based contracting, razor and blade, rent instead of buy, revenue
sharing, reverse engineering, reverse innovation, robin hood, self-service, shop in shop, solution provider, subscription, supermarket, target the poor, trash to cash, two-sided market, ultimate luxury, user design and white label.

Table 3. Key components of business models, based on Wirtz et al. (2016).

<table>
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<tr>
<th>Key Components of Business Models</th>
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<tr>
<td><strong>Strategy</strong></td>
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<tr>
<td><strong>Resources</strong></td>
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<tr>
<td><strong>Network</strong></td>
</tr>
<tr>
<td><strong>Customers</strong></td>
</tr>
<tr>
<td><strong>Market Offering (value proposition)</strong></td>
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<td><strong>Revenues</strong></td>
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<td><strong>Service Provision</strong></td>
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<td><strong>Procurement</strong></td>
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<td><strong>Finances</strong></td>
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From the above it is clear that sustainability has historically not been an explicit and major field of interest in the research and practice of business models.

2.4 Business Models and Sustainability

An increasing interest in sustainability in the discourse on business models seems logical and essential in times of companies’ increasingly challenging quest for competitive advantage, in combination with more and more discussions about companies’ impacts on and responsibility for society, the environment, and multiple stakeholders (Wirtz et al., 2016).

Today, the majority of managers among those who say that their company’s sustainability activities have added to profits also say that these activities have led to business model innovations (Borzo 2005). The IBM global report (Giesen et al. 2007) points out that there has been a growing interest among companies in the relevance of sustainability for the success of their business models. Unit (2005) also points in that direction, and asserts that the majority of business executives are identifying the design of new business models as a greater source of competitive advantage than new products and services per se.

Osterwalder and Pigneur (2011) state that social and environmental purposes do not have to be sacrificed for profits, and profits do not have to be sacrificed
for social and environmental purposes, but that the two purposes can become a source of competitive advantage.

Of special interest for this thesis is a global executive study by Kiron (2013), showing that many companies that have considered sustainability proactivity as necessary to be competitive, and that have changed their business models accordingly, are finding success. Nearly half of the companies changed their business models as a result of sustainability opportunities. The report also concludes that the proportion of companies for which sustainability has become a permanent element, and a source of profit, is growing. Thus, business model innovation seems to be developing as a crucial means for combined sustainability proactivity and profitability in business.

Boons and Lüdeke-Freund (2013) stated that research has so far tended to neglect the integration between business model design and sustainability and proposed normative requirements for a sustainable business model concept by combining studies by Osterwalder (2004) and Doganova and Eyquem-Renaut (2009): (1) value proposition; (2) supply chain; (3) customer interface and (4) financial model. These proposed normative requirements have to be met for business models to contribute to sustainable innovation and are based on a definition of sustainable innovation grounded in what the authors refer to as “wider normative concepts”, such as environmental sustainability or sustainable development. Moreover, the authors state that a sustainable value proposition should be based on business-society dialogs that must identify trade-offs between optimal product and service performance and improved social and environmental effects.

According to Kiron et al. (2012), business model innovation is a lever for organizational sustainability and a sustainability strategy is necessary to being competitive. Moreover, business models can serve as a new unit of discussion and analysis of sustainability initiatives (Lee and Casalegno 2010). Additionally, Stubbs and Cocklin (2010) point out that organizations’ business models should express their purpose and vision in terms of sustainability. Nevertheless, current business model approaches are not facilitating strategic decision making and there is a need for better analytical support (Seelos 2010).

The development of business models for sustainability may require innovation to provide insights and examples related to the achievement of sustainability through social and technical transitions, production processes, lifestyles and consumption patterns (Schaltegger et al. 2012, Wells 2013).
The number of approaches to sustainable business model design has been growing. A triple layered business model canvas based on the business model canvas of Osterwalder and Pigneur (2010) was proposed by Joyce et al. (2015), to support the design of a sustainable business model by addressing the key pillars of sustainability (i.e. social, ecological and economic). Furthermore, a transdisciplinary review of the literature – an ontology for strongly sustainable business models is presented by Upward and Jones (2015). The authors aimed at understanding what a successful sustainable business is and an outcome of the review is a suggested tool to support the development of strongly sustainable business models.

Especially the social dimension of sustainability has been a challenge for business to understand and operationalize. It is often discussed in relation to a special “social business” route. A social business does not strive to maximize profits but rather to serve humanity’s most pressing needs. A social business pays back only the original investment and reinvests its profits in innovations or further growth that advance its social goals. A social business aims at solving social problems with products and services at affordable prices, or giving the poor and marginalized people ownership in a business (Yunus et al. 2010). Examples of social innovation and business model types include (Prahalad 2004): buy one give one, cooperative ownership, inclusive sourcing, building a market place, pricing, microfinance and micro-franchise.

An example of a social business is the case of Grameen Shakti, which is focused on meeting the energy needs of in rural areas by popularizing solar home systems and other renewable energy technologies. Currently this is one of the largest and fastest growing rural based renewable energy companies in the world.

However, to label a certain type of business as “social” does not come without complications. Could that foster the impression that other businesses could go on as before, as long as there is a certain amount of social business? Rather it is essential to integrate a full sustainability perspective (including the social dimension) in all business.

2.5 Sustainability

Sustainability, or Sustainable Development, is present in the literature in a wide variety of disciplines. It is not the intention here to give a comprehensive and detailed coverage of the concept from all disciplinary perspectives. Below a brief high-level overview is given and then the focus turns to perspectives
most relevant to the focus of this thesis, i.e., sustainability in relation to PSS and Business Models.

The awareness of society’s sustainability challenges, and related knowledge, started to grow notably in the middle of the previous century. Examples of pioneers include Leopold (1949), Carson (1962), Ehrlich (1968), Meadows et al. (1972), Schumacher (1973), and Lovelock (1979). The likely most well-known definition of the concept was released in 1987 by the World Commission on Environment and Development (WCED 1987), also known as the Brundtland Commission. In their report, sustainable development was defined as: “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. This has been widely endorsed. However, it has also been criticized, e.g., for being vague and difficult to operationalize (e.g. Jacobs 1999, McKenzie 2004). According to the former UN Secretary-General Kofi Anan “Our biggest challenge in this new century is to take an idea that seems abstract – sustainable development – and turn it into a daily reality for all the world’s people.” (Educating for a Sustainable Future 2004, p. 48)

Many scientists have continued to study and try to raise awareness of the sustainability challenges, as well as to develop approaches to address them. Examples include Elkington (1987), Pearce et al. (1989), Daly et al. (1989), Hawken (1993), Steffen et al. (2004), Rockström et al. (2009) and Steffen et al. (2015). Many tools, methods and concepts intended to support implementation of sustainable development are now available. Examples include: Life Cycle Assessment, Cradle to Cradle, Ecological Footprinting, Environmental Product Declaration, Sustainable Product Development, Clean Technologies, Environmental Management Systems, Corporate Social Responsibility, Stakeholder Engagement Standard (AA1000), Social Accountability Standards (SA8000), Global Sullivan Principles, International Labor Organization Standards, ECO-Efficiency, Eco-Design, ISO 14001, OHSAS 18001, Dow Jones Sustainability World and European Index, and Carbon Disclosure Project.

The concept of circular economy has recently gained significant attention (MacArthur 2013): “A circular economy is one that is restorative and regenerative by design, and which aims to keep products, components and materials at their highest utility and value at all times, distinguishing between technical and biological cycles”. The concept brings many potential benefits. However, it also leaves some aspects of a full sustainability perspective unanswered. To make most of the concept, it is important to be aware of those aspects when strategies and business models are designed. One aspect is how
much various materials need to be recycled for society to be sustainable. Those needs are different for different materials. To recycle more than before, or as much as perceived possible, or as much as perceived economically optimal, will not necessarily suffice for sustainability. Some materials should actually not be recycled but substituted in certain applications, since they cannot be technically or economically safe-guarded enough to be within sustainability constraints from a planetary perspective if used in large volumes (e.g. CFC in consumer goods). Furthermore, sustainability is not only about flows. Also spatial considerations are necessary to safe-guard nature’s integrity (Robèrt et al. 2016) and the social dimension of sustainability (Missimer et al. 2016a, 2016b) cannot be meaningfully discussed in terms of (circular) flows. Excluding certain aspects of a full sustainability perspective implies a risk for businesses to miss certain opportunities for innovation and also a risk for society since partly misguided and counterproductive innovation could result.

Generally, to be supportive of the development of sustainability-promoting PSS and business models, researchers and practitioners should be seeking for a methodology that provides a full strategic and experientially-informed sustainability perspective as a foundation for continued work. This is motivated by the systematic literature review presented in Paper A of this thesis.

Several authors are working on combining strategic thinking and/or strategic management with sustainability (e.g. Robinson 1990, Baumgartner and Ebner 2010, Baumgartner and Korhonen 2010, Lozano 2013, Engert et al. 2015). However, to the knowledge of the present author there is only one methodology that explicitly includes an operational, principled definition of sustainability aimed to fulfill certain criteria for being useful for backcasting planning and redesign for sustainability. To be strategic it is necessary to be able to define the goal, and in such a complex context as sustainable development the goal should be framed by basic principles as boundary conditions for sustainable visions (e.g. Broman and Robèrt 2016). To be useful for this purpose such principles must be necessary and sufficient for sustainability, and to facilitate cross-disciplinary and cross-sector collaboration, guide innovation, and enable comprehension and monitoring of transitions, sustainability principles should be general, concrete, and non-overlapping (ibid).

Broman and Robèrt (2016) describes a framework for strategic sustainable development (FSSD) which includes, e.g., a principled definition of sustainability aimed to assure such sustainable envisioning, and strategic guidelines for how organizations can support society’s transition towards fulfillment of the sustainability definition in ways that strengthen the
organization. The authors present some observed benefits of this methodology, briefly discussed in Paper A and below. With those qualities and benefits, proven in practice in a wide range of cases, the FSSD directly responds to the need identified in the systematic literature review presented in Paper A. This methodology should therefore be particularly suitable for informing sustainable PSS and business model innovation and design.

2.6 Framework for Strategic Sustainable Development

As described by Broman and Robèrt (2016), the Framework for Strategic Sustainable Development (FSSD) includes some main features: A funnel metaphor facilitating an understanding of the sustainability challenge and the self-benefit of competent proactivity; A five-level structuring and inter-relational model distinguishing and clarifying the inter-relationships between phenomena of fundamentally different character; A principled definition of sustainability useful as boundary conditions for backcasting planning and redesign for sustainability; and An operational procedure for creative co-creation of strategic transitions towards sustainability.

For a comprehensive description and discussion, please refer to (Broman and Robèrt 2016). Brief descriptions are given in the appended papers and below.

The FSSD is designed to give guidance on how to develop any region, organization, project or planning endeavour towards social and ecological sustainability in an economically viable way. It has been under continuous development through scientific consensus process including theoretical exploration, refinement and testing in iterative learning loops between scientists and practitioners from business and society (Broman and Robèrt 2016).

The general benefits of sustainable development now seem to be gradually better appreciated, and lack of understanding is perhaps a declining obstacle to more sustainable business activities. There will be a shared cost to everyone if there is continued loss of biodiversity, natural resources, health of ecosystems and climate stability; the same applies to loss of trust between people and their leaders and institutions (Basile et al. 2012). It is to an individual business’ and society’s benefit in the long term to avoid that cost.

However, the short term self-interest in being proactive, over and above policies and legislation for the common good, is not as widely appreciated or understood. It is still the case that many leaders are watching “competitors”, including other nations, to ensure that the “costs” for transitions to sustainable
practices are shared by all (Robèrt and Broman 2016). This ignores the fact that the declining potential to sustain civilization means that it is a good idea for the bottom line of individual organizations to be comparatively proactive. The gradual loss of the social and ecological systems’ capacity can be conceptualized as those systems moving deeper and deeper into a funnel whose narrowing circumference represents increasingly harsher constraints and smaller degrees of freedom. It follows that the risk of being hit financially by “the narrowing wall of the funnel” are relatively higher for those organizations whose contribution to the global problem is relatively large, and that the business risk is accelerating for those organizations (e.g. Holmberg and Robèrt 2000, Robèrt and Broman 2016). It also follows that there is business opportunity for those organizations that develop products, services and business models that align with the inevitably and sometimes abruptly changing conditions in global markets that can already be foreseen in principle (e.g. Basile et al 2011, Willard 2012, Robert and Broman 2016).

Any organization which requires more resources and/or creates more waste per added value, thereby becoming increasingly irrelevant in markets that evolve as a consequence of the funnel, is subject to increasingly larger financial risks than its competitors. Such organizations will increasingly, and often in abrupt ways that will be increasingly difficult to foresee in detail, experience harsh financial impacts due to the narrowing funnel. Even if it is possible to postpone the consequences somewhat, e.g., by political lobbying, it will eventually be impossible to avoid encountering higher and higher relative costs for resources, waste management, insurance, loans, etc., as well as lower creativity and higher opportunity costs to satisfy needs further ahead in the funnel (Robert and Broman 2016). The opposite is true for those organizations that are skillfully and gradually becoming part of the solution (Kiron et al. 2013, Robert and Broman 2016), developing their practices so that they are moving towards the opening of the funnel.

This emphasis on dynamic aspects is different from the traditional approach of many sustainable development proponents, who more typically tend to narrowly focus on the public relations value of sustainable development communications. But gains from improved PR are usually very small. In purely financial terms it corresponds merely to how much extra customers are prepared to pay for products or services provided by “nice” organizations. Again, the funnel-metaphor points at major benefits resulting from adapting in time to more and more sustainability-driven markets. It is about the competence to foresee inevitable changes and providing products and services that are sustainably produced, and that will help others to be sustainable.
How could it be possible to systematically exploit the above outlined potential to capitalize on the dynamics of sustainability, as visualized by the funnel-metaphor? The generic design of the FSSD lends itself well to create cohesion in all elements of business design, including for choosing and informing of tools for decision support and monitoring. To that end, successfully planning and acting strategically in complex systems relies on a clear intellectual differentiation between five different (but interacting) levels (Broman and Robèrt 2016).

The five-level model of the FSSD is illustrated in Figure 6 and the levels applied to sustainability are described below, based on descriptions by, e.g., Robèrt et al. (2012), Robèrt et al. (2013), Broman and Robèrt (2016) and Robèrt and Broman (2016).

1. The System Level
This level describes the overall major functions of the system. It is necessary to understand the system enough to be able to approach the next level of the framework (how to define what we want in the system). For sustainability, the relevant overall system is the biosphere with its human society and our knowledge on stocks, flows, biogeochemical cycles, biodiversity and resilience, human needs, and the basic relationships between human practices and their impacts.

An overall outline of the current systematic degradation of this system (unsustainability of the global human society) belongs to this level, including respect for the complexity of the challenge, the myriad of sustainability related impacts of the “funnel”. The organization (e.g. a business), with all its interdependencies with natural systems, as well as with its suppliers and clients and other stakeholders, is part of this complex pattern of destruction.
But the organization could also contribute to turning problems into opportunities. For that to be feasible, the complexity of unsustainability calls for a methodological need to avoid reductionism, i.e., understanding basic mechanisms by which the degradation of the biosphere occurs. Such an understanding would allow for business organizations to approach sustainability by using the basic destruction mechanisms as exclusion criteria for redesign of business. So, during the development of the FSSD, repeated attempts were made to aggregate the myriad sustainability related impacts identified at the systems level into basic mechanisms of destruction.

Basic destruction mechanisms on that largest needed system level would be generic, i.e., the same across the whole value chain and among other stakeholders. If it would be possible to apply negations of such basic destruction mechanisms as exclusion criteria for redesign, i.e., generic constraints or “boundary conditions” for any sustainable organization and any sustainable value chain, any organization could ask: “In what way do we contribute to society’s violation of those boundary conditions, and how can we, in our organization, benefit from gradually becoming part of the societal solution instead?” Or in other words, the generic quality of boundary conditions would allow for systematic and strategic joint approaches.

2. The Success Level
This level specifies the definition of the objective of sustainable planning — success of the region, organization or other subject of the planning within the boundary conditions of a global sustainable society. To that end, basic principles framing a sustainable society and any organization in it are sought. To be functional for strategic sustainable development, the set of principles must be: (e.g. Broman and Robèrt 2016): (i) necessary, but not more to avoid unnecessary restrictions and to reduce distraction over elements that may be debatable, and (ii) sufficient, and not less to cover all aspects of sustainability. In addition, the set of principles should be (iii) general to make sense for all stakeholders and thus allow for cross-disciplinary and cross-sector cooperation, (iv) concrete to inspire and guide innovation, problem solving and actions, and (v) non-overlapping to enable comprehension and facilitate development of indicators for monitoring. Following these criteria, basic sustainability principles have been derived from understanding first-order mechanisms through which society currently causes destruction of the socio-ecological system; and the principles reads (Broman and Robèrt 2016):

In a sustainable society, nature is not subject to systematically increasing...

1. ... concentrations of substances extracted from the Earth’s crust. This means
limited extraction and safeguarding so that concentrations of lithospheric substances do not increase systematically in the atmosphere, the oceans, the soil or other parts of nature; e.g. fossil carbon and metals;

2. *concentrations of substances produced by society.* This means conscious molecular design, limited production and safeguarding so that concentrations of societally produced substances do not increase systematically in the atmosphere, the oceans, the soil or other parts of nature; e.g. NOx and CFC;

3. *degradation by physical means.* This means that the area, thickness and quality of soils, the availability of fresh water, the biodiversity, and other aspects of biological productivity and resilience, are not systematically deteriorated by mismanagement, displacement or other forms of physical manipulation; e.g. over harvesting of forests and over-fishing;

and people are not subject to structural obstacles to ...

4. *health.* This means that people are not exposed to social conditions that systematically undermine their possibilities to avoid injury and illness; physically, mentally or emotionally; e.g. by dangerous working conditions or insufficient rest from work;

5. *influence.* This means that people are not systematically hindered from participating in shaping the social systems they are part of; e.g. by suppression of free speech or neglect of opinions;

6. *competence.* This means that people are not systematically hindered from learning and developing competence individually and together; e.g. by obstacles for education or insufficient possibilities for personal development;

7. *impartiality.* This means that people are not systematically exposed to partial treatment; e.g. by discrimination or unfair selection to job positions;

8. *meaning-making.* This means that people are not systematically hindered from creating individual meaning and co-creating common meaning; e.g. by suppression of cultural expression or obstacles to co-creation of purposeful conditions.

The next level requires this key second level.
3. The Strategic Guidelines Level
This level specifies the guidelines for how to approach the above outlined sustainable objective strategically. If one does not know where to go, one cannot even attempt to be strategic. And for long-term endeavors in complex systems the goal must be defined by principles and not in detail – nobody can look into the future. This implies a step-by-step approach towards the principled objective in a way that ensures that financial, social, and ecological resources continue to feed the process. In chess, moves serve as strategic steps to checkmate, and early in the game the exact image of check-mate cannot be determined. Trade-offs, in chess or in the “game of sustainable development”, are selected from their capacity to serve as platforms towards complying with principles of success, rather than choices between inherent evils in the short term. For the individual organization wanting to apply the above basic principles for sustainability for its own practices and development, the relevant question is: “In what way do we currently contribute to violating those principles, and what options exist for the future when we are no longer part of the problem but instead the solution?”

4. The Actions Level
This level is about putting concrete measures (e.g. investments) into stepwise action programs in line with the strategic guidelines at level 3.

5. The Tools Level
Concepts, methods and tools are often required for decision support, monitoring and disclosures of the actions (4) to ensure they are chosen strategically (3) to arrive stepwise at the objective (2) in the system (1). Examples in sustainable development are modelling, management systems, indicators, life cycle assessments, etc. The FSSD is designed to not compete with any other concept, method or tool, but to be structuring and unifying to aid people in making the best use of any other concept, method or tool, depending on purpose and context.

The unique FSSD property of defining sustainability by basic principles, offers a unique opportunity to develop concepts, methods and tools for analyses, envisioning, design of action programs, decision support, monitoring, modeling, simulation, product development, etc., all aligned with one and the same overall goal. The FSSD has been used to make more systematic use of ISO 14001 (Robèrt 2000, Robèrt et al. 2002, MacDonald 2005), Life Cycle Assessment (Andersson et al. 1998, Ny et al. 2006), Industrial Ecology (Korhonen 2004) and Product Development Methods (Byggeth et al. 2007). The FSSD has been applied to assess existing products and industrial plants (Ny et al. 2008). It has provided a basis for discussions to integrate concepts such as
Zero Emissions, Cleaner Production, Sustainable Technology Development and Natural Capitalism (Robèrt et al. 2002) and Corporate Social Responsibility (Waage et al. 2005). The FSSD has also been proposed to be used as a shared mental model in product-service system innovation and value chain management (e.g. Thompson 2012, Bratt 2014).

The FSSD uses an operational application procedure with four general steps as illustrated in Figure 7.

![Figure 7. The ABCD procedure (Broman and Robèrt 2016, p. 21).](image)

*In the A-step* participants learn about and apply the FSSD to share and discuss the topic or planning endeavour and agree on a preliminary principled vision of success, framed by the basic sustainability principles. It is important to stress, again, the *self-benefit* of contributing to society’s fulfilment of the boundary conditions for sustainability (Robèrt and Broman 2016). It is essential that sustainability is not regarded as a side-passenger to decisions made for other reasons. It is only when the business case of sustainability is fully understood that integrated goals will actually be used for the evaluations of all investments. This is particularly important when evaluating large investments that tie resources for relatively long time-periods.
In the **B-step** participants explore the current situation in context of the sustainability-integrated business success of the A-step. They list the main challenges of current activities in relation to the objective they want to reach as well as current assets to deal with those challenges.

In the **C-step** participants turn to brainstorming. To deal with the listed challenges under B, future possible solutions and steps are listed. Those are scrutinized with respect to the integrated goal, temporarily disregarding constraints related to the current situation, e.g., constraints related to the current infrastructure, the current energy system, the current dependencies in the value chain and to other stakeholders, financial capacity, etc. The question is, at this stage: “what is theoretically possible within the constraints provided by our integrated goal?”

Before proceeding, it should be stressed that the B and C steps, though seemingly trivial, are different to traditional analyzes of business and business opportunities. Current practices (B) are assessed, and future opportunities (C) are derived, from the perspective of a vision framed by a principled definition of sustainability. This is at the core of the FSSD, i.e., “Backcasting from Principles”, as opposed to either Forecasting, i.e., projection from current situations and trends in an attempt to predict the future and deal with foreseeable problems, or Backcasting from Scenarios, i.e., from detailed images of goals. As pointed out above; in the sustainability context it is more helpful to backcast from a principled definition of success or from scenarios framed by such principles (e.g. Ny 2009, Broman and Robèrt 2016).

In the **D-step** the more pragmatic strategic dimension comes to the fore when participants prioritize amongst the brain-stormed solutions of (C), i.e., begin outlining a stepwise business plan to make use of the investment decisions explored in the previous step. In this D-step, priorities are set with an intuitive logic. It means a stepwise approach, ensuring that early steps are designed to serve as (1) flexible platforms for forthcoming steps (from the C-list) that, taken together, are likely to bring society, the organization and the planning endeavour to the defined success, by striking a good balance between (2) direction and advancement speed with respect to the defined success and (3) return on investment to sustain the transition process. The logic creates the opportunity for pragmatic leadership.
3 Research Design and Methods

This chapter provides a brief description of the overall research process and the rationale for the application of some specific methods, tools and techniques used to identify/generate, select and analyze data in order to understand the research problem, produce results and validate the study.

3.1 Overall Research Design

The overall research design was guided, in general, by a scheme proposed by Flowerdew and Martin (2005). The process is iterative throughout the four sections (Table 4), although seemingly linear in table format. The process was used to guide the whole research work as well as the individual studies.

Table 4. Research design, based on Flowerdew and Martin (2005).

<table>
<thead>
<tr>
<th>Aim</th>
<th>Means</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Section A</strong> Preparing for the research.</td>
<td>Choosing a topic and defining the aim, research questions and methodological approach by: Dialogues with supervisors, research funders, potential case companies, etc. Finding previous work on the topic and collecting secondary data by: Reviewing work from the own group; Snowballing literature review; BTH library and search systems; Systematic literature review using online databases (e.g., Web of Science, Scopus, Google Scholar); Supplementary expert input.</td>
<td>Business model design for sustainability as the topic; Mainly qualitative research approach, guided by the Framework for Strategic Sustainable Development; Main research question and research questions for the different papers (studies). Contextual material from previous work (e.g. selected and categorized publications in the fields of PSS, business models, sustainability, and at their interface) forming a basis for the thesis and papers, research reports and a resource kit for practitioners.</td>
</tr>
<tr>
<td><strong>Section B</strong> Collecting primary data.</td>
<td>Questionnaires; Interviews; Focus (reference) groups; Participatory approaches including, e.g., FSSD-guided workshops, problem-based learning, creative problem solving techniques and participant observation.</td>
<td>Contextual material (e.g. transcriptions, observation notes, sketches, business model templates, prototypes, insights and reflections, graphics and diagrams) forming a basis for the thesis and papers, research reports and a resource kit for practitioners.</td>
</tr>
</tbody>
</table>
The four sections in Table 4 and some of the methods, tools and techniques used are briefly discussed below. Several of the methods, tools and techniques were used both for the purpose generating and capturing data in the research process and as elements of the proposed approach that constitute the result.

### 3.2 Section A - Preparing for the Research

#### 3.2.1 Topic, Aim, Research Questions and Approach

This stage included dialogues and study design activities with supervisors, research funders and potential case companies for choosing the topic, specifying the aim, defining research questions and selecting methodological approaches.

