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Designing Product-Service System Framework

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ABSTRACT:
Multiple previous studies have focused on either PSS innovation or Design Thinking, but none have examined the combination of PSS fundamentals and Design Thinking methodology. As a result, the thesis's objective is to develop a framework for PSS innovation that is iterative in nature and customer-centric. CompanyCo, a electronics manufacturing company, is used as a case company for this study. The thesis aims to develop a process for the Product-Service System (PSS) innovation that supports CompanyCo's strengths, capabilities, and strategy.

First, this study demonstrated through a case study in district heating that an appropriate PSS innovation framework for CompanyCo's emerging offering could be based on The New Double Diamond Model of Design Thinking, the Design Thinking macro process, and PSS fundamentals. The framework is divided into "finding the right problem," which defines the problem, and "finding the right solution," which drafts the solution via PSS essentials and rapid prototyping.

Secondly, the thesis explores CompanyCo’s capabilities and pitfalls towards servitisation as descriptive "current state study.” Questionnaire were conducted for this study: an online form. The study aims to understand the organisation's current situation and help it become a more agile PSS provider. A single company was studied using multi-method qualitative and quantitative research.

The findings indicate that the strengths to leverage in servitisation are CompanyCo's dedicated people and their enthusiasm for driving a cross-organisational development strategy and PSS's. CompanyCo's product portfolio is well-positioned towards servitisation due to its end-to-end capabilities, scientific innovation, and value-adding products that include a tangible component of value. Study subject’s hardware portfolio represents an opportunity to capitalize on potential value-added pricing and value communication opportunities. Pitfalls to servitisation include CompanyCo's unclear processes for customer information, daily customer information flow, and transparency of the service offering's cost structure. Consistency in PSS solutions, marketing, producing, and selling customised bundles are significant challenges. The findings suggest that hardware manufacturing traditions continue to haunt the transition, manifesting themselves in the company's tooling and processes. The result covers only a minority of the company’s employees, and only one framework is used. This can bias the results.

The thesis shows that the designed PSS innovation framework could be used for PSS innovation in the case company. The research company solely determines the theoretical framework's applicability. The framework could have been tested on multiple companies. Case studies are highly subjective, allowing for researcher and interpreter errors. The thesis took a specific approach (iterative, customer-centric procedures) rather than considering alternative viewpoints.

KEYWORDS: Product-Service Systems, Design Thinking, Innovation Process, Servitisation, Rapid prototyping

Contents

Figures

Tables

Abbreviations

B2B	*Business-to-Business*
B2G	*Business-to-Government*
CAPEX	*Capital Expenditures*
DER	*Distributed Energy Resources*
OPEX	*Operational Expenditures*
PSS	*Product Service System*
TOC	*Total Ownership Cost*
PIC	*Product Inventory Cost*
COGS	*Cost Of Good Sold*

1 Introduction

Manufacturers are increasingly orientated to servitise or add services to their offerings (Annarelli et al., 2019; Baines et al., 2007). Servitisation refers to the process of generating revenue streams for manufacturers through the provision of services (Ellram, 1993; Kindström, 2010; Oliva & Kallenberg, 2003; Tukker, 2004). Servitisation has become a common trend for many manufacturers operating in the business-to-business (B2B) context (Meier et al., 2010), which is the focus of this study.

The thesis reviews the key elements of PSS design and Design Thinking processes to understand the variety of new servitisation approaches. In this emerging field, the thesis aims to develop an innovation process for the PSS innovation that supports CompanyCo's, a business in the electronics manufacturing, strengths, capabilities, and strategic business development in CompanyCo's emergent offering. CompanyCo's ability to recognise its strengths and weaknesses to improve customer-centric development is vital for business growth in the emergent offering.

CompanyCo is a traditional deep-tech engineering house with solid capabilities and a track record in electronics hardware development. Part of its strategy is to sustain long-term market leadership and expand to new markets with growth opportunities. The plan also includes the creation of new recurring revenue streams and the servitisation of the business in emerging and growth areas. Renewable energy, automobiles, and smart cities are examples of growth sectors that are driven by megatrends. In this field, differentiation comes from professional measurements to decision-supporting digital insights and combining these bundles of result-driven services with a broad hardware portfolio. These decision-supporting digital insights require new skills and competencies in Servitisation, Product-Service Systems (PSS), and agile development such as Design Thinking methods.