The topic was chosen based on a combination of an interest from the researcher(s), an interest among funders and potential research partners and the need described in Chapter 2.

The overall methodological approach chosen to conduct this research was mainly qualitative. Qualitative methods present the possibility to work with multiple contexts for understanding, demonstrating and comparing the phenomena under study; enable the development of a view of some aspects that cannot be understood in numerical terms and through statistical analysis; allow for results to be based on direct interaction of the researcher with the situations under study; allow room for flexible ways to perform data collection, analysis and interpretation and to yield results that may help to develop new ways of understanding (USC Libraries Research Guides 2016). However,
quantitative methods were also used in this thesis where possible and useful (e.g. in Paper A and Paper D).

Based on the background of the fields given in Chapter 2 and the qualities and benefits of the Framework for Strategic Sustainable Development (FSSD) described there and in the given references, the FSSD was chosen as the main framework to inform the studies from a sustainability perspective. In particular, the structure (five-level model) and process guidance (ABCD-procedure) were found useful to support this applied research in the interactions with various research partners. The FSSD was also used to clarify why the research problem studied in this thesis is significant. More specifically, the FSSD strengthened the study in the following ways:

- Helped to clarify existing perspectives in the field of sustainable development.
- Served to guide research processes for understanding, analyzing and designing ways to investigate relationships between socio-ecological systems and business models.
- Provided the basis for the deduction of research hypotheses, choice of methods, and definition of research scope.
- Helped to articulate theoretical assumptions in relation to other research fields and perspectives.
- Provided boundary conditions in the form of sustainability principles to guide assessments of socio-ecological interactions and to serve as constraints for creativity and innovation.
- Helped to position various phenomena observed throughout the research in a strategic sustainable development context and to generalize the results.
- Provided means to guide the research efforts and improve professional practice through the development of a resource kit for practitioners.
- Provided a pragmatic and peer-reviewed methodology for integration and application of sustainability goals into case-based efforts.

3.2.2 Previous Work and Secondary Data

This thesis builds on previous thesis work at Blekinge Institute of Technology (BTH) as one of the grounds, e.g., the works of Hallstedt (2008), Ny (2009), Thompson (2012), Bratt (2014) and Missimer (2015). This includes, to some degree, work in all the three fields explored in this thesis. However, the strong
focus and deep studies on business models and their role for strategic sustainable development is new.

During this preparatory phase of the thesis work, a systematic exploration of existing literature and available data started. Sources included local BTH library resources as well as the use of online databases and search engines.

Methods and resources used to obtain secondary data included: Systematic literature review (Kitchenham and Charters 2007); Snowballing literature studies (Wohlin 2014); Online databases such as Web of Science, Scopus, and Google Scholar. Supplementary input was obtained from experts at BTH and among the potential partners.

A systematic literature review is a means of evaluating and interpreting all available research relevant to a particular research question or topic of interest. Systematic reviews aim to present a fair evaluation of a research topic by using a trustworthy, rigorous, and auditable methodology (Kitchenham and Charters 2007). The methodology used in this work is described in Paper A.

Major outcomes of Section A were the chosen topic, main approach, main research question and research questions for the different papers (studies), and contextual material from previous work forming a basis for the thesis and papers, research reports and a resource kit for practitioners.

3.3 Section B - Collecting Primary Data

Methods used to collect primary data included questionnaires, interviews, focus (reference) groups, and various participatory approaches including, e.g., FSSD-guided workshops, problem-based learning, creative problem solving techniques and participant observation. The researcher(s) personally experiencing the reality in the participating organizations was critical to understand the phenomena explored in this thesis. The participatory work was also important for the co-generation of results with practitioners (i.e. the type of professionals that are supposed to use and gain from the results produced in this research). Thus, sections B and C of the overall research process were partly and from time to time sliding into each other. The specific data collection methods are described in the respective paper. Because of the central role of participatory approaches, these are discussed also below. For a description of the FSSD and its operational procedure (typically used to guide interactive work in a workshop format), see Chapter 2 and the references given therein.
3.3.1 Participatory Research Approaches

Some general principles for participatory research approaches are given by Patton (2005):

- The process involves participants in learning inquiry logic and skills, (e.g. establishing priorities, focusing questions, interpreting data, data-base decision making, and connecting processes to outcomes).
- Participants in the process own the inquiry. They are involved authentically in making major focus and design decisions. They draw and apply conclusions. Participation is real, not token.
- Participants work together as a group and the inquiry facilitator supports group cohesion and collective inquiry.
- All aspects of the inquiry, from research focus to data analysis, are undertaken in ways that are understandable and meaningful to participants.
- The researcher or evaluator acts as a facilitator, collaborator, and learning resource; participants are coequal.
- The inquiry facilitator recognizes and values participants’ perspectives and expertise and works to help participants recognize and value their own and each other’s expertise.

Status and power differences between the inquiry facilitator and participants are minimized, as much as possible, practical, and authentic, without patronizing or game playing.

Problem-based Learning

Problem-based learning (PBL) is an active method to question existing solutions and knowledge and to speculate and generate new solutions and knowledge rooted in practice related to real-life challenges and questions posed by researchers and case-study organizations (Biggs and Tang 2011, Savin-Baden 2000). The aim of PBL includes developing content-related skills, attitudes, know-how and professional wisdom. Thus, problems and questions were selected throughout the thesis in support of these overarching aims. PBL was specifically used as a style of active learning about sustainability and business model innovation and design in FSSD-guided workshops.
Creative Problem Solving Techniques

The concept was coined by Parnes (1967) and it was initially based on six steps: objective finding, data finding, problem finding, idea finding, solution finding and acceptance finding. Creative problem solving involves divergent and convergent thinking (Guilford 1967), and focusing on the “best” answer, where “best” is contextualized to the given situation. Divergent thinking is the process of generating multiple related ideas for a given topic or solutions to a problem. Convergent thinking is the ability to apply rules to arrive at a single “correct” solution to a problem. This is sometimes illustrated by the so-called double diamond (Figure 8).

![Double Diamond Diagram](image)

**Figure 8.** Divergent and convergent thinking, The Double Diamond, recreated from (Design Council 2007).

The double diamond process model given by, e.g., the Design Council (2007) was used throughout the participatory efforts in this thesis work as a process to move from discovery to delivery, e.g., during the C-step and D-step of the ABCD-procedure of the FSSD. The process emphasizes both front-end phases (e.g. discover, define) and execution phases at the back-end phases of product- and service design (e.g. develop, deliver). The overall goal is to arrive at a suite of consensus solutions that lead to deliverable outcomes. Various methods and techniques can be assigned to each of these phases to help guiding different modes of thinking and trigger creativity and innovation, such as brainstorming (Rowe 1987, Faste 2012, Kelley 2007, Kelley and Kelley 2013).
Design Thinking for Innovation (Figure 9) is another (related) process model aimed to support divergent and convergent thinking. It is typically used by designers to solve complex problems and find desirable solutions for clients. It is a process used to map and guide different modes of thinking in order to trigger creativity and innovation (McKim 1973, Rowe 1987, Faste 2012, Kelley 2007, Kelley and Kelley 2013). As per Brown, “Design thinking is a discipline that uses the designer’s sensibility and methods to match people’s needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity.” (Brown 2008, p. 84). Design thinking for innovation was applied in multiple case-based projects in this thesis work as a vehicle to elicit new ideas and support the overall application of the FSSD.

Case Organizations
In this thesis real-world business models from case-companies within diverse sectors were used as a unit of analysis (Bryman and Bell 2015) for the investigation of the main research question. A summary of the case organizations and people involved in the respective study is given in Table 5. The case studies were generally informed by recommendations by (Yin 2009), Bryman (2012) and Bryman and Bell (2015).

The key outcome from Section B was contextual material from the performed research, such as transcriptions, observation notes, sketches, business model templates, prototypes, insights and reflections, graphics and diagrams. This material formed a basis for the thesis and papers, research reports and a resource kit for practitioners.
### Table 5. Case organizations involved in the research.

**Paper B: Systematic Guidance for How to Integrate a Strategic Sustainability Perspective in Core Business Decision Systems**

<table>
<thead>
<tr>
<th>Organizations</th>
<th>Activity Types</th>
<th>Departments/ Roles</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABB High Voltage Cables, Hammarplast</td>
<td>Interviews, site visits, feedback and discussion for validation</td>
<td>Manager New Products, Manager Operations, Managing Director, Product Developers, Sustainability Officers</td>
</tr>
</tbody>
</table>

**Paper C: Sustainability Self-Assessment and Business Model Design**

<table>
<thead>
<tr>
<th>Organizations</th>
<th>Activity Types</th>
<th>Departments/ Roles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cascades Djupafors, Tetra Pak Technical Service, Scandic Hotels, Affärsverken (Energy Utility), Volvo Construction Equipment</td>
<td>Interviews, workshops for assessment, co-creation, feedback and validation</td>
<td>Purchasing Managers, Business Managers, Sustainability Experts, Project Leaders</td>
</tr>
</tbody>
</table>

**Paper D: District Heating and CHP – a Vital Role for the Development towards a Sustainable Society?**

<table>
<thead>
<tr>
<th>Organization</th>
<th>Activity Types</th>
<th>Department/Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swedish District Heating Association</td>
<td>Workshops for feedback and validation, modeling, simulation</td>
<td>National Reference Group (See: Paper D)</td>
</tr>
</tbody>
</table>

**Paper E: An Approach to Business Model Innovation and Design for Strategic Sustainable Development**

<table>
<thead>
<tr>
<th>Organizations</th>
<th>Activity Types</th>
<th>Departments/ Roles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aura Light International,</td>
<td>Interviews, questionnaires, workshops for assessment, co-creation (using conceptual modeling and creativity techniques), feedback and validation</td>
<td>CEO, VP Business Development, VP Product Development, Sustainability Manager, Business Developers, Product Developers, Engineers</td>
</tr>
</tbody>
</table>

### 3.4 Section C - Analysis of Data and Generation of Results

The phenomena under study were understood from the perspective of complex systems (i.e. systems that constitute of a relatively large number of parts that interact in complex ways to produce behavior that is sometimes
counterintuitive and unpredictable). Therefore, the systems approach provided by the FSSD was used as an overall guide to the data analyzes.

The various types of data and materials obtained from the diverse sources described above were organized into categories (e.g. the categories PSS, Business Models and Sustainability). Various sub-categories were also created and labelled (coded) during the research process. As mentioned in the previous section, many of the methods and techniques described there were used also to generate results (e.g. the design methods). Also modeling (both conceptual and technical), simulation and logical reasoning were used to generate results.

The search for patterns and structures in the collected data, the logical reasoning and the designing led to structured thoughts, ideas and designs, finally ending up in the proposed approach to “Business Model Design for Strategic Sustainable Development”. All of this formed a basis for the thesis and papers, research reports and a resource kit for practitioners.

3.5 Section D - Reporting

The reporting process is an important part of the research process, not only because it represents a main channel of dissemination of results, but also because it works as a kind of analytical method. The results coming out of creative processes need to be scrutinized at some stage by the analytical and critical side of the brain, and the writing process is a means for doing so. What seemed to be a great idea or solution in a creativity session might turn out to not actually hold to scrutiny when it is to be described in text. It is in place here to remind about the iterative nature of the whole process as pointed out before. Reporting being listed last in Table 4 does not mean that all writing happened at the end. It happened many times throughout the process, in smaller or bigger pieces. Obviously the appended papers were written at different times throughout the process, but also the papers were written in parts at different times. Smaller iteration loops happened within bigger iteration loops.

The writing process also often forms part of validity considerations. Since the papers appended to this thesis have been written with co-authors, this became one way of checking interpretations, conclusions and descriptions. Also the external partners taking part in the studies were helpful for this purpose. According to Maxwell (2012) a validity check is in essence to ask: “How might your results and conclusions be wrong?” Hand-shaking interpretations and conclusions with the participating external partners was an important part of pursuing this question. Getting information from several sources
(triangulation) also supported validity. For example, information from the academic literature could be checked against information obtained from the case organizations and vice versa.

In qualitative research it is more common to talk about credibility than validity. Again referring to Maxwell, validity should be seen as the “credibility of a description, conclusion, explanation, interpretation or other sort of account” (Maxwell 2012, p. 122).

As support for the actual writing of papers and the thesis, the advice given by Gustavii (2000) was found very useful.

The final outcomes from this section were the thesis and Papers A, B, C, D and E, research reports and a resource kit for practitioners.
4  Summary of Appended Papers

This chapter presents brief summaries of the appended papers, clarifies how they contribute to the thesis and clarifies the present author’s contribution to the papers.

4.1  Paper A

*Exploring the Nexus of Product-Service Systems, Business Models and Sustainability - a need for strategic and practical approaches*

*Submitted as:*

*Summary*

The paper explores the connections and the potential functional nexus between the three fields of Product-Service Systems (PSS), Business Models and Sustainability, in pursuit of possible key enablers to further realization of the potential for sustainability-promoting PSS. The motivation for the study is that progress has been relatively slow as regards realizing this potential and that a lack of practical approaches to the design of *business models* capable of supporting implementation of such PSS has been proposed as a partial reason. A systematic review and analysis of the academic literature shows that, although a relatively new and unexplored endeavor, there is growing effort at the interface of the three fields. The review indicates that the main deficit so far is that the PSS and business model fields lack *concrete* guidelines and *practical* tools for how to embrace the sustainability dimension in a *strategic* way. Especially the strategic dimension emerges as a general finding from diverse sources as a potential key enabler for mutual benefits across the three fields. The study thus points to the need for research aiming at developing such guidelines and tools, and also at exploring case-based applications to create experiential knowledge, to fill the gaps in current theory and practice.

*Relation in Thesis*

This paper is the result of a literature review process over the PhD work. The review provides a background of the fields studied in the thesis and of their integration. The outcome points clearly to the strategic dimension as key for obtaining sustainability-promoting PSS and business models, and thus the
paper sets the scene for and motivates the approach taken in the other papers and the thesis as a whole.

**Contribution of Author**
The author initiated the study by establishing the basis for the systematic literature review, led data collection, data categorization and data analysis, led the results generation process, led the writing process, and handled the submission process.

### 4.2 Paper B

*Systematic Guidance for How to Integrate a Strategic Sustainability Perspective in Core Business Decision Systems*

**Published as:**

**Summary**
The paper is an initial response to the challenge of sustainability integration into core business and product development processes, and specifically into the strategic decision processes. Many existing supporting tools, methods and concepts are mainly focusing on specific environmental aspects. They therefore often fail to serve companies in integrating more comprehensive sustainability thinking into their strategic decision processes, and consequently into their core business and product development. The paper presents an approach to: (i) assessing the current state of sustainability integration in a company’s decision systems and (ii) integrating strategic sustainability thinking into the decision processes, i.e., aligning vision, management system and tools to help prioritize actions in a backcasting plan for development towards a sustainable company within a sustainable society. The approach includes a SWOT-analysis supported strategic capability assessment and generic guidelines for how to identify appropriate targets and indicators, all informed by a framework for strategic sustainable development.

**Relation in Thesis**
This paper provides a starting point for the integration of a strategic sustainability perspective in organizations’ cultures and operations (vision, management and tools) and serves as a basis for the business models assessment and business model design approaches in the coming papers.
Contribution of Author
The author participated in the study design, data collection, data categorization and data analysis, participated in the results generation process, led the writing process, handled the submission and review process, and also presented the paper at the ICED conference in 2009.

4.3 Paper C

Sustainability Self-Assessment and Business Model Design

Published as:

Summary
The paper presents the development of, and a suggestion for, a sustainability self-assessment tool. The suggested tool was tested among some case organizations and in particular it was investigated whether the tool was perceived by those organizations to be: (i) easy to comprehend, (ii) relevant, (iii) capable of differentiating the organizations in a comprehensive way, (iv) helpful for discovering insufficiencies that the organizations are not already aware of and (v) helpful for the generation and selection of ideas for upstream solutions, business model innovation and for formulation of goals and strategies. The tests showed that the self-assessment matrix provided opportunity for dialogue and clearly exposed opportunities and challenges. It also provided guidance for idea generation for how to move towards higher levels of maturity. The profile visualization used in the tool was highly appreciated by the organizations. The business model design templates extended the maturity matrix deeper into the value chain and linked to typical business model terminology. In one case study, modeling of future energy systems in housing and buildings that followed the creativity exercises triggered insights for prototyping innovative business models.

Relation in Thesis
This paper brings Paper B further by proposing a hands-on tool for assessing gaps from a strategic sustainability point of view and to stimulate generation of ideas for innovative business models.
Contribution of Author
The author led the study design, data collection, data categorization and data analysis, led the results generation process, led the writing process, handled the submission and review process, and also presented the paper at the Sustainable Innovation Conference in 2012.

4.4 Paper D

District Heating and CHP – a Vital Role for the Development towards a Sustainable Society?

Published as:

Summary
The paper presents a study of a local energy system with a special focus on the role of district heating and combined heat and power generation (CHP) for sustainable development. By using methods and tools for energy systems analysis, and by expanding the perspective to include a wider value network and a backcasting perspective (provided by a business model development approach informed by a framework for strategic sustainable development), it was shown that mutually supportive actions can be found. It was shown that although district heating might not have any major sustainability advantages over other heating technologies in a sustainable society, it can play a vital role for the development towards such a society. It was also shown that if the local energy utility cooperates with a local industry plant and invests in a new CHP plant, both emissions and costs can be significantly reduced compared to business as usual. Furthermore, the approach clarified, in particular through the strategic backcasting perspective, the risks of uncritically assuming an increasing access to certain types of fuels.

Relation in Thesis
This paper shows how modeling and simulation methods and tools can be integrated into decision support and be used for clarification of the implications of alternative business models and development paths. Specifically, it shows how such methods and tools can be used for supporting prioritization of early smart actions in a backcasting plan and for successive redesigns of the plan, and how such methods and tools can be used to
compare the consequences of business model designs focused on incremental versus radical innovation.

**Contribution of Author**
The author participated in the study design, data collection, data categorization and data analysis, participated in the modeling and simulation, participated in the writing process and handled the submission and review process, and also presented the paper at the USCUDAR conference in 2012.

### 4.5 Paper E

*An Approach to Business Models Innovation and Design for Strategic Sustainable Development*

**Published as:**

**Summary**
The paper describes how the Framework for Strategic Sustainable Development (FSSD) could inform business model innovation and design through a proposed concrete approach that combines the FSSD with the Business Model Canvas (BMC) and other supplementary tools, methods and concepts such as creativity techniques, value network mapping, life-cycle assessment, and product-service systems. The combined approach was applied in a real case of business model evolution towards providing sustainable PSS solutions in the form of light as a service, for the purpose of initial testing and evaluation. This indicated that the new approach is useful in practice for its intended primary purpose and also that it can strengthen each supplementary tool, method and concept in its own respective primary purpose. Some general benefits of the new approach is that it facilitates, e.g., business scalability and risk avoidance and clarifies the interplay between classical business model development and strategic sustainability thinking. This provides a foundation for better investment strategies and facilitates a broadened view on, and a more solid foundation for, collaboration with stakeholders that are increasingly important to sustainable business success.

**Relation in Thesis**
This paper is a direct response to the gaps identified in the systematic literature review presented in Paper A and brings together the experiences
gained in the studies presented in Papers B, C and D to provide an answer to the main research question of the thesis.

**Contribution of Author**
The author led the study design, data collection, data categorization and data analysis, led the results generation process, led the writing process, and handled the submission and review process.
5 Main Result

The results of the individual papers are presented in the respective paper and brief summaries were given in Chapter 4. This chapter presents the main synthesized result of the thesis, as a response to the main research question.

**Business Model Design for Strategic Sustainable Development**

An Approach to Business Model Design for Strategic Sustainable Development is presented in more detail in Paper E by means of an example. It is also described thoroughly in a resource kit for practitioners. Here a brief and general version is given.

Based on the identified need for practical support and the importance of the strategic dimension (see Paper A and previous chapters), the new approach is guided by the Framework for Strategic Sustainable Development (FSSD; Broman and Robèrt 2016) and entails a combination with a practical tool for business model development known as the Business Model Canvas (BMC; Osterwalder and Pigneur 2010). See Chapter 2 for a description of the FSSD and Paper E for a description of the BMC. Specific aspects of the complementarity of the two are also given in Paper E. Also other supporting tools, methods and concepts, such as creativity techniques, value network mapping, and life-cycle assessment are recommended to include as needed from case to case. Not least the product-service systems (PSS) view is included (see Chapter 2). Specifically, the implementation process of the new approach is organized along the ABCD-procedure of the FSSD (see Chapter 2), as shown in Figure 10 and summarized below.

**A-STEP**

**Recommended activities:** A facilitator should, preferably in workshop format, introduce the FSSD, the BMC and the combined FSSD-BMC approach to the participants in the organization and possibly participants from the value chain (as appropriate depending on the depth reached in the iterative work). It is important to have top management and other key actors involved in this step, such as the CEO, sustainability director, key business developers and key product developers. It is important in this step to include PSS thinking and the potential strategic pathways towards sustainability this can enable, e.g., to offer functions (result-oriented PSS). To assure a strategic sustainability perspective, the FSSD should be used for overall guidance for the work. An important question is: How are future markets likely to evolve in “the funnel”, and how can our organization best aid various stakeholders in moving towards
sustainability? The integration guidance presented in Paper B could be used to support the work. Modeling and simulation tools can be used to visualize the considered visions and/or the agreed upon vision and also facilitate learning.

**Expected outcomes:** An agreed description of the organization’s mission or core purpose and a vision framed by the sustainability principles of the FSSD, preferably including a sketched partial pilot business model (using the BMC) with proposed value propositions/business ideas. Again, when laying these foundations for the coming work, it is important to not only focus on the direct sustainability impacts of the organization but to also think about how the organization can help others become sustainable through its PSS offerings (and thus speed up society’s transition towards sustainability), and by doing so also improve its own competitiveness.

**B-STEP**

**Recommended activities:** The same participants (possibly without top management) should here map and assess the current business model (using the BMC) and the current value network and its sustainability implications (using value network mapping and analysis templates). The following main question should guide this work: *How are stakeholder relationships in the value network of the business model configured and what are the sustainability implications of this configuration?* More specifically, the following activities and product life stages should be addressed: design, production, distribution, use, and end of life (collection, reuse/recycling and/or disposal), and the participants should aim to: (1) Identify all key stakeholders related to each activity and product life stage. (2) Identify the relationships between the key stakeholders and characterize the respective relationship. (3) Identify information flows, material flows, energy flows and socio-ecological sustainability issues among key stakeholders throughout product life stages. The sustainability principles of the FSSD should be used for the sustainability assessment. The assessment guidance presented in Paper B and the sustainability self-assessment tool presented in Paper C could be used to support the work. Strategic life-cycle assessment and life-cycle assessment tools could also be used as needed. Also modeling and simulation tools could be used to estimate magnitudes when life-cycle data is not available.

**Expected outcomes:** The participants will here gain an overview of the current business model as captured by the BMC and the current value network and its implications as captured by the value network mapping and analysis templates. The outcomes will include insights about existing patterns and trends within the organization and its value network. For example, insights about flows of
materials that are currently emitted from the value network and are systematically accumulating in the ecosystem. Generally, there will be an overview of socio-ecological sustainability challenges that the organization and its value network contribute to, but also an overview of assets of the organization and its value network in relation to the vision. From step A and B there should now be a good understanding of the gap between the sustainable vision and the current situation, as a foundation for the creative work in the next step.

**C-STEP**

**Recommended activities:** Based on the identified challenges and assets in the B step and the gap to the vision, the same participants (preferably including top management) will now use creativity and problem solving techniques (such as context mapping, brainstorming and the ones exemplified in Chapter 3) to develop and list possible solutions and prototype various possible business models, using the BMC to capture and integrate the solution ideas and to present the prototyped models to get feedback and support for prioritization. Modeling and simulation tools (e.g. as those used in Paper D) could be used to stimulate creativity, but only for that purpose in this step, not for convergent work. Constraints based on the current situation should not be allowed to hamper creativity. In this step, the only constraints to consider are those implied by the sustainability principles of the FSSD.

**Expected outcomes:** The participants will here have a wide array of possible solutions to the identified challenges, considering also the identified assets, for closing the gap to the vision. This includes new business model prototypes. Examples of changes could be new financial models, reduction of ecological impacts through dematerialization and substitution of problematic substances, development of new needfinding approaches and tools, expanded multi-stakeholder collaboration, and training programs. The outcomes from this divergent step form the basis for the convergent work in the next step.

**D-STEP**

**Recommended activities:** The participants will here prioritize among the possible solutions and prototyped business models from the C-step, using the strategic guidelines of the FSSD. Top management should be involved in this step so that the prioritized actions (the strategy of the organization) is fully embraced by top management and that the organization knows that. In this step, modeling and simulation tools (e.g. as those used in Paper D), investment
calculus tools and other decision support should be used as appropriate to support the convergent work.

**Expected outcomes:** In the end, a prioritized business model and related actions for its implementation put into a strategic plan are the results of this step. However, since this is an iterative process there might be a number of alternative business models as an outcome, which will be taken through the previous steps again for further assessment and development before final decisions on priorities are made. As in all strategic planning, there is also a need for continuous reassessment of the plan and the business model as the contextual conditions change over their implementation.

![Figure 10. Business Model Design for Strategic Sustainable Development.](image)

The new approach should preferably be used as early as possible in the innovation process, where the opportunity for influencing the impacts of the resulting products and services over their life-cycles is the greatest (e.g. Charter and Chick 1997, McAloone and Tan 2005). Furthermore, as pointed out by Thompson (2012), PSS development and design should happen at an overall systems level first, rather than developing and designing physical products first and then think about service components. Also, e.g., Ericson and Larsson (2005) point out the importance of parallel product development and business development. The proposed approach to business model design for strategic sustainable development described above supports these views.
6 Discussion

This chapter provides a discussion of the results of the thesis, a critical assessment, a comparison with results of similar studies, and some final remarks and directions for future work.

6.1 Main Message

The overall aim of this work was to develop an approach to business model design that supports strategic sustainable development, i.e., supports organizations to contribute to society’s transition towards sustainability in a way that strengthens the organization.

The literature reviews performed during this work support the idea that tools, methods, concepts and approaches for business model design can best contribute to sustainability when all aspects of their application and implementation are guided by an understanding of strategic sustainable development. This includes an understanding of what sustainability is and of how in principle to develop sustainability-promoting, economically viable strategies. In particular the systematic literature review presented in Paper A points out the importance of the strategic dimension, and also a need for concrete guidelines and practical tools.

In pursuit of this idea, some existing tools, methods and concepts, such as Product-Service Systems (PSS), the Business Model Canvas (BMC), energy modeling and simulation tools, etc., have been combined with the Framework for Strategic Sustainable Development (FSSD) in a number of real-world studies as presented in Papers B through E. Also new guidance and a new tool were developed as presented in Papers B and C. The studies provided pragmatic insight for the layering of strategic sustainability thinking directly into business model innovation and design. Throughout the work, participating partners were able to successfully use strategic sustainability perspectives and design/redesign processes to develop novel business approaches and models, including PSS, which were economically feasible and aligned with sustainable development. For example, the proposed approach proved useful in real-world business model evolution as presented in Paper E. According to the CEO of the case organization (Aura Light International), the new PSS-offer and business model (Light as a Service) is already responsible for 10% of the revenue stream and is expected to be at 20% of the revenue stream of the company by the
first quarter of 2017\(^2\). The new approach has clearly been helpful in shifting the business logic form having sales of physical products as the main basis of revenue into having the provision of *sustainable solutions* as the main basis of revenue in the future, in line with the new mission and vision of the company.

The new approach especially embraces the importance of the product design/development function in a company. It is in the early phases of the innovation process where most sustainability challenges can be solved and most opportunities can be captured (e.g. Charter and Chick 1997, McAlone and Tan 2005). Adding in PSS thinking in business model design required the type of intimate knowledge on product design, delivery and utility that only product designers/developers could supply. Bringing together business developers and product designers/developers in the early phases of the innovation process is, therefore, critical. However, this does not mean that product designers/developers will automatically assure specific solutions simply through their inclusion. Transforming from pure physical product logics to PSS and further to sustainable PSS required a suite of actors engaging in a broader discussion that considered a new cyclical perspective of possible PSS value propositions. Development of sustainable solutions required a strong focus on promoting multi-stakeholder and expert collaboration for succeeding with the design of successful and innovative business models, guided by overarching sustainability knowledge and supported by pragmatic tools and business-model design processes.

### 6.2 Critical Assessment

The fact that only the redesign of existing business models was studied in real cases both in this thesis and throughout the majority of the literature reviewed is a weakness and indicates a need for testing the approach also in real cases involving start-up businesses.

Furthermore, only a small number of cases or units of analysis were studied in the thesis. This should be extended in future work to create better representation of diverse business sectors and provide wider validation of the proposed approach. While there are common large themes identified (e.g. the utility of a strategic sustainability lens), each studied case showed the need for engagement with diverse audiences within distinct contexts. For example, working with community-utility-based district heating providers did share some similarities to working with strictly privately owned companies in terms

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\(^2\) Personal communication between CEO Martin Malmros and Prof. Göran Broman, September, 2016.
of, e.g., need for internal and external education, engagement, ideation and trust building. Still, each context required attention to, e.g., different internal culture, different overall goals, and different scope of operations. However, the diversity of work presented, while being small in sample size, is still fairly high and should provide some confidence in the common themes that have been highlighted.

The relative lack of existing studies and data within this emerging research field (on the interface of PSS, business models and sustainability), combined with the applied nature of this field of study and goals of this thesis, meant that significant emphasis needed to be placed on action research and primary data collection. Given the time constraints of the PhD work, the selection of cases had to be partly opportunistic, i.e., to some degree limited to available relationships. In the future, a more cohesive suite of case studies could provide deeper insight into effective implementation efforts within various business sectors and approaches.

Given the complex system that makes up the nexus of PSS, business models and sustainability, simple cause-effect studies are inadequate for arriving at generalizable conclusions. Unfortunately, this also means that classic experimental methods are insufficient for effective research. As a result, the task was, and the future task will be, to iterate and innovate the research process and build a growing data pool to see if the constructs, explanations and interpretations make sense and/or need adjustments.

In the work so far, triangulation served the primary purpose of avoiding bias and providing confidence that the complete body of existing work was considered for the delineation of research question(s), research approaches and comparative analyzes within the thesis. Two kinds of triangulation were employed; sources triangulation and analyst triangulation. The triangulation of sources enabled validation of the quality and credibility of secondary data, using literature from many different authors and from different databases. Analyst triangulation was employed by use of multiple analysts to review the findings, i.e., multiple researchers in the teams, involvement of practitioners and utilization of peer review evaluation.

6.3 Comparison with Other Studies

As mentioned in Chapter 2 and Paper A, Boons and Lüdeke Freund (2013) present normative requirements that business models should meet in order to support sustainable innovations. To some extent their results—in terms of core components of a sustainable business model—are similar to the results of this
thesis. However, though the study supports the idea of developing tools for how to integrate sustainability thinking into PSS and business model development, it does not suggest any concrete approach for how to do this. As argued in this thesis, a major barrier to sustainable innovation is the unawareness of an operational definition of sustainability and of strategic guidelines for organizations to support society’s compliance with the definition. Using the FSSD to guide business model design and PSS innovation is a way of addressing that barrier.

Bocken et al. (2014) suggest that certain business model archetypes could contribute to building up business models in support of sustainability. They clearly suggest strategic means and emphasize, e.g., functionality rather than ownership as one of the archetypes, and thus provides strong support for the combined approach proposed in this thesis. The concrete A-B-C-D steps of the suggested approach bring this idea further towards practical applicability and the operational definition of sustainability allows for evaluation from the full scope of sustainability. Also Reim et al. (2015) are supportive of looking for more operational ways of doing the integration of the three fields as this thesis has proposed a concrete approach for.

The reasoning behind the framework of strongly sustainable business models (Upward and Jones 2015) largely supports the work in this thesis. There are clear similarities with the reasoning in this thesis, e.g., related to product development, stakeholders and measurement. The relationships to PSS are not so clear, though, and the focus is more on ontological aspects and the understanding of terms than on practical how aspects.

Joyce et al. (2015) extend the original business model canvas (Osterwalder and Pigneur 2010) by adding two layers: an environmental layer based on a life-cycle perspective and a social layer based on a stakeholder perspective. An aim was to make more explicit how an organization generates multiple types of value – economic, environmental and social. There are some similarities to the approach presented in this thesis, e.g., the use of the business model canvas, the life-cycle perspective, and inclusion of the social dimension. However, the approach proposed in this thesis emphasizes the use of strategic life-cycle assessment before more comprehensive life-cycle assessments are (possibly) performed. The approach presented in this thesis also does not add complexity to the BMC itself but uses the FSSD to guide the use of the original BMC and provides sustainability complementarity. The complementarity between the FSSD and the BMC is thoroughly outlined in Paper E.
In various ways, previous work has identified a need for strategic and pragmatic approaches to business model development informed by global sustainability considerations, as well as the potential of PSS in this context. Some progress has been made along those lines, but arguably this thesis brings a stronger focus onto the interface of the fields of PSS, business models and sustainability and proposes a concrete approach to business model design for strategic sustainable development as outlined in Chapter 5 and Paper E, and also in a resource kit for practitioners. An important contribution is the use of an operational principled definition of sustainability. Within the boundaries delineated by science-based sustainability principles, more robust sustainable business opportunities can be identified. In the absence of the latter, “sustainable” business model archetypes for circularity, e.g., are not necessarily sustainable. A cyclical business model that embeds child labor, e.g., is certainly possible, but might violate principles for social sustainability. Also, strategic guidance is necessary to deal with trade-offs, e.g., to understand which resources should be kept in closed loops and which ones should be phased out, and then design for reuse, recycling, up-cycling and support systems as appropriate.

6.4 Concluding Remarks and Future Work

The research presented in this thesis shows that without the addition of a science-based definition of sustainability and guidelines for how an organization can support sustainable development and strengthen its own competitiveness, businesses will run into limitations that are continuously emerging as consequences of unsustainable development and/or more skillful navigation of society’s transition towards sustainability among competitors. The new approach outlined in this thesis highlights the need for directly integrating an appropriate sustainability lens when considering emerging markets. In the culminating effort of this thesis, the new combined approach highlights the great potential that exists for business, both individually and as a global institution, if a systematic and strategic approach to sustainable development is layered into business-model development. The new approach helped to clarify strengths and weaknesses of current business models from a strategic sustainability perspective; to transform an organization’s vision and strategy into a sustainability-framed vision and a sustainability-promoting strategy; and to communicate the new vision and strategy to the value network as a basis for engaging important stakeholders in the change. For example, the new approach supported one of the partner companies in its transformation towards providing sustainable PSS solutions in the form of light as a service.
Generally, the new approach allows for a suite of classic business objectives to be strengthened. For example:

- **Differentiation and ongoing value creation**: many businesses today find their products and services, even their brands, in the midst of global mass commodification. The approach developed in this thesis puts an emphasis on developing sustainable and ongoing value-creation supported by functional product-service mixes, which can more easily be kept unique, e.g., by being locally adaptive and flexible, while being informed by global sustainability considerations.

- **Scalability**: combination of the FSSD, PSS and the BMC allows for businesses to avoid developing their business based on behaviors that are demonstrably unable to scale to a global level (e.g. failing to understand implications of relying on unsustainably managed natural resources and failing to take into account wide spread impacts across multiple socio-economic sectors of globally successful business actions). Thus, without the integration of strategic sustainability thinking, the “holy grail” of globally transformative business becomes economically unsound.

- **Risk Avoidance**: similar to scalability, the integration of a strategic sustainability lens into the classic business model paradigm clarifies a number of previously invisible risks in the business model development process.

- **Investment Strategy**: the combination of highlighting new scalability issues and risks provides a more complete lens for the identification and development of strategic investment pathways, i.e., generating and prioritization actions into flexible platforms for sustainable business success, including potential resource requirements.

- **Partnerships and Social Integration**: the broadened and more realistic business landscape provided by the new approach highlights a suite of new potential partnerships, relationships, cooperative activities and integration across an enlarged group of institutions that are increasingly important to business success.

The new approach to Business Model Design for Strategic Sustainable Development also highlights the general value of bringing specific sectorial-development aspects to more general frameworks for sustainable development. While the FSSD brings critical information and guidance for sustainable development in any institutional context, by itself it does not provide all the information needed for the sustainable development of
successful institutions in any given arena (e.g. business, government, NGO or other emerging institutions). Having the combination of both overarching strategic guidance (e.g. the FSSD) and sector-specific needs and tools (e.g. the BMC and other support tools for business) is becoming increasingly important as all sectors must evolve for sustainable development.

Overall, the new approach clarifies the interplay between classical business model development and strategic sustainability thinking and highlights the opportunity for novel business model design for future sustainable success.

Next steps of this research will include wider testing to possibly build a stronger overall evidence base. More extensive studies are now needed to confirm the initial results and to capture improvement potentials of the presented approach. Including cases of development of entirely new businesses, as well as widening the scope to more comprehensively include also the realization phase of the innovation process, is also motivated.
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Paper A

Exploring the Nexus of Product-Service Systems, Business Models and Sustainability - a need for strategic and practical approaches
Exploring the Nexus of Product-Service Systems, Business Models and Sustainability - a need for strategic and practical approaches

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Abstract

Product-Service Systems (PSS) have been identified as potentially important for addressing sustainability challenges. However, progress has been relatively slow as regards realizing this potential, and a lack of practical approaches to the design of business models capable of supporting implementation of such PSS has been proposed as a partial reason. The aim of this study is to explore connections and the potential functional nexus between the three fields of PSS, Business Models and Sustainability, in pursuit of possible key enablers to further realization of the potential for sustainability-promoting PSS. A systematic review and analysis of the academic literature is performed. The review shows that, although a relatively new and unexplored endeavor, there is growing effort at the interface of the three fields. The review indicates that the main deficit so far is that the PSS and business model fields lack concrete guidelines and practical tools for how to embrace the sustainability dimension in a strategic way. Especially the strategic dimension emerges as a general finding from diverse sources as a potential key enabler for mutual benefits across the three fields. The study thus points to the need for research aiming at developing such guidelines and tools, and also at exploring case-based applications to create experiential knowledge, to fill the gaps in current theory and practice.

Keywords: sustainability, strategy, sustainable product-service systems, sustainable business model, systematic literature review, strategic sustainable development.
1 Introduction

Given the central role of human economic activity in global development, sustainability-informed business activities will be a key part of any sustainable future (Basile et al. 2011). It has been proposed that product-service systems (PSS) have the opportunity to both be put into effective practice and to contribute significantly to sustainable development of society (Stahel 1997, Goedkoop et al. 1999, Mont 2002, Tukker 2004). However, progress has been relatively slow as regards realizing this potential (Vasantha et al. 2012, Tukker 2015), and a lack of practical approaches to the design of business models capable of supporting PSS implementation has been proposed as a partial reason Vasantha et al. (2012). Thus, understanding the interfaces between the three fields of PSS, Business Models and Sustainability is critical.

The idea of co-developing tangible products with intangible services to create a combined higher-value product-service offering has been explored from multiple perspectives (e.g. Mont 2002, Baines et al. 2009). For example, market evolution such as the desire for “just-in-time” solutions has led to increased servitization of manufacturing firms in order to adapt to changing market conditions for those firms (Baines et al. 2009). In areas where market-defining innovation of physical products is waning, the concept of PSS enables significant change in offers to customers that, in turn, allows PSS providers to continue to differentiate themselves from competitors (Sakao et al. 2009). The development of the PSS field has had some tangential development in the sustainability dimension, though much of the discussion has highlighted a lack of guaranteed improvement in sustainability performance simply by moving to PSS (Tukker 2004, 2015).

The literature in the area of business models has shifted over the previous decades, as the scope has converged to focus at the company level rather than a broader historical scope that included both a more detailed focus (product level) and a broader focus (industry level) (Wirtz et al. 2016). Osterwalder and Pigneur (2010) and the “Business Model Canvas” may be in part responsible for this (Alt and Zimmermann 2014) by providing a widespread tool for developing business models that are considered successful, but are not necessarily informed by broader global systems perspectives. And, as with PSS, there has been some exploration of various business aspects that either align or interfere with sustainable development. For example, today’s ubiquitous consumer-product business models that rely on “planned obsolescence” and linear “take-make-waste” production have been identified as central to sustainability challenges and, thus, highlight the need for the development of new business

More recently, studies have begun to link the three fields, but typically only two of the three at any one time. For example, significant work has focused on the sustainability potential of PSS, e.g., the work of Stahel (1997, 2007), Roy (2000), Enhenfeld (2001), Manzini and Vezzoli (2003), Tukker (2004), Tukker and Tischner (2006), Vezzoli et al. (2015), and Tukker (2015). The case for why businesses and their associated business models should pursue and support sustainability for self-beneficial economic reasons as well as for society at large has been increasingly made (e.g. McNall et al. 2011, Robèrt and Broman 2016, Willard 2016). What firms have done and can do aligned with sustainable development has also been described by, e.g., Boons and Lüdeke-Freund (2013), Schrettle et al. (2014), Clinton (2014), and Joyce et al. (2015). However, while the implication exists that all three fields should be combined to create sustainable enterprises, a significant gap as regards how remains.

1.1 Summary of Previous Literature Reviews
To clarify and justify the need for this literature review and to identify the existence of similar work that explores the interface of the fields of PSS, business models and sustainability, a preliminary search was conducted using Thomson Reuters Web of Science, Scopus and Google Scholar digital libraries. The search (performed on April 30th 2015) focused on article titles, abstracts and keywords using the search string: Sustainab* “product-service system*” OR PSS* Strateg* “Business Model*” “Systematic Review”

Four previous literature reviews were identified for preliminary comparisons.

Boons and Lüdeke-Freund (2013) reviewed 115 articles to answer the following questions: What does the current scientific literature reveal about the interrelations between business models and sustainable innovation? How can the business model perspective help to define future topics for research on sustainable innovation? Combining the work of Osterwalder (2004) and Doganova and Eyquem-Renault (2009), the authors propose a set of four generic normative requirements which they deem necessary in a business model to successfully market sustainable innovations: value proposition, supply chain, customer interface, and financial model.

The review concludes that sustainable innovation literature often tends to overlook the details of how firms integrate those four elements of a business model. Firms are often treated as black boxes looking either only at impacts of
external factors or analyzing specific internal subcomponents of the firm. In other situations value chain and value proposition aspects of the business model are discussed, but lack connection to the firm overall or discussion of the revenue model. Further, the review suggests that for a sustainable value proposition, business-society dialogues must identify trade-offs between optimal product and service performance. The idea of co-developing products and services, PSS, is mentioned only peripherally, while several core aspects of the PSS literature are briefly described in their discussion, i.e., opportunities for dematerialization, supply chain dynamics, customer interface, and shifting revenue models from selling physical artifacts toward selling functional results. Though the study supports the idea of developing tools for how to integrate sustainability thinking into PSS- and business model development, it does not suggest any concrete approach for how to do this.

Bocken et al. (2013) formalize a categorization of business model innovations to deliver sustainability that link the theory of business model innovation to actual transformations in industry that move toward sustainability. They suggest a business model defined by three main elements: the value proposition, value creation and delivery, and value capture. They introduce eight sustainable business model archetypes, grouped by three mechanisms (technological, social, and organizational) that may contribute to business model innovation for sustainability. For each of the eight archetypes, they describe the three elements. The technological group includes the archetypes: maximise material and energy efficiency, create value from waste, and substitute with renewables and natural processes. The social group includes: deliver functionality rather than ownership, adopt a stewardship role, and encourage sufficiency. The organizational group includes: re-purpose the business for society/environment, and develop scale up solutions.

The review’s conclusions clearly highlight the need for an integrated approach to sustainable enterprise that includes integrated sustainable PSS- and business-model development. Further, the authors identify four emerging themes in the study of sustainable business models: the role of technology advancement and level of innovation, application of a systems perspective, innovative approaches to collaboration, and the need for education to facilitate successful adoption of sustainable business models. They go a bit further than the previous review when it comes to suggesting strategic means, but general advice to consider efficiency, reduced waste and substitutions do not suffice when it comes to embrace the full scope of sustainability.

Reim et al. (2014) conducted a systematic literature review on PSS business models and tactics, noting that the PSS concept was “first convincingly
established in 1999 by (Goedkoop et al. 1999)” and PSS literature is mostly published after 2003. Thus, the authors identify the relatively early stage of the PSS approach from a maturity perspective and, in turn, reinforce the observation that most products are not developed or delivered within a larger functional economic value proposition that could include global system aspects over long time horizons. The review supports the idea that for the successful implementation of PSS, business models play a fundamental role. The article states that business models describe mechanisms for three things: how value is created, delivered, and captured. The article confirms earlier classifications of business models into product-oriented, use-oriented, and result-oriented models (e.g. Baines et al. 2007) that are popular within the PSS literature (e.g. Tukker 2004). The authors discuss the three mechanisms relating to value within each of the three classes of business models.

Moving from concept to practice, the authors explore tactics for PSS, defining tactics “as the company’s residual choices at an operational level after deciding which business model to apply” with reference to (Casadesus-Masanell and Ricart 2010). With this definition, they identify and discuss at length five sets of tactical practices. These tactical sets include: 1) contracts, 2) marketing, 3) networks, 4) product and service design, and 5) sustainability. In addition to proposing PSS tactics, Reim et al. (2014) further propose that there exists a critical link between the strategic aspect of business models and the tactical aspect of PSS that is seldom considered or explored.

With regard to sustainability, the authors discuss how methods and opportunities for improvements vary greatly depending upon the business model and identify two main aspects for consideration: First, resource utilization and the idea that services added to product offerings are likely to improve product utilization and/or reduce the number of products in use, both, presumably, sustainability improvements. Second, the extent of innovation, i.e., whether innovation happens through, e.g., increasing intensity of use (an incremental improvement to reduce the number of products and corresponding life cycles necessary to provide a specific amount of function) or through, e.g., novel means of fulfilling the function which may lead to radical improvements from a sustainability perspective. Like the previous reviews, it is supportive of looking for more operational ways of doing the integration of the three fields, but does not propose a concrete way forward for how to do this.

Finally, Upward and Jones (2015) conducted a transdisciplinary review of the literature. An enterprise framework compatible with natural and social science is presented. The review considered various articles for analysis with the intention of answering the question: What is a successful sustainable business?
The authors presented a framework for strongly sustainable business model (SSBM) propositions and principles, and then assessed gaps between what they propose and what they consider to be state-of-the-art for understanding business models without a sustainability focus represented by the Business Model Ontology (BMO) by Osterwalder (2004). This SSBM framework then attempts to bring the latest thinking in business models together with the latest thinking regarding sustainability, which has moved from “business that no longer seeks to be ‘less unsustainable’ (McDonough and Braungart 2002)” to businesses attempting to operate within planetary boundaries (Robèrt et al., 2013, Rockström et al., 2009).

They developed four formative propositions, suggesting that any ontology of a strongly sustainable business model would adhere to these: First, definition of a strongly sustainable firm as one that creates positive environmental, social, and economic value; Second, revision of a current “thin” definition of value “measured uniquely in monetary units (Blattberg, 2000)” in favor of “a socially responsive understanding of value;” Third, revision of the definition of business model, which they claim follows the “thin” definition of value with “reference only (and implicitly) the economic (marketplace) as a system boundary of concern.” Fourth, the revision of definition of profit towards the concept they introduce of “tri-profit”, which they differentiate from triple-bottom line (Norman and MacDonald 2004). This fourth review highlights even clearer the need for businesses to departure in planning from a well-defined and sufficiently large scope of social and ecological sustainability, and proposes a benchmarking model for how to assess progress accordingly. The relationships to PSS are not so clear, though, and the focus is more on ontological aspects and the understanding of terms than on practical how aspects.

All four reviews arise from the accelerating need for integrated approaches to developing sustainable businesses. In various ways, each review identifies the requirement for pragmatic approaches to business model development informed by global sustainability considerations. Business models must, in turn, be empowered and realized by functional design and delivery mechanisms that create sustainable economic value through, e.g., sustainable PSS. However, while the reviews have called out this need and have made suggestions for how to proceed or what is conceptually required, they have not formally and comprehensively reviewed the interface between all the three fields of PSS, business models and sustainability.
1.2 Aim and Research Questions
This literature reviews aims at answering the following research questions:

1) What does current academic literature reveal about the interface between the fields of PSS, business models and sustainability?

2) What does current academic literature reveal about the development of support for practitioners to integrate sustainability aspects into PSS- and business model development?

To answer these questions, this work aims to:

- Identify literature that describes the PSS and business model definitions, basic theories, key components and perspectives taken by authors in the respective field.
- Identify sustainability perspectives taken by authors in those fields.
- Investigate the interface between the three fields.
- Investigate the state of practical support for the development and implementation of PSS and supporting business models for sustainability.

2 Methods
In this paper a systematic literature review (SLR) approach is used. It is organized into three main stages: Preparing for the Research, Data Extraction, and Analysis of Data.

2.1 Preparing for the Research
The approach used to conduct the SLR was based on guidelines proposed by (Kitchenham and Charters 2007) and the Guide to Network for Business Sustainability (NBS) Systematic Reviews – for Researchers (n.d.). Systematic literature reviews intend to adopt a replicable, scientific, and transparent process and for this reason goes beyond a traditional general review (Cook et al. 1997).

2.1.1 Search Strategy
A search string was proposed and its quality evaluated with a trial search carried out on Thomson Reuters Web of Science and Scopus. To check the quality of this trial search, seven experts working in one or more of the fields of PSS, business models and sustainability were invited to provide a list of their top three to five references in these fields. Ten publications were selected to be compared with
the results of our trial search. The search string used ("product-service system*" OR "sustainab* product-service system*" OR "strateg* sustainab*" OR PSS AND "business model*"), captured nine out of the ten test publications.

2.1.2 Systematic Review Protocol
The main components of the review protocol are presented here. The databases searched were Thomson Reuters Web of Science and Scopus. Web of Science provides access to 12,000 journals focused on science, technology, social sciences, arts and humanities. Scopus provides access to 18,000 journals focused on physical sciences, health sciences, life sciences and social sciences. For the search process we adapted the strategy presented in the SLR conducted by Martins and Gorschek (2015). The keywords defined for the search string were extracted from the research questions.

By using this search string and manually adding relevant publications of top-cited authors in the studied fields, and also including relevant publications cited by them, we believe there is little chance that highly cited or high impact papers have been missed. If there is any bias, it is that some papers were excluded if they discussed a subject clearly overlapping with selected articles.

The protocol questions were considered from the following perspectives: population; intervention; selection criteria; and inclusion and exclusion criteria (Kitchenham and Charters, 2007).

The population is formed mainly by peer-reviewed publications. From these we extracted, organized, and summarized findings related to our research aims and questions (section 1.2). The aim of the intervention was to collect evidence in relation to (i) research that elicits relationships between, PSS, business models, and sustainability; (ii) how these initiatives were used by practitioners and to what extent; and (iii) specific factors of importance to research-practice not claimed before and that can help bridging gaps to practical implementation.

The selection criteria used in the SLR were that papers should be articles from journals, conferences, reports, including systematic literature reviews. Only articles written in English were considered.

The inclusion criteria were: studies that present, compare, or discuss initiatives that describes, specifies, and validates the fit between and co-evolvement of the fields of PSS, business models and sustainability. Studies relating empirical findings and practices aiming at embedding sustainability thinking into PSS were also included. Additional selections were done when the title and abstract of the study under analysis did not offer sufficient information to decide if it met the
inclusion criteria or not. In such a case, the additional selection process included the reading of the introduction and conclusion of the study.

The exclusion criteria were: studies that do not bring any discussion about initiatives that describes, specifies and validates the fit between and co-evolvement of the fields of business models and sustainability.

2.1.3 Data Properties
The information to be extracted is presented in Table 1.

Table 1. Data Properties (DP).

<table>
<thead>
<tr>
<th>ID</th>
<th>Data Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>DP1</td>
<td>Number of papers per year of publication; top publishers by number of publications.</td>
</tr>
<tr>
<td>DP2</td>
<td>PSS concept definitions and perspectives.</td>
</tr>
<tr>
<td>DP3</td>
<td>Business model concept definitions, basic theories, and key components.</td>
</tr>
<tr>
<td>DP4</td>
<td>Sustainability perspectives and claims taken by authors in the fields of PSS and/or business models.</td>
</tr>
</tbody>
</table>

3 Results and Discussion

3.1 Data Extraction
In the primary selection, 782 studies were captured (June 03, 2015). A total of 509 articles of these were excluded because they were out of the scope of this SLR. From the remaining 273 articles a total of 189 were excluded due to overlapping focus and because they did not present a new contribution, or proposed or discussed any aspects related to the interface between the studied concepts. Thus, 84 articles representing the breadth and depth of the three overlapping fields remained for data extraction, review and analysis.

3.1.1 Study Quality Assessment
Study quality assessment was performed using a checklist proposed by Kitchenham et al. (2007). The evaluated data was collected at the same time as the main data extraction activity. The quality assessment shows that research on the interface between PSS, business models and sustainability is emerging
(Table 2). However, the interface is not treated similarly by the selected studies. Out of the 84 selected studies only 21 treated the three fields in a balanced manner as per the assessment criteria.

Table 2. Quality assessment checklist, adapted from Kitchenham et al. (2007).

<table>
<thead>
<tr>
<th>ID</th>
<th>Quality Assessment Question</th>
<th>Yes</th>
<th>Partially (1 or 2 fields)</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>Is the aim of the study relevant to our RQs?</td>
<td>69</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(82.1 %)</td>
<td>(17.9 %)</td>
<td></td>
</tr>
<tr>
<td>Q2</td>
<td>Is the reporting coherent and clearly explained?</td>
<td>68</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(80.9 %)</td>
<td>(19.1 %)</td>
<td></td>
</tr>
<tr>
<td>Q3</td>
<td>Are the fields PSS, business models and sustainability treated similarly within the study?</td>
<td>21</td>
<td>57</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(25.0 %)</td>
<td>(67.9 %)</td>
<td>(7.1 %)</td>
</tr>
<tr>
<td>Q4</td>
<td>Are there facts validating implications of study outcomes for practice?</td>
<td>62</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(73.8 %)</td>
<td>(11.9 %)</td>
<td>(14.3 %)</td>
</tr>
<tr>
<td>Q5</td>
<td>Has knowledge or understanding been extended by the research?</td>
<td>57</td>
<td>22</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(67.8 %)</td>
<td>(26.2 %)</td>
<td>(6.0 %)</td>
</tr>
</tbody>
</table>

3.1.2 Threats to Validity
The tendency to produce erroneous results (e.g. positive rather than negative) is considered low in this SLR. To avoid bias, we justified each step of the scoping and justified the methods used; there was no limitation regarding sources of information, specific authors, publishers, journals or conferences. A triangulation between two major databases and some experts in the fields was also used to validate the SLR. However, the risk of missing relevant studies exists, mainly due to the growing number of publications at the interface of interest and also due to publications in non-English languages.

3.1.3 Data Extraction Consistency
The data extraction was based on the Data Properties (Table 1) and the data was analyzed using the Quality Assessment Checklist (Table 2) which provided a consistent way of assessing the articles and to help answering the research questions. This process aided in minimizing threats to data extraction consistency and subjective interpretation; therefore, the possibility of missing relevant data during the extraction process is very low.
3.2 Analysis of References

3.2.1 Numbers of Papers per Year
The numbers of papers published per year are shown in Figure 1. Note that more than half of the papers were published during the period 2010 to 2015, which shows that there is a growing interest and that the exploration of the nexus of fields is relatively novel.

![Number of papers per year of publication](image)

Figure 1. Number of papers per year of publication.

3.2.2 Top Publishers
Table 3 shows that the Journal of Cleaner Production (JCP) was the main source of the publications used in this paper. The other sources have low and rather similar numbers of publications, likely because sustainability is not one of their main focus areas.

Table 3. Top sources of publication (as of November 23, 2015).

<table>
<thead>
<tr>
<th>Source title</th>
<th>Publications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Journal of Cleaner Production</td>
<td>38</td>
</tr>
<tr>
<td>2 Blekinge Institute of Technology – Doctoral Dissertation Series</td>
<td>4</td>
</tr>
<tr>
<td>3 CIRP Journal of Manufacturing Science and Technology</td>
<td>4</td>
</tr>
<tr>
<td>4 Long Range Planning</td>
<td>4</td>
</tr>
<tr>
<td>5 Springer Science</td>
<td>4</td>
</tr>
<tr>
<td>6 Business Strategy and the Environment</td>
<td>3</td>
</tr>
<tr>
<td>7 Ecological Economics Journal</td>
<td>3</td>
</tr>
<tr>
<td>8 Energy Policy Journal</td>
<td>3</td>
</tr>
<tr>
<td>9 Wiley InterScience</td>
<td>3</td>
</tr>
<tr>
<td>10 Green Leaf Publishing</td>
<td>2</td>
</tr>
</tbody>
</table>
3.3 Development of the PSS Concept

3.3.1 PSS — Exploration
Research in the field of PSS has been growing continuously. The number of papers published annually has more than quadrupled in the last decade, while the number of scientific publications in general has doubled (Tukker 2015). Despite this rapid growth, there is no consensus on a common definition of the concept.

3.3.2 Frequency of Perspectives
In the PSS field, Boehm and Thomas (2013) observed that research comes out of noticeably distinct fields when they conducted a systematic review of literature that considered three different disciplines: Information Systems, Business Management, and Engineering and Design. Their aim was to provide a unified core definition of PSS, and their review compared and analyzed perspectives and views captured by articles in each of these three disciplines.

Boehm and Thomas (2013) stated that the strategic and business level views are the most frequent perspectives considered, followed by design and sustainability views, respectively (Figure 2). Their results show that the strategic perspective is stronger in the Business Management discipline (60 %), while the business level perspective is largest in the Information Systems discipline (54 %). The Engineering and Design discipline has the largest share of the design perspective (22 %) and the sustainability perspective (15 %).
3.3.3 Previous Literature Reviews
A list of literature reviews on PSS (Table 4) covers authors and titles in the period 2004–2014.

Table 4. Literature reviews on PSS.

<table>
<thead>
<tr>
<th>Author / Year</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tukker and Tischner (2006)</td>
<td>Product-services as a research field: past, present and future. Reflections from a decade of research</td>
</tr>
<tr>
<td>JCP Editorial Article (2006)</td>
<td>Product-Service Systems: reviewing achievements and refining the research agenda</td>
</tr>
<tr>
<td>Baines et al. (2007)</td>
<td>State-of-the-art in product service systems</td>
</tr>
<tr>
<td>Pawar et al. (2009)</td>
<td>The PSO triangle: designing product, service and organisation to create value.</td>
</tr>
<tr>
<td>Sakao et al. (2009)</td>
<td>Framing research for service orientation of manufacturers through PSS approaches.</td>
</tr>
<tr>
<td>Meier et al. (2010)</td>
<td>Industrial Product-Service Systems—IPS2</td>
</tr>
<tr>
<td>Berkovich et al. (2011)</td>
<td>Requirements engineering for product service systems</td>
</tr>
</tbody>
</table>
3.4 Development of the Business Model Concept

3.4.1 Business Model Concept — Exploration
The business model concept has gained growing attention. However, this field of research is at an early stage and many basic questions remain unanswered (Wirtz et al. 2011, 2016). These authors suggested that the reason for the difficulty in answering key questions is that the literature is fragmented, due to the varying perspectives taken by authors in different disciplines.

3.4.2 Business Model Concept — Basic Theories
Research in the business model field has been dominated by three basic theoretical perspectives: technology, organization and strategy (Wirtz et al. 2011, 2016). These are briefly described below and the historical development is schematically illustrated in Figure 3.

*Technology-Oriented:* The origins of publications within this theoretical perspective are primarily between 1970 and 2002. Until 1999 they had an emphasis on systems modeling. Between 2000 and 2002 publications were dominated by e-business (internet-based business concepts), and since then more strategy-oriented articles have been published (Wirtz et al. 2016).
**Organization-Oriented:** This perspective is characterized by an abstract representation of the company architecture, including overriding corporate design, capabilities, innovation linkage structures and decision making. This perspective include definitions of business models as representations and stories that explain how enterprises work; the architectural design of organization structures, and descriptions of the business activity. Authors taking the strategic perspective described this perspective as a support for the creation and execution of competitive strategic objectives related to governance, corporate culture, products and services, and for capturing value within the value network (Wirtz et al. 2016).

**Strategy-Oriented:** This perspective is characterized by an integrated description of entrepreneurial activities that relate to vision and mission of a company’s business models, competitive strategy, innovation, capabilities and value creation logic. This perspective has been considered to have an essential influence on and guidance for the development of business models (Wirtz et al. 2016).

**Figure 3.** Development of three basic theoretical perspectives in the direction of a converging business model view, recreated from (Wirtz et al. 2016, p.39).
3.4.3 Business Model Concept – Key Components

The theoretical perspectives provided in previous sections point to key components of the business model concept. According to Wirtz et al. (2016) the component-oriented view is part of many peoples’ understanding of the concept of business model, and that the content of a business model is often expressed by referring to its components. The authors present the following components and partial models of an integrated business model: Strategy; Material and immaterial resources; A network-oriented view; Customers; Value proposition; Revenue model; Service provision; Procurement; Financial model. Thus, business models are often presented as a set of differentiable parts rather than as a “whole” created by the sum of parts, some parts of that may be differentiable, others that are not, and some aspects that fall beyond the scope of a “part” (e.g., value derived from integrated linkages, value or impacts difficult to measure with parts-based metrics, or impacts created by unintended consequences external to any business sub-part).

3.5 Sustainability Perspectives and Claims

The sustainability perspectives and claims by authors in the field of PSS and/or Business Models are presented and interpreted below.

3.5.1 Needs and Challenges of Integration

Addressing sustainability challenges both demands and brings great opportunity for innovation in all dimensions of business, from overall creation of value and definition of business success to product and service delivery (Basile et al. 2011). Unit (2005) suggests that the majority of business executives are identifying the design of new business models as a greater source of competitive advantage than new products and services per se. In order to extend the effort to include sustainability, Lee and Casalegno (2010) propose “business model” as a new unit of discussion and analysis for sustainability initiatives. Business model innovation has been shown to be a critical lever for overall organizational sustainability (Kiron et al. 2013). And integrating sustainability strategy is not only possible, but required for businesses to be competitive according to several authors (e.g. Baumgartner and Ebner 2010, Osterwalder and Pigneur 2011). However, the grand challenge remains: current business model innovation and design generally fails to sufficiently embrace the sustainability dimension (Boons and Lüdeke-Freund 2013, Upward and Jones, 2016). The business case of sustainability is typically not understood profoundly enough (e.g. Stubbs and Cocklin 2008), and the planning horizon and system scope are often insufficient (e.g. Baumgartner and Korhonen 2010).

Various PSS approaches have been proposed as an opportunity for promoting sustainability and strategic business model development (Manzini and Vezzoli
Rifkin (2014) potentially links PSS to business model innovation when describing how decision makers are changing their business models to operate in a market where the relationship with products and services is shifting from one based on ownership (i.e., goods sold) to one based on access and exchange of combined goods and services (i.e., PSS) at near-zero marginal costs. Here, the competitive edge shifts toward business models capable of applying modern information technology and supply webs to provide easily accessible and highly contextualized high performance services with fewer intermediates.

However, while the logical leap can be made that PSS in the context described above could enhance sustainability performance in businesses, e.g., through enhanced product stewardship promoted by service contracts and cyclical use of resources as part of product-service efficiencies (Mont, 2002, Maxwell et al. 2006, Tukker, 2015), the business case for, and integration of, sustainability considerations is not inherent to the ongoing business model innovation process (Schaltegger et al. 2012, Upward and Jones 2016). Further, while sustainability is often mentioned in the field of PSS, there is little concrete support to actually promote integration of sustainability aspects (Vasantha et al. 2012, Tukker 2015). Tukker (2015) identified that environment is not the main subject of papers on PSS and that research from a business perspective remains more important than environmental research, noting that that PSS publications in general are more focused on traditional competitiveness than sustainability issues. This is a longstanding challenge. Ehrenfeld (2001) argued that in the PSS field there is a need for a coherent strategy foundation that point towards sustainability. The result is that a gap remains in experiential knowledge for how to successfully combine strategic sustainability thinking, PSS and business model innovation and design, as further discussed below.

### 3.5.2 Strategy as a Required Foundation for Integration

A strategic perspective has been highlighted by a diverse suite of authors as critical for the alignment between PSS, business models and sustainability in various ways. Robèrt et al. (2002) argue that a clear sustainability vision is an inherent prerequisite for applying the term strategy in any planning and integration effort. Similarly, Manzini and Vezzoli (2002) pointed to the need to shift business focus from designing and selling physical products only, to designing, and selling, a system of products and services capable of fulfilling specific demands, while concomitantly re-orienting current unsustainable trends in production and consumption. A business model can, in this perspective, be framed as a link between planning to reach a future vision (strategy), and operative implementation (Wirtz et al. 2016). Thompson et al. (2011) investigated how a framework for strategic sustainable development
could promote understanding of sustainability issues and provide insights into how both incremental and radical strategic approaches could be aligned within PSS innovation.

Broman and Robèrt (2016) write about a framework for strategic sustainable development (FSSD). The paper describes the importance of using a planning process linked to a sustainability-principles framed vision of success and value creation to guide practitioners in developing and prioritizing actions and strategic plans that are aligned with sustainable development. Complementing this, Ceschin (2014) explores through a series of case studies the role of strategic design in supporting the introduction and scaling up of sustainable PSS innovations. A new strategic design role is described in which the development of sustainable PSS concepts is coupled with the designing of appropriate transition paths to gradually introduce and disseminate these concepts. Ny (2009) integrated a strategic approach to sustainability with life cycle assessment, modeling and simulation, which is central to sustainability-informed PSS development. He also pointed at the possibility to use his results as a basis for a later development of a “design-space”, where strategic life cycle assessment could turn to sustainable supply-chain management. Actors along a value chain could cooperate to address the full sustainability scope of their joint challenges, opportunities and strategic prioritizations, designing unsustainability out of value chains as well as society at large.

Kiron et al. (2012) identifies a motive force for applying a strategic sustainability lens, in general, to business model development and PSS. The authors describe findings from a survey showing that sustainability strategy is necessary to being competitive. Customer preference for sustainable products and services is identified as a major reason for changing companies’ business model. Additionally, investors are looking at sustainability performance as an indicator of overall business value. Sustainability factors considered in the survey emphasize the importance of the long-term perspective, economic sustainability of the organization, corporate social responsibility, employee health and wellbeing, environmental issues, customer health and well-being and safety issues.

Baumgartner and Korhonen (2010) argue that the slow progress in the sustainability field is due to the lack of a process for clarifying the connection between strategic thinking and sustainability. Among others, Bumgartner and Ebener (2010) and Engert et al. (2015) present research on corporate sustainability strategy.
The mentioned examples of references in this section all point, directly or indirectly, to the *strategic* dimension as a possible key enabler of sustainable PSS and business models.

### 3.5.3 Practice-oriented Research

The literature review also revealed that there is a lack of case-based, practice-oriented evidence regarding support for practitioners to actually design business models in conjunction with PSS to achieve sustainability-promoting PSS. The results indicate that traditional tools and methods currently used (e.g. LCA, Eco-Design, C2C, among others) are unlikely to be sufficient. It is evident that research in the business model practice-oriented field has grown in the last few years (e.g. Afuah 2004, Johnson et al. 2008, Osterwalder and Pigneur 2010, Wirtz 2016). Moreover, within such context there has also been a growing interest by industry in the relevance of the sustainability dimension for the success of their business models (Giesen 2007). However, the practice-oriented field is at an early stage of development (e.g. Boons and Lüdeke-Freund 2013, Bocken et al. 2013, Joyce et al. 2015, Breuer and Ludeke-Freund 2014, Reim et al. 2014, Upward and Jones 2016). While sustainability is often mentioned, there is little concrete guidance to actually support practitioners (Vasantha et al. 2012, Tukker 2015) when attempting to align sustainability, PSS and business-model development.

The SLR highlights that a common barrier for practitioners’ efficacy in working with sustainable PSS and business model innovation is the lack of a *pragmatic* structuring systems-perspective allowing for the *strategic* dimension to be included.

### 4 Conclusion

The aim of this systematic literature review was to find and investigate studies reporting approaches and interactions on the interface between the fields of PSS, business models and sustainability. The purpose was to understand how to embed sustainability aspects into the design of PSS and business models, and specifically, to search for enabling factors.

The review shows that, although a relatively new and unexplored endeavor, there is growing effort at the interface of the three fields. The review indicates that the main deficit so far is that the PSS and business model fields lack *concrete* guidelines and *practical* tools for how to embrace the sustainability dimension in a *strategic* way. Especially the strategic dimension emerges as a general
finding from diverse sources as a potential key enabler for mutual benefits across the three fields. The study thus points to the need for research aiming at developing such guidelines and tools, and also at exploring case-based applications to create experiential knowledge, to fill the gaps in current theory and practice.

Thus, we propose that researchers and practitioners should be seeking for a methodology that provides a strategic and experientially-informed sustainability perspective as a foundation for continued work. To be strategic it is necessary to be able to define the goal, and in such a complex context as sustainable development the goal should be framed by basic principles as boundary conditions for sustainable visions (e.g. Broman and Robèrt 2016). To be useful for this purpose such principles must be necessary and sufficient for sustainability, and to facilitate cross-disciplinary and cross-sector collaboration, guide innovation, and enable comprehension and monitoring of transitions, sustainability principles should be general, concrete, and non-overlapping (ibid). Broman and Robèrt (2016) describes a framework for strategic sustainable development (FSSD) which includes, e.g., a principled definition of sustainability aimed to assure such sustainable envisioning, and strategic guidelines for how organizations can support society’s transition towards fulfillment of the sustainability definition in ways that strengthen the organization. The authors present some observed benefits of this methodology, including, e.g., its ability to: clarify the true character of the sustainability challenge and the self-benefit of proactivity; support strategic management of system boundaries, trade-offs and problem solving (avoiding to create new problems while solving some problems, and even avoiding unknown problems); facilitate collaboration across disciplines, departments, organizations and sectors; and guide selection, development and combination of supplementary tools, methods, concepts and other forms of support for sustainable development, making it possible to increase their utility. With those qualities and benefits, proven in practice in a wide range of cases, the FSSD directly responds to the need identified in this SLR. The application of this methodology should therefore be explored more explicitly in future applied research efforts on business model design for strategic sustainable development.

Acknowledgements

Financial support from the Swedish Knowledge Foundation and Blekinge Institute of Technology is gratefully acknowledged.
References


Network for Business Sustainability, 2013. Systematic Reviews for Researchers, n.d.)


Systematic Guidance for How to Integrate a Strategic Sustainability Perspective in Core Business Decision Systems
Paper B is published as:
Systematic Guidance for How to Integrate a Strategic Sustainability Perspective in Core Business Decision Systems

César L. França
Sophie Hallstedt
Göran Broman

Abstract

Sustainability integration in core business and product development has been a challenge, even if many supporting methods, tools and concepts are available today. However, these are mainly focusing on specific environmental aspects and are often failing to serve companies in integrating sustainability thinking into their strategic decision processes, and consequently into their core business and product development. In this study a previous proposal for an approach to assessing the current state of sustainability integration in company decision systems was used at two case companies, ABB High Voltage Cables and Hammarplast AB. The purpose was to develop this approach further so that it can better assist decision makers (when initial assessment points to such gaps) to integrate sustainability thinking into the strategic decision processes, i.e. align vision, management system and tools to help prioritize actions in a backcasting plan for a sustainable company within a sustainable society. The developed approach includes a SWOT analysis supported strategic capability assessment, and generic guidelines for how to identify appropriate targets, which can also serve as a basis for development of indicators – all informed by a framework for strategic sustainable development.

Keywords: sustainability principles, backcasting, framework for strategic sustainable development, strategic decision processes, goal-oriented indicators.
1 Introduction

Many studies demonstrate that our society is contributing to negative impacts on the earth’s life sustaining systems, e.g., the climate system [1-3], and consequently we are heading into an unpredictable and unsustainable future, while, and to a great extent because, sustainability thinking remains essentially apart from core business decisions [4].

Bringing the concept of sustainable development [5] from theory to practice is imperative for future human wellbeing. This is realized by many and therefore several methods, tools and concepts have been developed to support operations; e.g. agenda 21 [6], conventions on climate change [7], sustainability assessment methodologies [8], strategic environmental assessment (SEA) [9], environmental management systems such as ISO 14001 [10], life cycle assessment (LCA) [11], ecological foot-printing [12], global reporting initiative [13], and many others. However, such approaches are mainly focusing on specific environmental issues and are often failing to support companies in integrating sustainability thinking into their decision processes, and consequently into their core business and product development.

This situation indicates an urgent need for an overarching science based approach that includes an operational definition of sustainability and that can be used to coordinate the use of existing methods, tools and concepts and bring out the best of them in different situations. A framework for strategic sustainable development (FSSD) [14-17], also known as the Natural Step framework (TNSF)\(^2\), is gaining international recognition for having these qualities and is used as a basis in the current study.

The aim of this study is to develop further a previously proposed approach to assessing the current state of sustainability integration in company decision systems [18]. The purpose is to create a better support for decision makers to integrate sustainability thinking into company’s strategic decision processes by filling out the gaps identified in the initial assessment, i.e. align vision, management system and tools to help prioritize actions in a backcasting plan for a sustainable company within a sustainable society. The need for this study is based on the conclusions from some introductory case studies [18]: i) senior managers are often failing to relate long-term strategic sustainability challenges to short term business challenges, ii) product developers are lacking systematic incentives, disincentives and monitoring systems to facilitate implementation of sustainability measures and iii) companies are lacking a standardized “toolbox” to integrate sustainability-related information in decision processes.
2 Methods

The aim and purpose of this study are pursued through literature studies and two company case studies. The methodological base is a framework for strategic sustainable development (FSSD) [14-17] and the assessment approach developed in a prior study [18]. The latter includes guiding questions in two steps: i) an inventory stage and ii) a strategic capability assessment stage.

2.1 Case Study Companies and Interview Process

A sustainability assessment was performed in case study companies and the results served as basis for further improvements. ABB High Voltage Cables AB is a business unit of ABB, which is a global leader in power and automation technologies organized in 5 divisions: Power Products, Power Systems, Automation Products, Process Automation and Robotics. The whole company, with headquarters in Zurich, Switzerland, has 115,000 employees and has operations in more than 100 countries. High Voltage Cables is based in Karlskrona, Sweden, with 500 employees and is part of ABB’s Power Systems Division. The company’s competitive edge is to help customers to use electrical power efficiently and effectively and to increase industrial productivity in a sustainable way. Therefore managers at High Voltage Cables recognize the importance of developing appropriate support for integrating sustainability into their business decisions, with a special interest in sustainable management of metals.

Hammarplast AB is a medium sized company responsible for the consumer business area within the Hammarplast Group, producing and marketing plastic and complementary consumer products for home and storage. It has 160 employees. Their strategic competitive edge is to create an innovative product-service system and thereby increase customer’s perceived value of their product. Hammarplast aims to become a global leader in the sector and by adopting this strategy it wants to be more profitable and build financial capacity to deal with major sustainability challenges related to the oil based raw material they use for plastic production. Therefore the managers recognize the importance of developing appropriate support for integrating sustainability into their vision, management system and tools.

All interviews included the following basic steps: recorded interviews with senior managers at production, product development and CEO levels. The process was conducted by two to three researchers to collect data concerning the company’s strategic decision processes in general and in relation to sustainability in particular as shown in table 1. The interviewees were scrutinized using the
mentioned guiding questions which are based on the strategic capability assessment stage and the FSSD. The results and findings from this analysis served as a basis for the verification of the assessment process as such and for further improvements.

2.2 Framework for Strategic Sustainable Development
Using the FSSD in this study is based on the reasoning that sustainability integration in decision processes occurs through a range complex internal and external interactions and this framework has proven successful in many cases of planning in complex systems [14-17]. It has backcasting from sustainability principles as a key feature and enables a clear and systematic understanding of strategic planning in general and in relation to sustainability in particular.

Backcasting from sustainability principles is the process of planning with the ultimate objective of sustainability in mind, defined by first-order sustainability principles. Instead of dealing with the problems one by one as they appear, backcasting is an approach where a successful outcome is imagined followed by the question “what shall we do today to get there?” To be useful for backcasting the sustainability principles are designed to fulfill a set of criteria. They should be: i) based on a scientific world view, ii) necessary and sufficient for sustainability, iii) general enough to be applicable everywhere and in all situations, iv) non-overlapping to facilitate comprehension and development of tools and indicators, and v) concrete enough to guide problem analysis and decision making.

Table 1. The inventory stage activities in the companies.

<table>
<thead>
<tr>
<th>Date</th>
<th>Company</th>
<th>Activity</th>
<th>Persons Involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>August 080814</td>
<td>High Voltage Cables</td>
<td>Interview</td>
<td>Manager New Products and Manager Operations</td>
</tr>
<tr>
<td>August 080826</td>
<td>High Voltage Cables</td>
<td>Interview</td>
<td>Manager Operations</td>
</tr>
<tr>
<td>September 080901</td>
<td>Hammarplast</td>
<td>Interview</td>
<td>Managing Director Product Development Manager</td>
</tr>
<tr>
<td>September 080910</td>
<td>Hammarplast</td>
<td>Interview</td>
<td></td>
</tr>
</tbody>
</table>
### 2.3 Assessing Sustainability Integration in Strategic Decision Systems

This approach offers a generic template that was previously used to assess sustainability integration in the strategic decision systems of the case study companies: *Tetra Pak Carton Ambient AB, Aura Light International AB, Evolator AB, Hydro Polymers Ltd*, and for verification to compare with the experiences of *Indigo Management AB and The Natural Step International*. It focuses on decision systems and interactions between senior management and product development levels. Decision systems here include methods, tools, processed information and actors involved in decisions at different organizational levels. This approach supports an inventory and a strategic capability assessment, as briefly explained below.

The **inventory** is the process of collecting information about general and sustainability related strategic decision systems, and about the interactions through such support between senior management and product development levels as shown in figure 1.

To understand the information flow and decision processes in companies, guiding questions based on sustainability principles and strategic guidelines of the FSSD are used. At this stage information required for the diagnostic of companies’ strategic capability is gathered. Overarching, detailed and control questions are used throughout the process [18]

The **strategic capability assessment** (SCA) is an evaluation of strategic decision systems in general and in relation to sustainability in particular. In this study the previous approach [18] is supplemented by a SWOT analysis [19], all guided by the FSSD and strategic capability assessment questions. The purpose is to stimulate integration of sustainability in the decision processes by utilizing the
company’s Strengths, identifying its Weaknesses to further eliminate them, explore potential Opportunities and find solutions to mitigate Threats [19].

**Figure 1.** Decision system in a company and interactions between senior management and product development levels.

The FSSD guided SWOT analysis was used also to support consensus building among participants and to leverage a co-creation process to generate improvement ideas and solutions to the challenges. The results of this serve as a basis for target identification and further development of indicators.

### 2.4 Guidelines for Identification of Appropriate Targets and Construction of Indicators

The FSSD (table 2-4) is used to develop guidelines for the identification of appropriate targets and to support companies to further develop their specific sustainability indicators. The process is initiated by understanding the five levels of the FSSD, which will inform the following stages: identification of specific GOALS, TARGETS and INDICATORS. Targets are quantified measures that can be described as stepping-stones, or flexible platforms, taking the company towards the goals. Indicators are variables informed by the targets that will support monitoring of the company’s progress towards established targets.
Table 2. Templates for assessing strategic capability of company decision systems – in general and for sustainability. [18]

<table>
<thead>
<tr>
<th>Levels of generic assessment framework</th>
<th>Template 1 - Assessing company decision system - for general strategic capability</th>
<th>Template 2 - Assessing company decision system - for strategic sustainable development capability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. System</td>
<td>How does the company describe its business idea, operations in relations to key stakeholders?</td>
<td>How does the company describe its business idea, operations in relations to the environment and societal stakeholders globally?</td>
</tr>
<tr>
<td></td>
<td>Advisor response: …</td>
<td>Advisor response: …</td>
</tr>
<tr>
<td></td>
<td>Company response: …</td>
<td>Company response: …</td>
</tr>
<tr>
<td>2. Success</td>
<td>How, if at all, does the company define its long-term success?</td>
<td>How, if at all, is global sustainability integrated in the company’s long-term success definition?</td>
</tr>
<tr>
<td></td>
<td>Advisor response: …</td>
<td>Advisor response: …</td>
</tr>
<tr>
<td></td>
<td>Company response: …</td>
<td>Company response: …</td>
</tr>
<tr>
<td>3. Strategic Guidelines</td>
<td>How, if at all, does the company use overarching strategic guidelines for planning towards success in general?</td>
<td>How, if at all, does the company integrate sustainability in overarching strategic guidelines?</td>
</tr>
<tr>
<td></td>
<td>Advisor response: …</td>
<td>Advisor response: …</td>
</tr>
<tr>
<td></td>
<td>Company response: …</td>
<td>Company response: …</td>
</tr>
<tr>
<td>4. Actions</td>
<td>How, if at all, are decisions in practice made in line with strategic guidelines towards the company’s long-term definition of success?</td>
<td>How, if at all, are decisions in practice made in line with strategic guidelines towards the company’s long-term definition of success?</td>
</tr>
<tr>
<td></td>
<td>Advisor response: …</td>
<td>Advisor response: …</td>
</tr>
<tr>
<td></td>
<td>Company response: …</td>
<td>Company response: …</td>
</tr>
<tr>
<td>5. ‘Tools’</td>
<td>How, if at all, are decisions justified and monitored by suitable methods, tools and concepts?</td>
<td>How, if at all, are decisions justified and monitored by suitable methods, tools and concepts?</td>
</tr>
<tr>
<td></td>
<td>Advisor response: …</td>
<td>Advisor response: …</td>
</tr>
<tr>
<td></td>
<td>Company response: …</td>
<td>Company response: …</td>
</tr>
</tbody>
</table>

3 Results

Figure 2 illustrates schematically a systematic guidance for how to integrate strategic sustainability thinking into a company’s decision system. The process
includes the original assessment approach [18] and the suggested added support.

3.1 Assessment of Sustainability Integration in Strategic Decision Processes

**Figure 2.** Processes and activities for how to integrate strategic sustainability thinking into a company’s decision system. In stage 1: Inventory and Strategic Capability Assessment (SCA stage 1) are based on previous studies [18]. Stage 2 is the added support and stage 3 shows recommended steps for the companies.

**Inventory Stage**
An approach based on Qualitative Research Interviews [20] resulted in recorded interviews that were transcribed, analyzed, verified, reported and sent for companies’ feedback. The aim was to establish consensus based on the findings of the inventory stage, and to create appropriate conditions to proceed to the next stages. A workshop to present the results and to introduce the methods was decided upon.

**Strategic Capability Assessment with SWOT Analysis**
Based on the FSSD and the Strategic Capability Assessment, SCA (see table 2), a SWOT analysis was conducted to identify strengths, weaknesses, opportunities
and threats regarding integration of sustainability thinking in the strategic decision processes of the case study companies. This supplemented SCA is performed after SCA stage 1 (see figure 2) and found to enhance data structuring and identification of sustainability gaps. It was found that sustainability thinking is not fully integrated in their strategic decision processes. Clearly, it is not enough to have sustainability embedded in the vision. It is necessary to also have a concrete sustainability definition to be able to set strategic targets and develop relevant indicators. Otherwise it is difficult to clearly communicate sustainability issues among employees and stakeholders. Examples of results from the assessment of the case study company High Voltage Cables are presented in table 3. The findings were similar in the other case study company.

Based on the identified gaps in the companies’ strategic decision processes, goal-oriented targets and indicators were identified as described in the next section.

3.2 FSSD and Goal-Oriented Targets and Indicators

In this study the FSSD is also used to inform development of goals, targets and formative indicators [22]. Upstream indicators are preferred to indicators only reflecting downstream actions and effects because upstream it is possible to prevent problems. This amendment is seen to: i) support structural integration of sustainability thinking in companies’ strategic decision systems, i.e. align vision, management system and tools, and ii) bring in the sustainability perspective in decision making and product development processes. Appropriate indicators are known to trigger improvements, development of ideas and problem solving [8]. During the past ten years there has been an increasing interest in linking indicators to goals. Recently the millennium development goals [23] became a major reference of such an approach.

Guidelines for the Construction of Targets and Indicators

Goal-oriented indicators in general are developed using pre-defined goals and targets [23]. The goal-oriented indicators in the new assessment approach are based on the FSSD five levels, which are used to inform the construction of the indicators. The process starts by understanding each of the FSSD’s five levels and its operational method - backcasting from sustainability principles. Each FSSD level enables the identification of an overall GOAL, which is expressed in qualitative terms. Quantified TARGETS related to the goal are then identified for different time perspectives. INDICATORS are the variables used to measure progress toward the targets.
The identification and construction of appropriate indicators is a process that needs to consider the characteristics of each company. This activity is informed by FSSD five levels and by Backcasting from Sustainability Principles. Some general support in building indicators can come from thinking about the following categories:

- **Input**: e.g., financial and physical resources (money, staff, materials, etc.).
- **Output**: e.g., the amount of goods and services produced by inputs (educational resources, research, tools for sustainable product development, return on investment rates, etc.).
- **Outcome:** e.g., final results related to FSSD goals: access to, use of, and satisfaction with services (participation rates, practical use applied research, etc.).

- **Impact:** e.g., influence, effect on: well-being, creation of a shared mental model (Sustainability awareness rates, economical social and environmental influence).

The use of these guidelines for the case study company High Voltage Cables is exemplified in table 4.

**Strategic Prioritization Support**
The FSSD systematic guidance for how to integrate sustainability thinking into the strategic decision processes, i.e. align vision, management system, tools and product development, is supported by a prioritization process through the selection of measures where “yes” can be answered to three key questions:

(i) will this measure bring us closer to compliance with all the principles of success (i.e. ‘sustainability principles”),

(ii) is the measure possible to develop further (if it needs to be to come into compliance with the principles of success), so that it doesn’t lead into a blind alley (i.e., is it a ‘flexible, technical platform’) and,

(iii) is it likely to generate a good return on investments?

Together “yes” to these questions brings about measures that provide good stepping stones for future successful moves while increasing the flow of money, or other required resources, to the process [26].
Table 4. Suggested FSSD Guidelines for Targets identification and further development of Indicators for the case study company High Voltage Cables.

<table>
<thead>
<tr>
<th>FSSD level</th>
<th>GOAL</th>
<th>TARGET</th>
<th>INDICATORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: The system level is a description of the overarching system in which we are planning and solving problems. In this case, the company within the society with the biosphere.</td>
<td>Ensured sustainability integration in core business and explained its relation to stakeholders globally.</td>
<td>1.1: Leverage as from 2010, continuous growth on the number of senior managers with knowledge concerning strategic sustainability planning. 1.2 ---</td>
<td>1.1.1: E.g., Proportion of investments allocated for sustainability capacity building programs, type of activity, purpose, area of influence, participation rates, etc. 1.2.1 ---</td>
</tr>
<tr>
<td>2: The success level describes the overall principles* that are fulfilled in the system when the goal is reached, in this case social and ecological sustainability.</td>
<td>Integrated a global sustainability perspective in the company's long term success definition.</td>
<td>2.1: Integrate within three years as from 2010, a clear sustainability definition into the company's vision documents, and communicate it to the company's 500 employees and stakeholders in general. 2.2: ---</td>
<td>2.1.1: E.g., volume of resources (financial, staff) allocated for developing and communicating the vision definition to employees and stakeholders, type of activity, purpose, participation rates, etc. 2.2.1 ---</td>
</tr>
<tr>
<td>3: The strategic level describes the strategic guidelines for planning towards success in the system, using Backcasting from Sustainability Principles [14 17].</td>
<td>Defined strategic guidelines to achieve the company's long term success in line with vision, management system and tools.</td>
<td>3.1: Integrate in senior management planning routines, within three years as from 2010, the use of the strategic guidelines based on backcasting from sustainability principles, to inform all actions considered first steps. 3.2: ---</td>
<td>3.1.1: E.g., number and type of early steps identified, staff involved, number and type of workshops, areas of influence, type and amount of investments, etc. 3.2.1 ---</td>
</tr>
<tr>
<td>4: The action level includes concrete actions that fit strategic guidelines. The actions are assessed to understand its relation with other levels, i.e. overall strategies to reach successes in the system.</td>
<td>Performed prioritized actions, i.e. actions that fit the strategic guidelines.</td>
<td>4.1: Develop within three years from 2010 the Sustainability Life Cycle Assessment [25] of HV Cables material (copper lead and aluminium). 4.2: Develop within three years from 2010 a sustainable material management database.</td>
<td>4.1.1: E.g., type of impacts, as regards Aluminium, Copper and Lead, amounts used, type of research produced etc. 4.2.1: ---</td>
</tr>
<tr>
<td>5: The tools level describes the tools used to manage and monitor the activities so that they are chosen in a strategic way to arrive at success in the system.</td>
<td>Ensured that decisions are justified and monitored by suitable methods, tools and concepts.</td>
<td>5.1: Develop within three years from 2010 a suitable toolbox, i.e. to combine the current tools and/or implement new suitable methods and tools.</td>
<td>5.1.1: E.g., number and types of tools of different kinds (system, strategic and capacity tools) within the toolbox that are based on a strategic sustainability perspective, etc. 5.2.1: ---</td>
</tr>
</tbody>
</table>
4 Concluding Remark

The importance of integrating sustainability thinking into the core business of companies is receiving greater and greater emphasis around the world. The systematic guidance for how to do this, involving a SWOT analysis supplemented strategic capability assessment and guidelines for development of relevant and feasible targets and indicators – all informed by a framework for strategic sustainable development – as presented in this paper, could therefore be of significant value for business and society. This is likely to assist decision makers to determine which actions that should or should not be taken in order to support sustainable development of the whole society and at the same time strengthening the own organization.

References


[7] United Nations Framework Convention on Climate Change UNFCCC /INFORMAL/84 - GE.05-62220 (E) 200705


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Sustainability Self-Assessment and Business Model Design
Paper C is published as:
1 Introduction

The business case of sustainability has been argued for by many authors (Willard, 2005; McNall et al., 2011). There is a large degree of consensus regarding the potential business impact of sustainability. However, most companies either are not acting or are falling short on execution (MIT Sloan, 2009). Relatively few companies consider innovation for sustainability substantially rewarding. Suggested solution for this includes better access to frameworks for understanding sustainability and value creation and the business cases thereof (MIT Sloan, 2009). Furthermore, it is well-known that support for generation and selection of ideas and for formulating goals and strategies is especially essential to have during the early phases of the innovation process (Roozenburg and Eekels, 1995).

The usual absence of an operational definition of sustainability is still a major barrier to corporate strategic sustainable development (Holmberg and Robèrt, 2000). A sustainability definition that can guide assessment of the current situation and stimulate generation of ideas for upstream solutions and strategic guidelines that can aid prioritization of early smart actions are among the most promising leverage points. A framework including those features is being developed in an international consensus process since twenty years (see, e.g., Robèrt et al., 2012). Among other things, this framework for strategic sustainable development FSSD, clarifies the self-interest in sustainability work and thus supports more widespread and proactive sustainable innovation.
In this study, the FSSD is used as the main basis for a new tool to be used in early phases of the innovation process for self-assessment of an organization’s current maturity and performance from an overall strategic sustainability point of view and for stimulating generation of ideas for business models design. We present a prototype version of such a tool and results from initial tests of this tool performed in four organizations. We study in particular whether the outlined tool is perceived by the organizations to be: (i) easy to comprehend, (ii) relevant, (iii) capable of differentiating the organizations in a comprehensive way, (iv) helpful for discovering insufficiencies that the organizations are not already aware of and (v) helpful for generation and selection of ideas for upstream solutions, business model innovation and for formulation of goals, and strategies.

2 Methods

The development of the sustainability self-assessment tool and related methodological process was guided by a framework for strategic sustainable development FSSD and its operational process backcasting from sustainability principles.

The framework for strategic sustainable development (FSSD), used as a foundation for this study and tool development, provides a generic support for backcasting planning in any field at any scale by applying generic sustainability principles as boundary conditions. The FSSD comprises five levels:

1. The system level – prompts a description of a topic with its nested subsystems in society in the biosphere,
2. The success level – prompts a description of success for the topic (e.g., success for a company in a future sustainable society), informed by basic sustainability principles,
3. The strategic level – includes guidelines for stepwise approaches towards compliance with the defined success,
4. The action level – prompts for concrete actions aligned with the strategic guidelines and put into a plan for compliance with the defined success, and
5. The tools level – links to concepts, methods and tools to support and monitor the transition between current situation and the defined success.

Backcasting implies that a successful outcome is imagined in the future, followed by the question: “what do we need to do today to reach that successful outcome?” The basic sustainability principles (level 2) have been derived from
understanding first-order mechanisms through which society currently causes destruction of the socio-ecological system, and reads:

In a sustainable society, nature is not subject to systematically increasing...

1. ...concentrations of substances extracted from the Earth’s crust (e.g. fossil carbon and metals);
2. ...concentrations of substances produced by society (e.g. CFC’s and NOX);
3. ...degradation by physical means (e.g. deforestation and overfishing)

and in that society

4. ...people are not subject to conditions that systematically undermine their capacity to meet their needs (e.g. through abuse of economic and political power).

The overarching guideline for organizations to support society’s compliance with these principles is to integrate them with the objectives of the organization, i.e., applying the sustainability principles as boundary conditions for redesign of visions and objectives, and then backcast from that integrated overarching goal. The FSSD implies a step-wise approach, ensuring that early steps are designed to serve as (i) flexible platforms for forthcoming steps that, taken together, are likely to bring the organization to the defined success by striking a good balance between (ii) direction and advancement speed with respect to the defined success and (iii) return on investment to sustain the transition process. A more comprehensive description of the FSSD is given by, e.g., Robèrt et al. (2012).

Other approaches, concepts, methods and tools that have been considered and used as a background for this study and tool development include, life cycle management (Ny et al., 2006), eco-design (McAlonee et al., 2008), sustainable product development (Hallstedt, et al., 2008), green procurement (Bratt. C. 2011; LEAP-GPP, 2006; Williams et al, 2007; Procura+ ICLEI, 2007), sustainability driven goals, targets and indicators (França et al, 2009), business models (Osterwalder and Pigneur, 2010; Casadesus-Massanell and Ricard, 2010; Margreta, 2002; Teece, 2009).

Testing and refinement of the proposed tool were supported by workshops and interviews with professionals from the following case study companies (table 1.)
Table 1. Case studies.

<table>
<thead>
<tr>
<th>Organization</th>
<th>Activities</th>
<th>Persons involved</th>
<th>Time</th>
</tr>
</thead>
</table>
| Cascades Djupafors AB (Packaging industry) | 2 workshops 1 interview/ assessment | Purchasing Managers  
Sustainability Experts – BTH | March / April 2010 |
| Tetra Pak Technical Service AB (Food process and packaging industry) | 2 workshops 1 interview/ assessment | Manager of Purchasing Department for Base Materials  
Sustainability Experts – BTH | March / April 2010 |
| Scandic Hotels AB (Hotel chain)     | 2 workshops 1 interview/ assessment | Manager of Sustainable Business  
Sustainability Experts – BTH | March / April 2010 |
| Affärssverken AB (Energy utility)   | 2 workshops 1 interview/ assessment | Managers, Project Directors from the company and municipality.  
Sustainability Experts – BTH | October / November 2010 |
| Volvo Construction Equipment AB (Heavy machinery industry) | 1 workshop | Managers, researchers and project directors  
Experts - BTH | October 2010 |

3 Results

The proposed tool consists of three main parts:

1. The Sustainability Self-Assessment Matrix
   A self-assessment matrix (tables 3-7) displays the five levels of the FSSD with an added set of statements and in relation to each of those four maturity degrees (MD). The MDs represent the organization’s maturity in addressing sustainability issues in a strategic way.
2. Sustainability Profile Visualization
A visual representation of the organization’s sustainability profile is included in
the tool to give a compact and easily accessible overview. As seen in table 6 the
case studies show a wide variety of sustainability profiles. For confidentiality
reasons we do not indicate in this paper which profile that belongs to which
organization.

3. Business Models Design Templates
The business model design templates (tables 8-12) are similar to the
Sustainability Self-Assessment Matrix but with MD4 given as the goal to guide
generation and selection of ideas for business models design. Templates
containing basic components of a business model and related building blocks
were outlined.

Figure 1. Process overview and results.
Table 2. Sustainability Self-Assessment Matrix - System Level.

<table>
<thead>
<tr>
<th>Maturity Degree Assessment (e.g.)</th>
<th>MD 1</th>
<th>MD 2</th>
<th>MD 3</th>
<th>MD 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - Systems</td>
<td>Statement</td>
<td>The organization has a clear understanding of the operational design of its business models in relation to the environmental and social systems globally (including value chain and all kinds of stakeholders).</td>
<td>We have little or no understanding or engagement with environmental issues and with societal stakeholders in our value chain.</td>
<td>We have conducted some environmental and social awareness activities, communication campaigns, and provided ad hoc reporting to some external stakeholders in our business system.</td>
</tr>
</tbody>
</table>

Table 3. Sustainability Self-Assessment Matrix - Success Level.

<table>
<thead>
<tr>
<th>Maturity Degree Assessment (e.g.)</th>
<th>MD 1</th>
<th>MD 2</th>
<th>MD 3</th>
<th>MD 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 - Success</td>
<td>Statement</td>
<td>The organization has a clear definition of success, including an operational definition of sustainability, and has an understanding of the business case of supporting society’s transformation towards this definition.</td>
<td>We have no formal corporate definition of sustainability; the term is used in different ways in different parts of the organization.</td>
<td>We have a formal corporate definition of sustainability, however, the term is used in a reasonably uniform way throughout the organization.</td>
</tr>
</tbody>
</table>

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### Table 4. Sustainability Self-Assessment Matrix - Strategic Level.

<table>
<thead>
<tr>
<th>Maturity Degree Assessment (e.g.)</th>
<th>3 - Strategic</th>
<th>MD 1</th>
<th>MD 2</th>
<th>MD 3</th>
<th>MD 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describes strategic guidelines that aid development towards success (including sustainability / success) in the system.</td>
<td>The organization has adopted/developed and built experience in using strategic guidelines that aid development towards sustainability.</td>
<td>We do not yet have any strategic guidelines related to sustainable development and consequently no experience in using such guidelines.</td>
<td>We have some strategic guidelines related to sustainable development and some experience in using those.</td>
<td>We have a set of strategic sustainability guidelines, goals, and experience in applying those for all kinds of investments, repeatedly and systematically across the organization.</td>
<td>We have a full set of strategic sustainability guidelines and goals with extensive experience in applying those for all kinds of investments repeatedly and systematically throughout our operations across the value network.</td>
</tr>
</tbody>
</table>

### Table 5. Sustainability Self-Assessment Matrix - Actions Level.

<table>
<thead>
<tr>
<th>Maturity Degree Assessment (e.g.)</th>
<th>4 - Actions</th>
<th>MD 1</th>
<th>MD 2</th>
<th>MD 3</th>
<th>MD 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describes concrete actions and plans of actions (strategies) that are aligned with strategic guidelines to arrive at success in the system.</td>
<td>The organization has well-documented concrete business plans that are fostered by strategic guidelines towards its goals and is systematically executing these plans together with relevant external stakeholders in its business system / value network.</td>
<td>We have no plans and there have been no or few actions that are fostered by strategic guidelines and a definition of sustainability, and there has not been communication regarding sustainability with stakeholders outside the organization.</td>
<td>We have some plans and there have been some actions that are fostered by strategic guidelines and a definition of sustainability, and also some cooperation regarding sustainability with some but not all relevant external stakeholders in our value network.</td>
<td>We have plans and plenty of examples of major actions and investments that are fostered by strategic guidelines and a definition of sustainability, and extensive cooperation regarding sustainability with some but not all relevant external stakeholders in our value network.</td>
<td>We have plans and there have been actions that involves investments in time and money that are fully fostered by strategic guidelines and a definition of sustainability, and extensive methodical cooperation regarding sustainability with relevant external stakeholders in the business system.</td>
</tr>
</tbody>
</table>
Table 6. Sustainability Self-Assessment Matrix - Tools Level.

<table>
<thead>
<tr>
<th>Maturation Degree Assessment (e.g.)</th>
<th>MD 1</th>
<th>MD 2</th>
<th>MD 3</th>
<th>MD 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>MD 1 (low)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MD 2 (high)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MD 3 (high)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MD 4 (high)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 7. Sustainability Profile Visualization.

<table>
<thead>
<tr>
<th>FSSD</th>
<th>MD1 [low]</th>
<th>MD2</th>
<th>MD3 [high]</th>
<th>MD4 [high]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systems</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Success</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strategic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tools</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 8. Business Model Design Templates – Targets and Indicators / System level.

<table>
<thead>
<tr>
<th>1.System</th>
<th>Statement</th>
<th>Goal / MD4</th>
<th>Value network and business systems</th>
<th>Assessments, Targets and Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The organization has a clear understanding of the operational design of its business models in relation to the environmental and social systems globally (including value chain and all kinds of stakeholders)</td>
<td>We have an extensive repeated and systematic sustainability evaluation within the company in relation to our sustainable vision and goals, which occurs across the value chain and with other stakeholders (extended enterprise)</td>
<td>Value Creation and Proposition</td>
<td>Processes, activities, resources, assets</td>
</tr>
<tr>
<td></td>
<td>Value Network and key Stakeholders</td>
<td>Suppliers, customers/users, relationships, information and material flows</td>
<td>Return on Investments / Value Capture</td>
<td>Revenue streams costs, life cycle costs, financial aspects and consumption patterns</td>
</tr>
</tbody>
</table>
Table 9. Business Model Design Templates – Targets and Indicators / Success level.

<table>
<thead>
<tr>
<th>2. Success</th>
<th>Statement</th>
<th>Goal / MD4</th>
<th>Value network and business systems</th>
<th>Assessments, Targets and Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describes the organization’s intrinsic goal, informed by sustainability principles applied as boundary conditions</td>
<td>The organization has a clear definition of success, including an operational definition of sustainability, and has an understanding of the business case of supporting society’s transformation towards this definition</td>
<td>We have a formal corporate definition of sustainability based on principles that are: necessary, sufficient, general, concrete and non-overlapping. We have full consensus and buy-in to this from senior management and across all the value chain including joint ventures</td>
<td>Value Creation and Proposition</td>
<td>Processes, activities, resources, assets</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Value Network and key Stakeholders</td>
<td>Suppliers, customers/users, relationships, information and material flows</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Return on Investments / Value Capture</td>
<td>Revenue streams costs, life cycle costs, financial aspects and consumption patterns</td>
</tr>
</tbody>
</table>

Table 10. Business Model Design Templates – Targets and Indicators / Strategic level.

<table>
<thead>
<tr>
<th>3. Strategic</th>
<th>Statement</th>
<th>Goal / MD4</th>
<th>Value network and business systems</th>
<th>Assessments, Targets and Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describes strategic guidelines that aid development towards success (including sustainability / success in the system)</td>
<td>The organization has adopted/developed and built experience in using strategic guidelines that aid development towards sustainability</td>
<td>We have a full set of strategic sustainability guidelines and goals with extensive experience in applying those for all kinds of investments repeatedly and systematically throughout our operations across the value network</td>
<td>Value Creation and Proposition</td>
<td>Processes, activities, resources, assets</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Value Network and key Stakeholders</td>
<td>Suppliers, customers/users, relationships, information and material flows</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Return on Investments / Value Capture</td>
<td>Revenue streams costs, life cycle costs, financial aspects and consumption patterns</td>
</tr>
</tbody>
</table>
Table 11. Business Model Design Templates – Targets and Indicators / Actions level.

<table>
<thead>
<tr>
<th>4. Action</th>
<th>Statement</th>
<th>Goal / MD4</th>
<th>Value network and business systems</th>
<th>Assessments, Targets and Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describes concrete actions and plans of actions (strategies) that are aligned with strategic guidelines to arrive at success in the system</td>
<td>The organization has well-documented concrete business plans that are fostered by strategic guidelines towards its goals and is systematically executing these plans together with relevant external stakeholders in its business system / value network</td>
<td>We have plans and there have been actions that involves investments in time and/or money that are fully fostered by strategic guidelines and a definition of sustainability, and extensive methodical cooperation regarding sustainability with relevant external stakeholders in the business system</td>
<td>Value Creation and Proposition</td>
<td>Processes, activities, resources, assets</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Value Network and key Stakeholders</td>
<td>Suppliers, customers/ users, relationships, information and material flows</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Return on Investments / Value Capture</td>
<td>Revenue streams costs, life cycle costs, financial aspects and consumption patterns</td>
</tr>
</tbody>
</table>

Table 12. Business Model Design Templates – Targets and Indicators / Tools level.

<table>
<thead>
<tr>
<th>5. Tools</th>
<th>Statement</th>
<th>Goal / MD4</th>
<th>Value network and business systems</th>
<th>Assessments, Targets and Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Tools</td>
<td>Describes various tools, methods and concepts used to assess, develop and monitor actions so that they are aligned with strategic guidelines to arrive at success/ sustainability in the system</td>
<td>The organization makes use of, and informs tools, methods and concepts in a way that supports rational and cohesive use of the systematic approaches outlined in the previous four levels of the framework</td>
<td>We have a complete set of tools, methods and concepts, all cohesively aligned with our overall business strategy to support strategic sustainable development</td>
<td>Value Creation and Proposition</td>
</tr>
<tr>
<td></td>
<td>Statement</td>
<td>Goal / MD4</td>
<td>Value network and business systems</td>
<td>Assessments, Targets and Indicators</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Value Network and key Stakeholders</td>
<td>Suppliers, customers/ users, relationships, information and material flows</td>
</tr>
</tbody>
</table>

4 Concluding Remarks

The tool presented in this paper comprises a Sustainability Self-Assessment Matrix that aim to aid clarification of the assessed organization’s maturity in addressing sustainability issues in a strategic way, a Sustainability Profile Visualization that aim to aid a compact and easily accessible overview of the
result of the above assessment and a set of Business Model Design Templates that aim to guide generation and selection of ideas for business models design.

From the testing in the case companies we conclude that the self-assessment matrix provided great opportunity for dialogue and clearly exposed opportunities and challenges that exist between the lower and the higher sustainability maturity degrees of the matrix. It also provided guidance for idea generation for how to move towards higher levels of maturity. By using the matrix, the companies were sensitized to an approach that is more strategic and less reductionist. The profile visualization was highly appreciated by the case companies as a way of summarizing the assessment results.

The business model design templates extended the maturity matrix deeper into the value chain and linked to typical business model terminology and at this stage of work with the case companies a range of creativity supporting tools for idea generation were introduced. In one case study, modelling of future energy systems in housing and buildings that followed the creativity exercises triggered insights for prototyping innovative business models, which included aspects such as resources availability, likely future customer preferences and user’s behaviours and lifestyles.

In summary, the case studies provided initial support for the desired ability of the presented tool; to assess and visualize the maturity of an organization from a strategic sustainability perspective and to trigger systematic cooperation for generation and selection of ideas for upstream solutions, new business models and strategic goals and indicators during early phases of the innovation process. Resources for training trainers in using aligned operational support methods and tools were identified as one of the main remaining needs. In future work we will develop such resources and also investigate the possibility of including into the tool itself more user guidance, case study examples and creativity supporting tools.

References


District Heating and CHP –
A Vital Role for the Development
towards a Sustainable Society?
Paper D is published as:
District Heating and CHP – A Vital Role for the Development towards a Sustainable Society?

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Göran Broman
César L. França

Abstract

In Sweden, district heating (DH) is quite well developed and is already mainly based on non-fossil fuels. Increased use of DH is therefore considered as a way of phasing out fossil energy for heating purposes. Furthermore, increased use of DH provides an increased basis for combined heat and power production (CHP). Considering that coal condensing is the marginal production of electricity in Europe, increased use of bio-fueled CHP leads to even greater reductions of global carbon dioxide (CO$_2$) emissions. However, in a sustainable society, where there is no longer a systematic increase of CO$_2$ (and no other sustainability problems), the benefits of DH are less obvious. The aim of this work is to explore the impact of DH and CHP in the development towards such a society. A local energy system is studied for five different time periods from 2010 to 2060 with different marginal technologies for electricity production. Results show that when the local energy utility co-operate with a local industry plant and invests in a new CHP plant for waste incineration the global CO$_2$ emissions for the whole studied time period will be reduced with about 48 000 tonnes, which corresponds to over 100 % of the emissions from today’s system for the same time period. When considering that bio fuel is a scarce resource, and that the amount of CO$_2$ emission linked to waste probably will be lower in sustainable society, the global CO$_2$ emissions will be about 250% lower compared to the system of today. The studied DH related cooperation and introduction of CHP will reduce the system cost for the whole studied energy system with 2 500 MSEK for the studied period. In general, the results indicate that the modeled measures will not have any major advantages over other heating technologies in a sustainable society but that it can play a vital role for the development towards such a society.

Keywords: Sustainable Society, Energy Systems, District Heating, Combined Heat and Power, Global CO$_2$ Emissions, Coal-fired Condensing Power Plant.
1 Introduction

Current energy systems are identified as significant contributors to society's currently unsustainable course [1], [2], [3]. Measures that will help redirect our energy system towards sustainability are therefore most vital to find.

In a fully deregulated European electricity market, it is usually coal-fired condensing power plants that have the highest variable cost and thus work as the marginal source of electricity. Electrical efficiencies of such coal-condensing plants are normally between 35% and 45%. However, it should be the plants with the poorest efficiency that supply the margin. Assuming the marginal power production with a 33% electrical efficiency, each MWh of electricity generated in such a coal fired condensing plant releases approximately 1 tonne of carbon dioxide [4]. The global CO₂ impact of 1 tonne per MWh for electricity can thus be compared to, e.g., 0.3 tonne CO₂ per MWh oil, 0.2 tonne per MWh natural gas and to biofuel that according to IPCC is considered as CO₂ neutral.

The principle of coal condensing power being on the margin of the Swedish electric power systems is supported in a report from the Swedish Energy Agency [5], where it is claimed that coal condensing power has been the last dispatched source of power that changes as demand rises or falls in recent years. The same report also states that in the short run, coal-condensing power will remain the marginal source, and in a longer perspective the marginal source in a European system will be natural gas based power plants. This above argumentation means that coal condensing is the marginal source today in Sweden as well as in the rest of the EU when considering a fully deregulated European electricity market with no restrictions on transfer capacity.

Several studies have analyzed different heating alternatives for detached houses including the primary energy use of the whole energy system, from the natural resource to the end-user. The results from these analyses show that DH using cogeneration is one of the most energy efficient heating systems and a means towards reaching the European Union’s goal of reducing the use of energy. In DH systems with combined heat and power (CHP) generation, this increased used of DH and district cooling (DC) is particularly interesting, since the increased heat production in the CHP-plants contributes to extra electricity generation.

Since Swedish DH systems are primarily supplied by renewable energy sources. DH in a CHP system means that the extra electricity produced in the CHP system can replace electricity produced with marginal condensing power plants and as
a result lower global emissions of CO₂. But when instead considering future energy scenarios that present a possibility to supply the world energy demand with renewable and sustainable energy sources, the positive climate benefits of replacing marginal production of electricity will need to be reevaluated since the marginal production of electricity will then not be based on fossil fuels.

The aim of this study is to analyze the impact of introducing CHP in the development towards a sustainable energy system where global energy demand is supplied with only renewable and sustainable energy sources. A regional energy system in Sweden is studied in a system perspective where global CO₂ emissions and system costs are optimized within different time periods from 2010 to 2060.

2 Case Study

The municipality of Olofström is situated in the south of Sweden and has about 7 300 inhabitants. The local energy utility is wholly owned by the municipality and has a DH system with a total heat demand of 40 GWh annually. Energy supply units used by the utility today include two biofuel-fired boilers with stack gas condensing which normally runs as base load production. LPG-fired heating boilers and electricity-driven boilers also produce heat for the DH grid. The Volvo Car plant, situated in the municipality, has a total heat demand of 36 GWh annually. The plant has a local heating system of its own supplied by LPG-fired boilers. Both the local energy utility and the Volvo Car plant are interested in co-operating on heat supply. This would mean that the boilers situated at Volvo Car would become part of the municipality’s district heating production. It would also mean investment in a pipeline that connects the plant with the municipality’s DH grid. There are also ongoing discussions regarding co-operation on excess heat from a large paper mill in the municipality.

In this paper, the above mentioned co-operation between the local energy utility and the Volvo Car plant, is analyzed together with possibilities to use the industrial excess heat for heat supply. Besides that, the effects of investing in a CHP plant are also studied. All measures are analyzed and optimized assuming a strategic development towards a situation where global energy demand is supplied with only renewable energy and sustainable sources in 2050.
3  Modeling

3.1  Method
To analyze the effects of the above mentioned DH related energy supply measures, an optimization model was used to minimize the costs of existing and potential new plants. The model is called MODEST, an acronym for Model for Optimization of Dynamic Energy System with Time-dependent components and boundary conditions [6], [7]. MODEST is a model framework developed for simulation of municipal and national energy systems and is based on linear programming. The aim of the optimization is to minimize the total cost of supplying the demand for heat and steam by finding the best types and sizes of new investments and the best operation of existing and potential plants. The total system cost is calculated as the present value of all capital costs of new installations, operation and maintenance costs, fuel costs, taxes and fees. In this study, the system is optimized over a period of 10 years for each time period and the capital costs are based on a discount rate of 6 %. Each year in the optimization model is divided into 12 months.

The method assumes an ideal situation where, e.g., the demand for district heating and electricity is known and the capacity of the plants is available. MODEST is not primarily a model for operational optimization, even if such can be made. Hourly and daily operations are not the aim of the model, although every hour of the year could be reflected. Even faster or continues fluctuations can, however, not be treated at all. MODEST has no other objective function than the total system cost. Minimization of emissions or the use of certain energy forms at cost maximum cannot be automatically dealt with. These drawbacks have not stopped the performances of the many case studies that have been carried out with MODEST. The model has been tested and applied to the electricity and district heating supply for approximately 50 local utilities, biomass use in several regions, and Swedish power supply [7], [8], [9].

3.2.1  Scenarios
The aim of the scenarios is to describe potential future cases under given circumstances. Different boundary conditions are simulated and their impacts on the energy system in its entirety are evaluated. Two scenarios for five different time periods; 2010-2020 (T1), 2020-2030 (T2), 2030-2040 (T3), 2040-2050 (T4) and 2050-2060 (T5) are analyzed in this study. Short descriptions of the scenarios are presented in table 1. Based on future renewable energy scenarios develop by Greenpeace, fuel costs for the five time periods are assumed according to table 3.
Table 1. Description of scenarios.

<table>
<thead>
<tr>
<th>No</th>
<th>Title</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Reference</td>
<td>The existing energy system of Olofström DH and of Volvo heating system</td>
</tr>
<tr>
<td>S2</td>
<td>COOP, CHP</td>
<td>Co-operation between Olofström DH - Volvo heating system, and an introduction of a CHP for waste incineration</td>
</tr>
</tbody>
</table>

3.3 Prerequisites for the Scenario S2

3.3.1 Modeling co-operation

In scenario S2, the Volvo Car plant is connected to the municipality’s DH grid through a two-way pipe. The investment in the pipeline is assumed to be 210 MSEK and the depreciation time is assumed to be 30 years. Since there are ongoing discussions regarding supplying the municipality’s DH grid with excess heat from an industrial paper mill, this is also included. The price that the Volvo Car plant pays for heat is assumed to be equal to the cost of producing heat.

3.3.2 Modeling a new CHP plant

Inputs for modeling a new CHP plant for waste incineration are presented in table 2. Since the local energy company is planning to condense moisture from the stack gases, this is also included in the scenario. The CHP plant is assumed to be shut down for maintenance and repairs in July. The income from selling electricity produced in the new CHP plant is assumed to be equal to the price of buying electricity in a common electricity market.

Table 2. Inputs for modeling new CHP plant.

<table>
<thead>
<tr>
<th>Inputs for modeling a new CHP plant</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum capacity, steam</td>
<td>20 MW</td>
</tr>
<tr>
<td>Relation between electricity and heat production</td>
<td>0.24</td>
</tr>
<tr>
<td>Investment, CHP boiler and steam turbine</td>
<td>77MSEK/MWel.</td>
</tr>
<tr>
<td>Depreciation time, CHP and steam turbine</td>
<td>20 years</td>
</tr>
</tbody>
</table>
3.3.3 Fuel Costs, Electricity Prices and CO₂ Emissions

Costs for fuel are shown in table 3. The cost of electricity used is based on historical data from Nordpool 2012 [10] and varies from 622 SEK/MWh down to 278 SEK/MWh. An electricity grid cost of 215 SEK/MWh and energy tax of 290 SEK/MWh are added.

Table 3. Fuel costs.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>195</td>
<td>-120</td>
<td>950</td>
<td>10</td>
</tr>
<tr>
<td>T2</td>
<td>233</td>
<td>-97</td>
<td>1117</td>
<td>20</td>
</tr>
<tr>
<td>T3</td>
<td>253</td>
<td>-84</td>
<td>1289</td>
<td>30</td>
</tr>
<tr>
<td>T4</td>
<td>261</td>
<td>-79</td>
<td>1289</td>
<td>40</td>
</tr>
<tr>
<td>T5</td>
<td>266</td>
<td>-76</td>
<td>1289</td>
<td>50</td>
</tr>
</tbody>
</table>

Table comments: Prices for T1 are collected from the local energy utility. Price development for all fuels for the periods T2 – T5 are based on Greenpeace estimations [11].

Net emissions of CO₂ are presented in table 4. Biofuel is considered to be carbon dioxide neutral, according to the IPCC guidelines for national greenhouse gas inventories. However, when considering that biofuel is a scarce resource, the use of biofuel will lead to increased use of coal somewhere else [12].

Table 4. Net emissions of CO₂ [kg/MWh].

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Waste</th>
<th>LPG</th>
<th>Biofuel</th>
<th>Biofuel a scarce resource¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emissions</td>
<td>100</td>
<td>265</td>
<td>0</td>
<td>336</td>
</tr>
</tbody>
</table>

¹ Replaced by coal.

Due to the deregulated European electricity market the change in electricity production and use is assumed to affect the European marginal electricity
production. In this study different marginal electricity facilities are considered for the studied time periods; coal condensing power, gas combined cycle condensing power and renewable energy sources according to table 5.

Table 5. Marginal production of electricity and global CO\textsubscript{2} emissions.

<table>
<thead>
<tr>
<th>Marginal production of electricity</th>
<th>Global CO\textsubscript{2} emissions [kg/MWh]</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 Coal condensing power\textsuperscript{1}</td>
<td>974</td>
</tr>
<tr>
<td>T2 Coal condensing power\textsuperscript{1}</td>
<td>974</td>
</tr>
<tr>
<td>T3 NGCC Gas combined cycle condensing power\textsuperscript{2}</td>
<td>374</td>
</tr>
<tr>
<td>T4 NGCC Gas combined cycle condensing power\textsuperscript{2}</td>
<td>374</td>
</tr>
<tr>
<td>T5 Renewable energy sources</td>
<td>0</td>
</tr>
</tbody>
</table>

\textsuperscript{1} electricity efficiency 38%
\textsuperscript{2} electricity efficiency 58%

4  Results

As described earlier, the system cost includes the present value of all the capital costs of new installations, operation and maintenance costs, fuel costs, taxes, and fees for a period of ten years. This means that the investment cost of a new pipeline between the municipality DH grid, the paper mill and the Volvo Car plant is included, and also the investment costs of a new combined heat and power plant.

4.1 Global CO\textsubscript{2} emissions

The electricity generated in scenario S2 will affect the global emissions of carbon dioxide when assuming that the marginal source of electricity in a European power system is coal-fired condensing power plants or natural gas combined cycle as in the time periods T1 – T4 (see table 5). However, in the time period T5 when the marginal production of carbon dioxide is renewable energy sources, there will be no reduction of global CO\textsubscript{2} emissions due the extra electricity produced in the new CHP plant. As can be concluded from figure 1, the global emissions of CO\textsubscript{2} due to an introduction of CHP for waste incineration, varies from -4 600 tonnes per year for the period T1 to 5 100 tonnes per year for period T5. The electricity produced in the new CHP plant will lead to a reduction of CO\textsubscript{2} emissions in another European country, which explains why the global emissions
of CO$_2$ will be negative in some scenarios. In figure 2 the reduction of global CO$_2$ emissions between scenario S1 and S2 is presented.

![Figure 1. Global CO$_2$ emissions, scenario S2.](image1)

![Figure 2. Reduced global CO$_2$ emissions due to introduction of CHP for waste incineration (S2) compared to the reference scenario (S1).](image2)

The total amount of global CO$_2$ emissions for the whole period from T1 till T5 equals -600 tonnes. This can be compared to the CO$_2$ emissions of 47 700 tonnes for the same period with today’s system (S1), a reduction corresponding to 101% for the studied system. The reduced global CO$_2$ emissions shown in figure 1, are based on a CO$_2$ emissions factor from waste of 100 kg/MWh (see table 5) for each time period. If instead CO$_2$ emissions from waste are assumed to decrease to 50 kg/MWh for time period T3 and– T4 and reduced to zero in T5, the total reduction of global CO$_2$ for the whole period from T1 to T5 will be
58 200 tonnes corresponding to a reduction of 122% (see figure 3). When considering that biofuel is a scarce resource, and that use of biofuel will lead to increased use of coal somewhere else, the reduction of global CO$_2$ when introducing CHP will instead be 118 500 tonnes for the same period corresponding to a reduction of 248% (see figure 3).

![Figure 3. Reduced global CO$_2$ emissions due to introduction of CHP for waste incineration (S2) compared to the system of today (S1).](image)

4.2 System Costs

The system costs for the modeled scenarios represent the cost to meet the demand of DH for the municipality and the Volvo Car plant including income from sold electricity. In figure 4 the reduced annual system costs for each time step are presented. The system cost shown in the figure represents the difference between the reference scenario S1 and the scenario when a CHP for waste incineration is introduced, S2. The total reduction in system cost for the whole period from T1 to T5 equals 2 500 MSEK.

![Figure 4. Reduced annual system cost due to introduction of CHP for waste incineration (S2) compared to the reference scenario (S1).](image)
5 Concluding Discussion

When coal condensing is the marginal production of electricity in Europe, CHP in a DH system will lead to increased possibilities to lower global CO₂ emissions as the increased electricity production in CHP replaces marginal electricity. However, in a sustainable society, where there is no longer a systematic increase of CO₂ (and no other sustainability problems), the benefits of DH and CHP are less obvious. In this paper the impact of DH and CHP in the development towards such a society has been analyzed. Results from the optimizations show that when considering cooperation on heat between a local energy utility and an industry plant, investment in a CHP plant for waste incineration will lead to reduced global CO₂ emissions with 48 300 tonnes, which corresponds to about 100 % of the emissions from today’s system for the same time period. When considering that today’s CO₂ emission factor for waste most likely will be lower in a future sustainable society the reduction of global CO₂ will be even higher. Taking into account that biofuel is a scarce resource, the reduction of CO₂ will be yet even higher, almost 250% compared to the system of today.

Implementing the analyzed measures will also give financial benefits. The total system cost for the studied system will 118 MSEK for the studied period, which can be compared to 2 600 MSEK for today’s system.

The benefits of investing in CHP are less obvious when considering a future sustainable society, where all electricity is produced by renewable energy sources. This paper show however that DH related energy supply measures like investing in a new CHP for waste incineration are vital to take in the development towards this sustainable situation.

Results show both reduced global CO₂ emissions as well as a decreased system cost for the studied system due to an introduction of CHP. For utilities, municipalities and other DH stakeholders to rationally develop viable investment strategies, decision support of the type used in this study is therefore obviously important.

6 Acknowledgements

Financial support from the Swedish District Heating Association is gratefully acknowledged.
References


An Approach to Business Model Innovation and Design for Strategic Sustainable Development
Paper E is published as:
An Approach to Business Models Innovation and Design for Strategic Sustainable Development

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Karl-Henrik Robèrt
George Basile
Louise Trygg

Abstract

Successful business is increasingly about understanding the challenges and opportunities linked to society’s transition towards sustainability and, e.g., being able to innovate, design and build business models that are functional in this context. However, current business model innovation and design generally fails to sufficiently embrace the sustainability dimension. Typically, the business case of sustainability is not understood profoundly enough; the planning horizon and system scope are insufficient; the competence to bring together people into systematic ventures towards sustainable business is too low. A unifying framework for sustainability analyses, planning, cross-disciplinary and cross-sector cooperation, and cohesive use of the myriad sustainability tools, methods and concepts has been developed: the Framework for Strategic Sustainable Development (FSSD). Similarly, a generic approach to business model design has been put forward: the Business Model Canvas (BMC). In this paper we explore how the FSSD could inform business model innovation and design by combining it with the BMC and supplementary tools, methods and concepts such as creativity techniques, value network mapping, life-cycle assessment, and product-service systems. The results show that the FSSD-BMC combination can support business model innovation and design for strategic sustainable development, as well as strengthen each supplementary tool, method and concept in its own primary purpose. We apply the combined approach, for the purpose of initial testing and presentation, to a real case of business model evolution. Based on our findings we propose a new approach to business model innovation and design for strategic sustainable development. The new approach facilitates, e.g., business scalability and risk avoidance and clarifies the interplay between classical business model development and strategic sustainability thinking. The new approach highlights the opportunity for novel business model design for future sustainable success.
Keywords: Business Model Design, Strategic Sustainable Development, Sustainable Business Model, Sustainable Product-Service Systems.

Highlights:
• A strategic sustainability framework is combined with the business model canvas.
• An approach to business model design for strategic sustainable development is proposed.
• The approach links an organization’s sustainable vision, strategy and business models.
• The approach highlights the opportunity for novel business model design.

1 Introduction

The ongoing degradation of ecological and social systems, and efforts to turn this trend around to achieve sustainable development, is redefining the overall conditions for business in the twenty-first century (McNall et al., 2011; Broman and Robèrt, 2016). Successful businesses must, thus, increasingly include and embed an understanding of the challenges and opportunities linked to society’s transition towards sustainability (Willard, 2012). Many businesses have realized this and have started to work with ‘sustainability’ in some way. They have, e.g., adopted sustainability values and new management systems, published sustainability reports, and created specific sustainability departments. However, a growing feeling of fatigue among senior managements has been reported, linked to a lack of ability to make further advances and embed sustainability throughout their organizations’ value creation processes, including products and services, operations and decision making in general (Bertels et al., 2010; Bansal et al., 2016).

1.1 Business Model Innovation and Design

Addressing sustainability challenges both demands and brings great opportunity for innovation in all dimensions of business, from overall creation of value and definition of business success to product and service delivery (Basile et al., 2011). An important but historically neglected aspect is the innovation and design of business models (Schaltegger et al., 2016). However, the accelerating need to identify new pathways for the innovation and design of sustainable business models has led to increased attention to the field (e.g., Bocken et al., 2014; Clinton and Whisnant, 2014; Upward and Jones, 2016; Kurucz et al., 2016).
Osterwalder and Pigneur (2010) define a business model as the rationale of how an organization creates, delivers, and captures value, and they provide a practitioner’s tool to operationalize this; the Business Model Canvas (BMC), which has become one de facto standard for business model development. Unit (2005) reports that the majority of business executives are identifying the design of new business models as a greater source of competitive advantage than new products and services per se. Extending the effort to include sustainability, Lee and Casalegno (2010) propose that the business model is a new unit of discussion and analysis for sustainability initiatives. Schaltegger et al. (2012) and Wells (2013) extend this further, concluding that to support systematic, ongoing creation of business cases for sustainability, business model innovation that goes well beyond traditional business model designs is required. Conversely, business model innovation has been shown to be a critical lever for overall organizational sustainability (Kiron et al., 2013) and that integrating sustainability strategy is not only possible, but required for businesses to be competitive (Baumgartner and Ebener, 2010; Osterwalder and Pigneur, 2011). However, the grand challenge remains: current business model innovation and design generally fails to sufficiently embrace the sustainability dimension (Boons and Lüdeke-Freund, 2013; Upward and Jones, 2016). The business case of sustainability is typically not understood profoundly enough (e.g., Stubbs and Cocklin, 2008); the planning horizon and system scope are often insufficient (e.g., Baumgartner and Korhonen, 2010); the competence to bring together people into systematic ventures towards sustainable business is typically too low (e.g., Rohrbeck et al., 2013). The result is a lost opportunity for advancing and embedding sustainability throughout business-value creation processes via business models that are designed to embrace emerging dimensions of global sustainability.

1.2 Product-Service Systems in Business Model Innovation

Business model innovation and design links business aspirations with the business platforms through which success can be realized (Osterwalder and Pigneur, 2010). A product-service systems (PSS) approach has been proposed as an opportunity for promoting sustainability and strategic business model development (Manzini and Vezzoli, 2003; Tukker, 2004; Tukker, 2015). PSS reconsiders the delivery of functional value to end-users through an integrated mix of product and service, whereby value creation is less about sales and ownership of individual products and more of a focus on the ongoing delivery of the service-value embedded in that product (Mont, 2002; Tukker, 2004). Rifkin (2015), e.g., potentially links PSS to business model innovation when describing how decision makers are changing their business models to operate in a market where the relationship with products and services is shifting from one based on ownership (i.e., goods sold) to one based on access and exchange of combined
goods and services (i.e., PSS) at near-zero marginal costs. Here, the competitive edge shifts toward business models capable of applying modern ICT and supply webs to provide easily accessible and highly contextualized high-performance services with fewer intermediates. However, while the logical leap can be made that PSS in the context described above could enhance sustainability performance in businesses, e.g., through enhanced product stewardship promoted by service contracts and cyclical use of resources as part of product-service efficiencies (Mont, 2002; Maxwell et al., 2006; Tukker, 2015), the business case for, and integration of, global sustainability considerations is not inherent to the ongoing business model innovation process (Schaltegger et al., 2012; Upward and Jones, 2016). Further, in the arena of PSS, while sustainability is often mentioned, there is little concrete support to actually promote integration of sustainability aspects (Vasantha et al., 2012; Tukker, 2015). This is a long-standing challenge. Ehrenfeld (2001) argued that in the product-service systems research field there is a need for a coherent strategy foundation that points towards sustainability. The result is that a gap remains in experiential knowledge for how to combine strategic sustainability thinking, PSS and business model innovation and design for sustainability. In this paper, we term this combination Sustainable PSS Innovation.

1.3 Merging Business Model Innovation and Design with a Systems Perspective for Strategic Sustainability Thinking

In this paper, we argue that a major barrier to sustainable business model innovation and design is the lack of a structuring systems perspective that includes an operational definition of sustainability and strategic guidelines for how an organization can support sustainable development of society while strengthening its own competitiveness. The importance of having a systems perspective when working with business models is highlighted by, e.g., Zott and Amit (2010), and Teece (2010) asserts that coupling strategy analysis with business model analysis is a way to protect competitive advantages that result from the design and implementation of new business models. Casadesus-Masanell and Ricart (2010) suggest that the business model is a way to put a strategy into practice, and argue that a business model is a reflection of the firm’s realized strategy. Thus, to design a business model that is both informed by and supports the execution of a sustainability-informed strategy, it is necessary to appropriately define sustainability and apply concrete strategic guidelines. The Framework for Strategic Sustainable Development (FSSD) includes an operational definition of sustainability and strategic guidelines for how an organization can support society’s transition towards sustainability while strengthening its own organization. The FSSD has also proven useful for structuring analyses and facilitating coordination of various tools, methods and concepts (Robèrt, et al, 2002; Robèrt et al., 2013; Broman and Robèrt, 2016). In
this study we therefore further explore how the FSSD could inform business model innovation and design via the BMC and supplementary tools, methods and concepts such as creativity techniques, value network mapping, life-cycle assessment, and PSS. The work is guided by the following overall research question: How can the FSSD support business model innovation and design for strategic sustainable development?

1.4 Paper structure
Besides this introduction, the paper includes the following five parts: research design, describing the research approach used and the case example; an overview of the main components of the study, including the FSSD and the BMC; results, including the proposed combined FSSD-BMC approach and findings in the case-study; discussion of the results and findings; and conclusions.

2 Research Design

In this paper, we use a qualitative case-study research approach, which according to, e.g., Patton (2002) is appropriate for investigating issues that are complex and difficult to quantify, as well as identifying themes, patterns, concepts and insights that are needed to understand such issues. We use this in combination with conceptual modeling and prototyping as outlined below.

The research was organized into three stages:

2.1 Stage 1. Preparing for the Research
Literature searches and selection of major papers related to business model design, PSS and strategic sustainable development were conducted through a snowballing procedure adapted from Wohlin (2014). Previous work was studied and the research need was clarified and summarized in a research question. The FSSD (Broman and Robèrt, 2016) stood out as a suitable overarching framework for guiding business model innovation and design for strategic sustainable development, for the reasons stated in the introduction. The BMC (Osterwalder and Pigneur, 2010) stood out as a suitable main tool to combine with the FSSD since the BMC is frequently referenced and considered as one de-facto standard support for traditional business model design.

We also identified a case useful for initial testing of the intended combination of the FSSD and the BMC. Since it takes significant time to reach more advanced levels of strategic sustainability thinking, we wanted a case company that was to some extent already familiar with this way of thinking and working. To be able
to really test the intended combined FSSD-BMC approach, we also wanted a case company being in the initial stages of significantly redesigning their overall business model, preferably from a classical product sales logic into a more service-oriented logic, because of the potential sustainability advantages of PSS identified in the literature as mentioned in the introduction. We also wanted a case company with which we had established contacts with business developers and product developers as well as with top management, to allow for a participatory approach and actual change (real decisions) during the study. The case of Aura Light fulfilled all those criteria. Aura Light has a history of strategic sustainability work, focusing on sustainable lighting solutions to professional customers, and is now aiming at shifting their business model from selling light products to selling light as a service. Aura Light subsidiaries and distributors sell lighting solutions worldwide with customers primarily found in industry, retail and the public sector. The company has approximately 300 employees, has its head office in Solna, Sweden, and main development and manufacturing facilities in Karlskrona and Vimmerby, Sweden. Europe and the U.S. are the main markets. The company has lately experienced a high growth rate and good profitability. According to its CEO, this is much due to their strategic sustainability work, also mirrored by a number of national and international awards. Increasingly, the company is interested in exploring a new PSS business model. The interest is driven by a belief that such a PSS model may have higher potential to support sustainable development, e.g., because of economic benefits both for the customers and Aura Light and because of better control of the materials used in the products, which could remain the property of the company. Aura Light is generally examining how to develop and communicate the full market benefits and customer value of the sustainability advantages of their offerings and wished to have their overall business and product development processes reviewed and renewed. The value network, of the current and future business models, was established as the main unit of analysis (Bernd, 2011). The case study set-up was generally informed by recommendations by Yin (2013) and Bryman (2015).

2.2 Stage 2. Prototyping and data analysis
The authors of this paper convened in several group modeling and prototyping sessions to explore, through conceptual modeling (e.g., Brooks, 2007; Kotiadis and Robinson, 2008; Jaccard and Jacoby, 2010) and by using various creativity approaches and tools (Amabile, 1997; Osterwalder and Pigneur, 2010; Kelley, 2001; Kelley, 2007; Carleton et al., 2011), how the FSSD could, in principle, be combined with the BMC in support of business model innovation and design for strategic sustainable development. Several workshops to discuss business model development approaches and to explore specific business model prototypes were then held with executives, business developers and product developers...
developers within the case company. Feedback was gathered directly at these occasions and also afterwards through qualitative interviews (Patton, 2002). We also took direct part in the actual business model innovation and redesign exploration at Aura Light in an action research mode (Reason and Bradbury, 2008). Observations were made during these occasions and we convened afterwards, taking a step back to reflect upon and discuss our respective observations (perceptions) as researchers. The FSSD was used to guide data collection and data analysis. Specifically, to support the value network mapping and analysis we developed five FSSD-informed generic templates, covering: design, production, distribution, use, and end of life. The following main question was asked: How are stakeholder relationships in the value network of the business model configured and what are the sustainability implications of this configuration? This was broken down into sub-questions to help us identify key stakeholders related to each activity and product life stage, identify and characterize the relationships, and identify information flows, material flows, energy flows and socio-ecological sustainability issues (vis-à-vis the sustainability principles of the FSSD). All of this informed new conceptual modeling and prototyping of a combined FSSD-BMC approach. The iterative process is open-ended and remains in progress. See section 4 for more details.

2.3 Stage 3. Presenting results
A preliminary combined FSSD-BMC approach is presented in this paper in the context of the case of Aura Light aiming at shifting their business model from selling light products to selling light as a service.

3 Main Components

In this section, we present the main components of the intended combined approach; the BMC and the FSSD.

3.1 Overview of the BMC
The BMC (Osterwalder and Pigneur, 2010) is a tool that can be used to visualize an existing or potential business model in a single page. The tool can be used by individuals and organizations to facilitate design and re-design of business models as it provides a shared language of business model terms and clarifies their relations. The BMC includes nine basic building blocks and visualizes a logic for how an organization creates, delivers and captures value, covering the four main areas of a business: customers, value offer, infrastructure, and financial viability. The building blocks are briefly described below (see also Figure 1).
**Customers segments** describes the different groups of people or organizations an enterprise aims to reach and serve. The focus is on exploring, understanding and delineating specific customer needs. Examples of customer segments are: mass market, niche market, segmented market, diversified market, and multi-sided market.

**Value proposition** describes the bundle of products and services that create value for a specific customer segment. Examples of aspects that can contribute to customer value creation are: newness, performance, customization, ‘getting the job done’, brand/status, price, cost reduction, risk reduction, accessibility, convenience, and usability.

**Figure 1.** The Business Model Canvas (BMC).

**Channels** describes how a company communicates with and reaches its customer segments to deliver a value proposition. These customer touch-points play an important role in the customer’s experience. The channels serve several functions, including: raising awareness among customers about a company’s products and services, helping customers evaluate a company’s value proposition, allowing customers to purchase specific products and services, delivering a value proposition to customers, and providing post-purchase customer support. Channels can be direct or indirect through partners. Examples include: own sales force, own stores, web stores, partner stores and wholesalers.

**Customer relationships** describes the types of relationships a company establishes with specific customer segments. Customer relationships can range from personal to automate and are driven by the following motivations: customer acquisition, customer retention, and boosting sales (upselling). The
customer relationships deeply influence the overall customer experience. Several categories of customer relationships can be distinguished, e.g., personal assistance, dedicated personal assistance, self-service, automated services, communities, and co-creation.

**Revenue streams** describes the revenue streams, i.e., the cash a company generates from each customer segment. Costs (see below) are subtracted from revenues to calculate earnings. This way, it can be deemed whether the business model is profitable (i.e. successful) or not. A business model can involve two different types of revenue streams: transaction revenues resulting from a one-time customer payment and recurring revenues resulting from ongoing payments. There are several ways to generate revenue streams, including: asset sale, usage fees, subscription fees, lending, renting, leasing, licensing, brokerage fees, and advertising.

**Cost structure** describes all costs incurred to operate a business model. It includes costs for creating and delivering value, maintaining customer relationships, and generating revenue. Many business models fall under two broad classes of cost structures: cost-driven and value-driven. Cost structures can have the following characteristics: fixed costs, variable costs, economies of scale, and economies of scope.

**Key resources** describes the most important assets required to make a business model work. Key resources can be physical, financial, intellectual or human. Key resources can be owned or leased by the company or acquired from key partners.

**Key activities** describes the most important things a company should do to make its business model work successfully. Key activities are required to create and offer a value proposition, reach markets, maintain customer relationships, and earn revenues. Examples of some categories of key activities are production, problem solving, and network related activities.

**Key partners** describes the network of suppliers and other partners that make the business model work. Some main types of partnerships are: strategic alliances between non-competitors, strategic partnerships between competitors (coopetition), joint ventures to develop new business, and buyer-supplier relationships to assure reliable supplies. Some motivations for creating partnerships are: optimization and economy of scale, reduction of risk and uncertainty, and acquisition of particular resources and activities.
3.2 Overview of the FSSD
An up-to-date and comprehensive description of the FSSD is given by Broman and Robèrt (2016). We briefly summarize its main features here.

3.2.1 The Funnel-metaphor
The ongoing loss of the ecological and social systems’ capacities to support fulfillment of human needs can be conceptualized as those systems moving deeper and deeper into a funnel whose narrowing circumference represents increasingly harsher constraints and smaller degrees of freedom for the human civilization (Figure 2). Organizations who are dependent on relatively larger resource-flows, waste-flows, etc. (thereby contributing relatively more than others to the in-leaning wall of the funnel) and who stay relatively more ignorant about the necessary and already ongoing paradigm shift towards sustainability, are also those organizations exposed to higher and higher economic risks. Such organizations will increasingly, and often in abrupt ways that will be increasingly difficult to foresee in detail, experience harsh financial impacts due to the narrowing funnel. Even if it is possible to postpone some of the economic consequences somewhat, e.g., by political lobbying against tax increases on unsustainable practices, it will eventually be impossible to avoid higher and higher costs for resources, waste management, insurances, credits, etc. Such organizations also risk losing innovation opportunities, market shares and new markets to competitors who skillfully become part of ‘the solution’, developing their practices so that they are moving towards the opening of the funnel. The funnel-metaphor helps clarify the systematic and dynamic character of the sustainability challenge as well as the self-benefit of sustainability proactivity. Understanding these dynamics is a good starting point when developing business models in our time. For a further discussion of the funnel metaphor and the business case of sustainability, please refer to, e.g., (Holmberg and Robèrt, 2000; Robèrt and Broman, 2016).
3.2.2 The Five-level Model

How could it be possible to systematically exploit the above outlined potential to capitalize on the dynamics of sustainability, as made clear by the funnel-metaphor? The generic design of the FSSD, and not least its structuring and coordinating qualities, should lend itself well to create cohesion among all aspects of business model innovation and design, including for choosing, combining, informing or developing support tools. The structuring and coordinating qualities of the FSSD rely partly on a clear intellectual differentiation between phenomena of fundamentally different character. This is accomplished by the five-level model of the FSSD.

**The system level:** This level describes the overall major functions of the system an actor (e.g., an organization) is in and depend on, i.e., markets, value-chains and other stakeholder networks within society within the biosphere. The organization needs to understand this system enough, to at least be able to approach the next level and define a vision within sustainability constraints, i.e., what it is the organization wants in the system. The organization, with all its
interdependencies with natural systems, as well as with its suppliers and clients and other stakeholders, is explored and mapped at this level.

**The success level:** This level specifies a vision or visions of success for the organization or other subject of the planning *within* robust boundary conditions for a global sustainable society (sustainability principles; see below). It is important to note that the vision(s) can comprise additional success criteria and that many possibilities for sustainable visions exist.

**The strategic guidelines level:** This level specifies generic guidelines for how to approach the outlined sustainability-framed vision strategically (D-step of the ABCD-procedure; see below). It implies a step-by-step approach that ensures that resources, including financial resources, continue to feed the process towards the defined vision. Additional guidelines can be added by an individual organization depending on the context. It is important to note that many viable pathways to a vision usually exist.

**The actions level:** This level describes concrete actions that have been prioritized into a strategic plan¹ using the above strategic guidelines to arrive at the vision of success in the system. It is important to note that the plan needs to be continuously re-assessed and adjusted as the specific contextual conditions change over time.

**The tools level:** tools, methods, concepts and other types of support are often required to aid decision making, monitoring and disclosures of the actions to ensure they are chosen strategically to arrive at the defined success in the system. Examples are modeling tools, management systems, indicators, life-cycle assessment tools, etc. It is important to note that the FSSD is designed to not compete with any other type of support for sustainable development, but to be structuring and unifying to aid people in making the best use of all available support depending on purpose and context.

### 3.2.3 The Sustainability Principles

To be functional for strategic sustainable development, the set of framing principles need to be: (i) necessary, but not more to avoid unnecessary restrictions and to reduce distraction over elements that may be debatable, and (ii) sufficient, to cover all aspects of sustainability. In addition, the set of principles should be (iii) general to make sense to all stakeholders and thus allow

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¹ A combination of actions is often referred to as a ‘strategy’. The term ‘strategy’ therefore belongs to this fourth level, and should not be confused with the strategic guidelines level. Strategic guidelines are informing combinations of actions to really be strategic, deserving the term ‘strategy’.
for cross-disciplinary and cross-sector cooperation, (iv) concrete to inspire and guide innovation, problem solving and actions, and (v) non-overlapping to enable comprehension and facilitate development of indicators for monitoring progress. Guided by these criteria, the following basic sustainability principles have been derived from understanding first-order mechanisms through which society causes destruction of the socio-ecological system (Broman and Robèrt, 2015):

In a sustainable society, nature is not subject to systematically increasing:

1...concentrations of substances extracted from the Earth’s crust (e.g., fossil carbon and metals);
2...concentrations of substances produced by society (e.g., CFCs and NOx);
3...degradation by physical means (e.g., over-harvesting of forests and over-fishing);

and people are not subject to structural obstacles to:

4...health (e.g., by dangerous working conditions or insufficient rest from work);
5...influence (e.g., by suppression of free speech or neglect of opinions);
6...competence (e.g., by obstacles to education or insufficient possibilities for personal development);
7...impartiality (e.g., by discrimination or unfair selection to job positions);
8...meaning-making (e.g., by suppression of cultural expression or obstacles to co-creation of purposeful conditions).

3.3 The ABCD-procedure
The FSSD uses an application procedure with four general steps as follows (see also Figure 2):

(A) Participants learn and apply the FSSD to share and discuss the topic of the planning endeavour in the context of the global sustainability challenge and related opportunities, and the participants agree on a preliminary vision of success, framed by the basic sustainability principles. This vision sits, metaphorically, at the future ‘opening of the funnel’. The vision usually contains aspects such as core purpose, core values and overall long-term goals.

(B) Participants assess the current situation through the lens of the sustainability-framed vision of success (A). The assessment should in particular
review how the organization contributes to society’s violations of the sustainability principles as well as current assets to deal with those challenges.

(C) Participants turn to creative thinking and co-create possible solutions that can help closing the gap between the vision (A) and the current situation (B). Constraints related to the current situation are temporarily disregarded, e.g., constraints related to the current infrastructure, the current energy system, the current dependencies in the value chain and to other stakeholders, current financial capacity, etc. Before proceeding, it should be stressed that the (B) and (C) steps, though seemingly trivial, are different to traditional analyses of business and business opportunities. Current practices (B) are assessed, and future opportunities (C) are derived, through the lens of robust sustainability principles that need to be fulfilled in the future. This is at the core of the FSSD, i.e., ‘backcasting from sustainability principles’, as opposed to either forecasting, i.e., projection from current situations and trends in an attempt to predict the future and fix the problems that can be anticipated, or ‘backcasting from scenarios’, i.e., planning from detailed images of the future. In the sustainability context it is more helpful to backcast from a principled definition of success or from scenarios framed by such principles (Ny et al., 2006; Broman and Robèrt, 2016).

(D) Participants apply the more pragmatic strategic dimension and prioritize amongst the possible solutions (C), i.e., begin outlining a concrete plan for closing the gap between the vision (A) and the current situation (B). In this D-step, priorities are set with an intuitive logic. It means a stepwise approach, ensuring that early steps are designed to serve as (1) flexible platforms for forthcoming steps that, taken together, are likely to bring society, the organization and the planning endeavour to the defined success, while striking a good balance between (2) direction and advancement speed with respect to the defined success and (3) return on investment to sustain the transition process. This logic creates the opportunity for pragmatic leadership, not only looking at the promise of an improved bottom-line in the future, but also considering short-term profits designed in a way that opens up the potential for the longer-term profits. This way, the FSSD allows for the above outlined self-benefit of sustainability proactivity to be captured by businesses.

4 Results

As pointed out by many, it is important to work with business model development and value creation (including product and service development) in
parallel and to coordinate these processes, as these activities (should) strongly influence each other (Boons and Lüdeke-Freund, 2013; Bernd, 2011; Breuer and Lüdeke-Freund, 2014; Wells, 2013). The FSSD offers a possibility to facilitate communication and coordination between these processes through a shared mental model and language regarding strategic sustainable development. The combination of the FSSD with tools, methods and models for product development has been explored by, e.g., Hallstedt (2008), Ny (2009), and Thompson (2012).

Regarding FSSD-informed business model development, we propose the approach presented below (section 4.1). As explained in the research design section, the evolution of the combined FSSD-BMC approach has been iterative and has included both theoretical work and co-creation and testing with case partners. We present the latest version of the approach in the context of the application to the case of Aura Light aiming at shifting their business model from selling light products to selling light as a service. Presenting the proposed approach this way allows us to convey more specifically and in concrete terms how the approach is intended to be used. We end the results presentation by summarizing the complementarity of the FSSD and the BMC that we have noted (section 4.2).

4.1 Business Model Innovation and Design for Strategic Sustainable Development

The combined FSSD-BMC approach we propose is organized along the ABCD-procedure of the FSSD. As described by Broman and Robèrt (2016), the ABCD-procedure is iterative. We present the current status in each of the A, B, C and D steps, respectively. Due to confidentiality we do not provide all details of the case outcomes.

4.1.1 A Step

**Activities:** The FSSD, the BMC, the combined FSSD-BMC approach and supplementary tools, methods and concepts such as creativity techniques, value network mapping, life-cycle assessment, and product-service systems were introduced by researchers and advisors, through a series of workshops and meetings, to the CEO, the sustainability manager, and key business developers and product developers at Aura Light. The participants discussed all of this, and reviewed and revised the strategic documents of the company, during and between the workshops and meetings. The FSSD was used as the overall guide for the work.

**Outcomes:** The company’s mission (core purpose) and vision are now described through the following statements. **Mission:** Aura Light develops and supplies
sustainable lighting solutions to professional customers enabling them to reduce cost, energy consumption and environmental impact. Vision: Aura Light’s vision is to become the global leading partner for sustainable lighting solutions to professional customers. Note the key words sustainable and solutions, implying a focus on sustainable PSS. Aura Light clearly states in their strategy documents that sustainable ultimately means that the company has eliminated its contribution to society’s violation of the FSSD sustainability principles. Lighting solutions are described in the strategy documents as both products and projects with different levels of complexity that solve the lighting needs of the customers. The trend is towards more complex, systemically sustainability-informed solutions.

4.1.2 B Step
The B step was performed in two stages.

4.1.2.1 Stage 1: Mapping the Current Business Model
Activities: Analysis of the current business model was done through workshops and interviews with the same people as above. Observations and secondary research complemented the analysis. The BMC was used to capture the business model.

Outcomes: Participants gained an overview of the full business model as captured by the BMC. Examples of outcomes for the BMC building blocks are briefly shown in Figure 4. The financial model (primarily ‘revenue streams’) was identified as a major challenge with the current business model. The current revenue streams are mainly based on direct sales of physical products to the customers who become owners and then take responsibility for installations, maintenance and the end of life of the product. The high quality and high energy-efficiency and the long lifetime of Aura Light’s products are beneficial from a life-cycle cost point of view. However, these characteristics also imply a relatively high price (investment). Some customers have limited access to capital for investments and the perceived high ‘cost’ (initial investment) can then constitute an obstacle for sales of these high-end products. The ongoing technology shift to light emitting diodes (LEDs) also contributes to hesitation among the customers. The fast development of the new LED-technology and the lack of long-time experience of its use tend to make customers postpone big investments.

4.1.2.2 Stage 2: Mapping the Current Value Network and Analyzing its Sustainability Implications
Activities: Value network mapping was justified based on a need to more deeply understand networks and value creation systems (Boons and Lüdeke-Freund,
and to capture how it currently reflects the dialogue among stakeholders and their efforts to embed socio-ecological and economic aspects into their development processes and operations. As mentioned in section 2, the following main question was asked: *How are stakeholder relationships in the value network of the business model configured and what are the sustainability implications of this configuration?* We used the five generic ‘value network mapping and analysis templates’ also mentioned in section 2. These templates were used to analyse the following activities and product life stages: design, production, distribution, use, and end of life (collection, reuse/recycling and/or disposal).

More specifically we aimed to: (1) Identify all key stakeholders related to each activity and product life stage. (2) Identify the relationships between the key stakeholders and characterize the respective relationship. (3) Identify information flows, material flows, energy flows and socio-ecological sustainability issues among key stakeholders throughout product life stages. The mappings and analyzes were focused on Aura Light’s NoctiLED street light fixture (Figure 3) as an example. Similar results should be expected for other products. The sustainability principles of the FSSD were used for the sustainability analysis. Data for the analyzes was provided by Aura Light and complemented with information from a comparative life-cycle assessment of street light technologies using the software SimaPRO V.7.3.2 (Hadi et al., 2013). The components considered were: ballast, housing, fitting, lamp, lens, and packaging.

![Figure 3. NoctiLED as part of Aura Light’s street lighting system.](image)
Outcomes: The outcomes include insights about existing patterns and trends within Aura Light and the value network and challenges and assets in relation to the vision. Some examples of current challenges are:

- Investors might see difficulties to recover the goods if customer does not pay their fees.
- The focus on sales of physical products in the current business model is related to one-way flows of materials (rather than reuse/recycling).
- Management routines and incentives are set up for selling (more of) physical products.
- The Aura Light design group (product development group) is focused on, is used to, and has competence in developing physical products.
- The Aura Light sales force is focused on, is used to, and has competence in developing physical products, and the needfinding tools are adapted to this.
- There is a rather weak connection between the Aura Light design group and other functions such as business development, procurement, sales and auditing.
- The attention and communication around sustainability performance are mainly linked to energy-efficiency and not so much to the other sustainability aspects as informed by the FSSD sustainability principles.
• Some company functions and value network partners have a rather limited sustainability competence.

• The top-management’s desired shift towards a more service-oriented business model, and the implications thereof for business as well as sustainability, do not seem clear to all employees and partners in the value network, and the customers are not used to this kind of business model (they are used to owning their light installations).

Generally, the culture of selling product-service systems is not embedded in the organizations. The mind-sets of the organizations and the whole value network are currently focused on direct sales and transactions of physical products. The above challenges imply a need for a shift in mind-sets, management routines and incentives, stronger connections between units within and between the organizations, competence development, and more communication between units and organizations.

Some examples of current assets in relation to the vision are that Aura Light:

• Has a strong light competence and is perceived as a light expert, bringing smarter solutions and peace of mind to customers.

• Has strong personalized customer relations allowing for thorough identification of customer issues and needs, and, in combination with its smaller size, a possibility to be faster to market.

• Has experience of customizing solutions directly with customers.

• Has high quality products that are suitable for being part of a PSS offer.

• Is being perceived as a technology benchmark in the market.

The design group was identified a key unit that can play a major role in the exploration of a new set-up of the business model and value network. For example, designers can inform procurers about potential opportunities to drive innovation and generally much of the sustainability impacts throughout product life-cycles are determined in the early phases of product (and service) development (Hallstedt, 2008; Ny, 2009; Bratt, 2014). This insight was strengthened among all participants and this constitutes an important general result captured in the design template. Given the importance of the design group, we present some examples of outcomes of the value network mapping and analysis captured in the other templates from the perspective of the design group. Regarding the production stage, designers gained insights about flows of
materials that are currently emitted from the production systems and are systematically accumulating in the ecosystem. Regarding the distribution stage, designers noticed how the one-way material flows are currently designed, and how the value network is not optimized regarding logistics (e.g., regarding location of manufacturing). Insights gained from the use stage were mainly related to the negative impact of non-renewable energy use to power the light installations. From the end of life stage, designers gained insights on, e.g., limitations in the current LED recycling program that Aura Light has joined. Overall, the highest sustainability impact occurs during the use stage if the customers use fossil fuel based electricity, which Aura Light has no means to influence with the current business model (users buying the electricity), besides using as energy efficient LEDs as possible in the products.

From the sustainability analysis, based on the mapped flows and other gathered data, a list of socio-ecological sustainability issues was generated, covering all product life stages (Chai, 2013). Examples of issues are the use of some substances in the LEDs associated with risks of systematic increases in concentrations in nature with the current weaknesses in the LED recycling program (e.g., some rare metals and phosphates), fossil transportation fuels and the associated systematic increase in concentration of carbon dioxide in the atmosphere, and some difficulties to audit social conditions in all tiers of the supply chain. Some of these issues are currently being investigated further.

4.1.3 C Step
Activities: Based on the identified challenges and assets in the B step and the gap to the vision, the same participants used some creativity and problem solving techniques to develop and list possible solutions. In this step, the only constraints considered were those implied by the sustainability principles of the FSSD.

Firstly, the tool context mapping (Carleton et al., 2011) was used to capture some broad themes that the participants came to think of when considering the identified gap as well as perceptions of general emergent technologies and business models in the lighting business area. The participants then used brainstorming techniques (Amabile, 1997; Kelley, 2001; Kelley 2007) to generate more specific possible solutions and to prototype new business models (Osterwalder and Pigneur, 2010), using the BMC to capture and integrate the solution ideas and to present the prototyped business models to get feedback and support for prioritization.

Outcomes: The broad themes that surfaced during the context mapping were: selling light as a service (LaaS); sustainable PSS; energy performance contracting
(EPC); personalized energy houses and smart sustainable grids, influencing legislation, and linking renewable energy to the business model.

Examples of more specific solution ideas that were generated during brainstorming and prototyping workshops are:

- Create a new financial model that removes the perceived high cost (initial investment) for the customers as well as the uncertainty of when to shift to a new technology, possibly by establishing a finance institute (Aura Finance\(^2\)) and including upgrading options in the offers. The new model should improve the cash-flow for the customers and Aura Light and remove the lighting installation from the balance sheet.

- Create remote control of the installations to be able to cut light delivery if the customer does not pay.

- Advance the sustainability agenda further, and thereby differentiation to competitors, by offering solutions that even more contribute to human development and reduced ecological impacts, e.g., through advanced control engineering and adaption of light intensity, light color, etc., to varying needs among customers, and through further assessment and dematerialization and substitution of the substances that surfaced as potentially problematic in the B-list.

- Assess and develop the competence and set of methods and tools for integration of sustainability considerations in product development, business development, procurement, sales and other processes, and for parallel development of physical products and services.

- Develop new needfinding tool(s) and involve the design group more in needfinding and sales work.

- Promote multi-stakeholder cooperation, integrating costumers and key partners more in the innovation process, to achieve more customized and unique sustainable PSS offers – total solutions that are also harder for competitors to replicate and that can help differentiate Aura Light from competitors that are strong on the product level.

- Identify key stakeholders and partners and consider acquiring some key partners for effective capacity building with respect to sustainable PSS solutions.

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\(^2\) This finance body has now been established, however, under another (longer legal) name. For simplicity, it is called Aura Finance in this paper.
• Assess employees’ knowledge and understanding of, and dedication to, the company’s vision and strategy and especially the focus on the key terms sustainable and solutions.

• Re-emphasize the vision and point out the direction towards sustainable PSS provision through intensified internal communication (‘president’s speech’, newsletters, group meetings, etc.) and clarify implications for the everyday work of all.

• Align management and reporting structures and routines, human resource development, and incentives with the new sustainable PSS ambition (shifting from a product oriented to a service-oriented company).

• Recruit personnel with a solid education in strategic sustainable development in combination with PSS innovation.

• Update and perform education of all employees to a basic level in strategic sustainable development, educate key people in the design group, business development group, procurement function and sales force further in sustainable PSS innovation.

• Develop a trainee program for new recruits with strategic sustainable development and sustainable PSS innovation included.

• Develop an educational module for partners and external audiences (some of those might also later become customers).

• Strengthen the design group and design function and its connectivity to other groups and functions in the organization by making design a core function and by securing strong connectivity especially to business development, procurement, needfinding, sales, service partners and auditing.

• Develop competence and capacity in the design group to work with the whole value network to develop LaaS offers, by e.g., considering options for taking back schemes, design for longevity, design for re-use in manufacture, design for material recovery, design for closed loop business models, design to improve the fixtures serviceability enabling replacement of individual components to reduce maintenance costs and enable recycling of parts instead of the entire fixture in order to reduce raw material consumption and increase product lifetime, etc.

• Develop competence and capacity in the business development group and sales force to identify and engage with the ‘right’ decision makers among potential customers. Possibly widen the value proposition to regional collaboration for sustainable energy systems and sustainable and safe cities.
• Promote creation of new value from existing (sometimes stranded) customer assets such as light poles by adding functions, e.g., for traffic monitoring and personal safety, for charging electrical vehicles, etc., as part of the total solution.

• Take full responsibilities for all fixtures and installations including reusing fixtures after upgrading them to minimize resource use and sustainability impacts.

Various business model prototypes were generated. An example including a new financial model, is shown in Figure 5.

![Figure 5. Examples of elements of one of the prototyped business models.](image-url)

### 4.1.4 D Step

**Activities:** The participants had workshops and meetings, and discussed by other means, prioritizations of the possible solutions and prototyped business models of the C-list, using the strategic guidelines of the FSSD. The top-management of Aura Light, and ultimately the CEO, made the final decisions.

**Outcomes:** Some of the ideas and possible solutions of the C-list have already been realized or partly realized. An example is that all components of the new financial model, including Aura Finance, are in place and the model will be activated as soon as the first LaaS deal is set (targeted 2016). A company producing and selling luminaires (Zobra) has also been acquired and new agreements with several other partners have been established. Aura Light has
also decided to invest further in research and development on methods and tools for integration of sustainability considerations in product development and business development and related processes (such as needfinding, procurement, etc.). Review and renewal of these processes has been initiated and will go on over the coming years. Further assessment of potentially problematic materials will also take place in the next year. The recommended recruitment has started to some extent but will be more pronounced in 2017-2018 for various reasons. Also in recruitment the (social) sustainability principles of the FSSD are considered, e.g., regarding impartiality. It is a decided target that all new employees should complete basic sustainability training. The more comprehensive education and capacity building are being discussed and will likely take place over several years. Involving the design group more in needfinding and sales has been initiated and will further emphasized in the coming years. Aligning management and reporting structures and routines will take some time. Some re-organization has been done to facilitate the new sustainable PSS orientation but this will also go on over several years.

A few business model prototypes were tentatively selected (prioritized) for further modeling and simulation and one of these is briefly described below in relation to the BMC building blocks (see also Figure 5).

The value proposition is lighting as a service (LaaS). The offer is a contract on a customized solution with possibilities for upgrading and at no upfront cost. The value proposition includes Aura Light’s full responsibility for all fixtures and installations, designed to improve serviceability, enabling replacement of individual components, recycling of parts and reduction of raw material consumption. The customer segments includes European municipalities, industry, office and retail. Aura Light’s international subsidiaries represent the main channels to reach the customers for sales and also to provide post purchase customer support. This includes maintenance, recovery, recycling and replacement of components. Co-creation of customized solutions, and education about sustainable production and consumption, personal assistance, and web-enabled service are the main support to promote customer relationships. To increase revenue streams, and reduce fluctuations, a new subsidiary is established, Aura Finance, as part of the new financial model. The owner of the streets, industry facility, office, etc., is seen as the main source for the revenue stream. Examples of key resources, necessary to make this business model work, are a sales force and original equipment manufacturers knowledgeable in sustainable PSS and Aura Light’s design group having advanced product knowledge. Examples of key activities are needfinding, financial arrangements, installation, education, and maintenance. The ability to manage key partners throughout product life-cycle stages represents an
essential aspect and significant strength for Aura Light. The **cost structure** aims to reflect the life-cycle costs and how they are distributed across the value network to create benefits for both the customers and Aura Light (such as improved cash-flow).

### 4.2 Complementarity of the BMC and the FSSD

Based on the observed complementarity of the BMC and the FSSD, potentially generalizable findings are synthesized and summarized in Table 1. The synthesis integrates observations from the case study with general questions, challenges and aspects from the literature on business model innovation and design for sustainability as, e.g., discussed in the introduction. Further discussion is provided in the Discussion and Conclusions sections below. The table is organized along the building blocks of the BMC as a means to highlight business model innovation and design dimensions. The building blocks ‘revenue streams’ and ‘cost structure’ have here been merged into ‘financial model’.

**Table 1.** Examples of complementarity of the BMC and the FSSD.

<table>
<thead>
<tr>
<th>BMC BLOCK</th>
<th>BMC/FSSD COMPLEMENTARITY</th>
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<tbody>
<tr>
<td><strong>CUSTOMER SEGMENTS</strong></td>
<td>The whole-system perspective and the sustainability lens of the FSSD can spur and enable the organization to reach out at larger groups of stakeholders along the life cycles and expanded value networks. This, in turn, can lead to that some of those stakeholders later become customers (more and more diverse revenue streams). The ‘users and use phase’ dimension added through sustainability analyzes can help to identify material flows and information exchanged by the stakeholders. Need-finding processes can be strengthened with the sustainability focus and are likely to generate new insights, strategies and actions. The global market is naturally considered as part of the segmentation. Customer wants can also become a better reflection of user needs and their relation to fundamental human needs. Conversely, the BMC can help bring about a more refined analysis of the system level of the FSSD, by assisting the exploration of customer segments more in detail.</td>
</tr>
<tr>
<td><strong>VALUE PROPOSITION</strong></td>
<td>The FSSD can add inspiration and guidance for the creation of sustainability-informed value propositions. For example, it can help the organization differentiate sustainability-promoting from unsustainability-promoting value propositions, via mapping of information, energy and material flows related to the considered specific value propositions throughout the value network and through assessment against the sustainability principles. It can also stimulate and inform innovation of novel value propositions with sustainability benefits embedded throughout the value network as a result of an understanding of the funnel-metaphor and how customer wants will likely change in a more and more sustainability-driven market. This should help to create of a <em>dynamic</em> view on value creation. Conversely, the BMC provides a template that can support exploration of the more near-term and classical business-case opportunities within the expanded sustainability-informed value case.</td>
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<tr>
<td>CHANNELS</td>
<td>The global and comprehensive sustainability perspective of the FSSD can help expand the organization’s view on potential touch-points and useful partnerships. The changes in channels needed to work with sustainability-promoting product-service systems can also become clearer (e.g., new types of partnerships and new types of messaging). Conversely, the BMC can assist in the exploration of distribution channels more in detail.</td>
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<tr>
<td>CUSTOMERS RELATIONSHIPS</td>
<td>The FSSD can guide information and education for sustainability-promoting behavior change in the value network, including customers and users. It can also help the organization to be cognizant about the value of trust in the customer relations and guide trust building processes. Conversely, the BMC can clarify that customer relationships can function as strategic opportunities to optimize the business for a sustainability-promoting value proposition.</td>
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<tr>
<td>REVENUE STREAMS AND COST STRUCTURE (FINANCIAL MODEL)</td>
<td>Through, e.g., the funnel-metaphor and the D-step of the ABCD-procedure, the FSSD can help the organization understand not only current financial aspects of different solutions, but the dynamic, strategic implications of sustainability related changes of revenue opportunities and drivers of costs that will likely happen over time. Conversely, the BMC adds specificity and can assure that essential common revenue and cost types are not forgotten.</td>
</tr>
<tr>
<td>KEY RESOURCES</td>
<td>The FSSD can help expand the organization’s view on key resources and prompt more specific questions on not only current but also future resource availability, sustainability impacts of different resources, and other risks and opportunities related to the dynamics of the funnel. Conversely, the BMC can help clarify and categorize key resources that are essential to a company and that should all be explored when developing strategic plans towards the sustainability-framed vision.</td>
</tr>
<tr>
<td>KEY ACTIVITIES</td>
<td>The strategic plan established through the FSSD-work can directly inform key activities and how they will likely change over time. The FSSD can also help the organization identify and use appropriate supplementary tools and other forms of support. Conversely, the BMC can aid ideation of possible activities and assure that essential common activities are considered.</td>
</tr>
<tr>
<td>KEY PARTNERS</td>
<td>The FSSD can help expand the organization’s view on suitable partners and spur ideas for wider partnerships, including non-traditional partnerships with, e.g., municipalities and other public institutions. It can also guide the creation and facilitation of multi-stakeholder collaboration, and through this, identification of new business opportunities. The FSSD may serve as an effective shared mental model for stakeholder networks to work together with product-service systems. Conversely, the BMC adds specificity and can help structure the partnership creation process.</td>
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5 Discussion

Today’s classic business model development paradigm, as a whole and as captured in the BMC, is incomplete (Upward and Jones, 2016). This would appear obvious when today’s biggest challenge to business is considered, i.e., society is not currently ecologically and socially sustainable — including all facets of civilization such as business itself. However, using only the BMC might result in business models that are identified as ‘successful’ regardless of their large-
scale or long-term impacts on society at large. From a business point of view this implies, e.g., that classic business model development as captured by the BMC does not ensure businesses that are globally scalable. Without the addition of sustainability principles and guidelines for how an organization can support sustainable development while strengthening its own competitiveness, businesses will run into emerging limitations from today’s unsustainable development and also risk being outcompeted by businesses that more skillfully navigate the necessary and accelerating shift towards global sustainability. Therefore, in this paper we have explored the specific question: How can the FSSD support business model innovation and design for strategic sustainable development?

The approach presented in this paper, combining the BMC and the FSSD, provides guidance for avoiding such limitations and for capturing business opportunities associated with the development of an organization’s vision, strategy and business models in support of strategic sustainable development (as outlined in Table 1). Conversely, though well thought-through from a strategic sustainability point of view, we have also shown that the FSSD can be enhanced as regards its business perspective. It was possible to find sites of the FSSD where the BMC blocks could complete the FSSD and sharpen the FSSD system mapping for business-model development of sustainable businesses. Our analysis also shows that language, scope, limitations and presentation technique differ in some aspects, e.g., revenue streams and cost structure in the BMC are in the FSSD described as return on investments with the scope going beyond only financial revenue streams and costs (Willard, 2012). The BMC adds business specificity, assuring that essential business-model aspects are not forgotten, and provides a means for realization of novel sustainability strategies. The BMC also adds a means for being visual and creative in mapping the extended enterprise, and to generate business-oriented solutions for related sustainability challenges.

Using the combined FSSD-BMC approach, the case company Aura Light was able to transform its vision and strategy from that of a classic product-sales business to a product-service enterprise, with sustainable LaaS as its new value proposition. This included re-visioning all aspects of the business from expanded partnerships required for a product-service providing business to product design to finance to value definition. However, a general challenge for this study was the lack of direct contact with all types of stakeholders that should be involved in multi-stakeholder collaboration within the developing arena of business model innovation and design for strategic sustainable development. Creative thinking and innovation require involvement and commitment of the full value network (Rohrbeck et al., 2013). Also, the utilization of a variety of
supplementary tools, methods and concepts does create a set of variables embedded within the results presented. Thus, the presented approach and others like it will benefit from more case studies for testing and feedback for further improvement and validation.

The results of this study largely align with those of Upward and Jones (2016), who develop a general ontology for strongly sustainable business models and (Kurucz et al., 2016). Our study also provides a real-world case example. The results support the idea that business models should, in general, express their purpose and vision in terms of sustainability as described by Stubbs and Cocklin (2010). The strategic dimension of sustainability proposed in this study addresses questions by Baumgartner and Korhonen (2010) related to the slow progress in sustainable business-model development and their proposition that there is a need for a process for clarifying the connection between strategic thinking and sustainability. The study is also consistent with the need pointed out by Zott and Amit (2010) for new research on the relationship between strategy and structure and on the boundaries of firms, as well as the importance of taking a systems perspective when working with business models. We found that the combination of the FSSD and the BMC-informed business model development process led to extended planning perspectives and horizons with respect to, e.g., key resources (e.g., the product design group reframed as a business-design group and sustainability-informed resource requirements and options), value-definition (e.g., new ideas on where value can be developed within a broader service-based business model), and key partners and operations (e.g., broader definition of useful and necessary operational partnerships and stakeholder relationship development). The integration between sustainability and a competitive strategy (i.e., a hybrid strategy) based on the offering of LaaS through the sales of lighting product-service systems is also aligned with the assertion of Baungartner and Ebener (2010) that hybrid strategies can be beneficial for society in general and for the company and customer, but requires a business ready and willing to undertake efforts that match competitive requirements and sustainability requirements. Also, Aura Light’s general business success from a strong sustainability focus provides support for the assertion of Osterwalder and Pigneur (2011) that social and environmental purposes do not have to be inherently sacrificed for profits or vice versa.

Finally, the FSSD-BMC approach also initially addresses questions and demands from various authors from the PSS field regarding the need for the development of support for sustainable PSS. Vasantha et al. (2012) concluded that the focus on sustainable PSS is not matched by support to achieve it. Tukker (2015) concluded that current research on PSS has mainly focused on improving
(traditional) competitiveness, lacking explicit attention to sustainability. In this study, strategic sustainability thinking was injected into a PSS business model innovation and design process.

6 Conclusions

Our study shows that there are no contradictions in principle between the FSSD and the BMC. On the contrary, the FSSD adds essential aspects to each of the nine BMC blocks – highlighting how business, in general, will be heavily influenced by an increasingly sustainability-driven market in line with the FSSD funnel dynamics, and how backcasting from the sustainability principles can be applied to strategically address those dynamics. The BMC adds business specificity, assuring that essential business-model aspects are not forgotten, adds a means for being visual and creative, and generally provides a means for realization of novel sustainability strategies. We also conclude that the FSSD-BMC approach (as the FSSD itself) is seldom self-sufficient. Depending on the context it is necessary to supplement the FSSD-BMC approach with, e.g., methods and tools for ideation, value network mapping, life-cycle assessment, and modeling and simulation of technical solutions.

The combined FSSD-BMC approach (and, in extension in combination with today’s standard business model development in general), highlights the great potential that exists for business, both individually and as a global institution, if a robust and systematic approach to sustainable development is layered into business-model development. The new approach to Business Model Innovation and Design for Strategic Sustainable Development highlights that for those business entrepreneurs, be it new businesses, or seeking to redesign a current business, a suite of classic business objectives is strengthened when sustainability is integrated as a primary value-creation aspect and operational framework. For example:

- **Scalability**: combination of the FSSD and the BMC allows for business models to avoid developing their businesses dependent on behaviors that are demonstrably unable to scale to a global level (e.g. failing to understand implications of relying on unsustainably managed natural resources and failing to take into account wide spread impacts across multiple socio-economic sectors of ‘globally successful’ business actions). Thus, without the integration of the FSSD, the ‘holy grail’ of globally transformative business becomes economically unsound.
• **Risk Avoidance**; similar to scalability, the integration of a strategic sustainability lens into the classic business model paradigm clarifies a number of previously invisible risks in the business model development process.

• **Investment Strategy**; the combination of highlighting new scalability issues and risks provides a more complete lens for the identification and development of strategic investment pathways, i.e., generating and prioritization actions into flexible platforms for sustainable business success, including potential resource requirements.

• **Partnerships and Social Integration**; the broadened and more realistic business landscape provided by the new approach highlights a suite of new potential partnerships, relationships, cooperative activities and integration across an enlarged group of social institutions that are increasingly important to business success.

The new approach to Business Model Innovation and Design for Strategic Sustainable Development also highlights the general value of bringing specific sectorial-development aspects to more general frameworks for sustainable development. While the FSSD brings critical information and guidance for sustainable development in any institutional context, by itself it does not provide *all* the information needed for the sustainable development of successful institutions in any given arena (e.g. business, government, NGO or other emerging institutions). Having the combination of both overarching strategic guidance (e.g., the FSSD) and sector-specific needs and tools (e.g., the BMC and other support tools for business) is becoming increasingly important as all institutional sectors must evolve for sustainable development and new institutions must be developed.

Overall, the new approach to Business Model Innovation and Design for Strategic Sustainable Development clarifies the interplay between classical business model development and strategic sustainability thinking and highlights the opportunity for novel business model design for future sustainable success.

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References


ABSTRACT

Humanity confronts an existential threat without historic precedent. Environmental pressures have reached such intensity and pace of change that the earth system may be irreversibly tipped into a new and unpredictable state. The emerging global reality is, in turn, redefining overall conditions for business success. Addressing these challenges both demands and brings great opportunities for innovation. An important and sometimes neglected aspect of innovation is the design or redesign of business models, which has been identified as a greater source of lasting competitive advantage than new products and services per se. The business model has also been suggested as a new unit of analysis when discussing sustainability. However, this is still a relatively underexplored area. The aim of this work was therefore to develop an approach to business model design that supports strategic sustainable development, i.e., supports organizations to contribute to society’s transition towards sustainability in a way that strengthens the organization.

To be able to design a business model that supports strategic sustainable development, it is necessary to know what sustainability is and how to develop sustainability-promoting, economically viable strategies. Therefore, the Framework for Strategic Sustainable Development, which includes, e.g., an operational definition of sustainability and strategic guidelines for how to approach it, was used as an overarching framework. Specific research methods and techniques included, e.g., literature reviews, questionnaires, interviews, work with focus groups, participatory action research with partner organizations, creative problem solving techniques, modeling, and simulation.

The literature reviews revealed potential sustainability benefits of developing business models in conjunction with product-service systems (PSS). However, a knowledge gap exists regarding how to effectively connect these fields. Arguably, PSS strategies can best contribute to sustainability when business models support their implementation and when both the business models and the PSS strategies are guided by an understanding of strategic sustainable development. Therefore, an integrated approach to Business Model Design for Strategic Sustainable Development was co-developed and tested in PSS innovation work with partners, e.g., companies within the energy and lighting sectors. The tests indicated that the new approach helped to clarify strengths and weaknesses of current business models from a strategic sustainability perspective; to transform an organization’s vision and strategy into a sustainability-framed vision and a sustainability-promoting strategy; and to communicate the new vision and strategy to the value network as a basis for engaging important stakeholders in the change. For example, the approach supported one of the partner companies in its transformation towards providing sustainable PSS solutions in the form of light as a service.

Examples of business benefits of the new approach include improved scalability and risk avoidance which provide a foundation for better investment strategies. Benefits also include improved differentiability and a broadened view on, and a more solid foundation for, collaboration with stakeholders that are increasingly important to sustainable business success.