The thesis aims to form a PSS innovation framework and practice it on CompanyCo's case in the business-to-business (B2B) energy supply and demand sector, giving the research

a more pragmatic perspective. The practice explores new service-oriented solution patterns that fit customer references in the external case study. The case study is conducted in the energy supply industry, specifically in district heating generation and distribution. The thesis supports the organisation contributing and growing to society's transition towards customer complexity and sustainability (Raddats et al., 2016).

In addition, the thesis studies CompanyCo's internal and external motivation towards PSS, the subcategory of servitisation as descriptive “current state study.” The "current status study" aims to increase understanding of the organisation's current situation, enabling the company to transition to an agile PSS producer. The study uses a normative and qualitative approach.

1.1 Background

The term "business servitisation" refers to a company's transition from a product- or service-focused model to one based on a bundle of products, services, and integrated systems (Annarelli et al., 2019). The term servitisation first appeared in the 1980s (Vandermerwe & Rada, 1988).

Servitisation has a variety of advantages for manufacturers. To begin, it can provide competitive advantages that serve to separate the company from competitors. Second, it can result in financial rewards, such as revenue growth. Finally, it may provide market-oriented benefits, such as client relationship improvement (Baines et al., 2007; Brax, 2005; Fang et al., 2008; Oliva & Kallenberg, 2003). Furthermore, advantages may be realised via predictable long-tail revenue and steady income (Annarelli et al., 2019; Meier et al., 2010).

According to Raddats et al. (2016), reasons for manufacturing companies' customers to adopt full-stack solutions include; service quality improvement, customer value improvement, and switching capital expenditure from CAPEX to OPEX investment. Capital

expenditures (CAPEX) are significant investments made by a business for long-term usage. Operating expenses (OPEX) are expenses incurred daily to keep a firm running (Ross, 2021).

1.1.1 Product-Service Systems

As a subcategory of servitisation, Product-Service systems are an integrated combination of products and services to better fulfil customer needs and have environmental benefits (Manzini & Vezzoli, 2003). Figure 1 illustrates the PSS as presented by Baines et al. (2007), demonstrating the company's path toward PSS's.

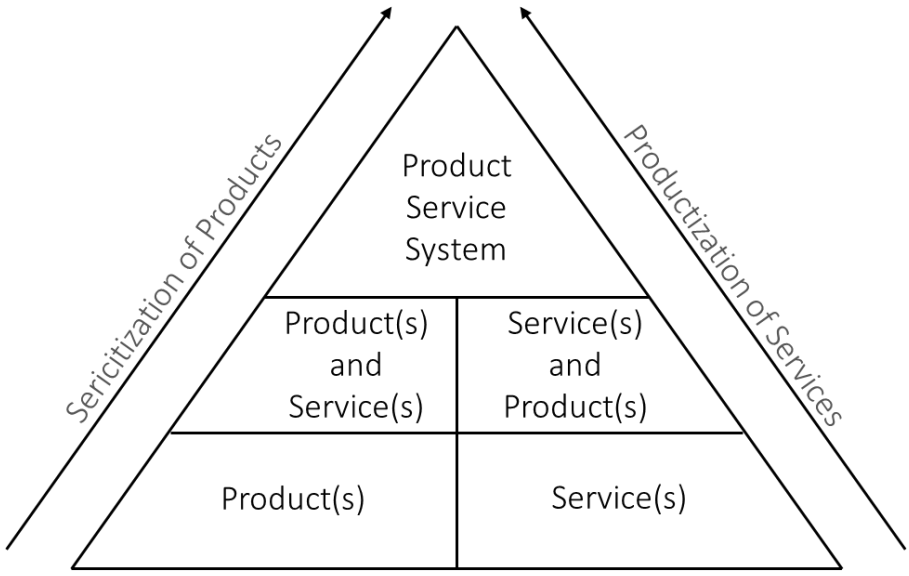

Figure 1. Product-service system (see Baines et al., 2007).

1.1.2 Design Thinking

Design Thinking has progressed from its academic roots in the 1980s to attain a broad audience in the corporate, entrepreneurial, business community (Brown, 2008) and beyond. Design Thinking is a creative process with analytical perspectives that allows

people to experiment, create through doing and prototyping, and gain customer feedback and iteration. Design Thinking acknowledges that a particular intuition and analytical approach are critical for innovative solutions (Razzouk & Shute, 2012). The basic steps of Design Thinking are shown in Figure 2.

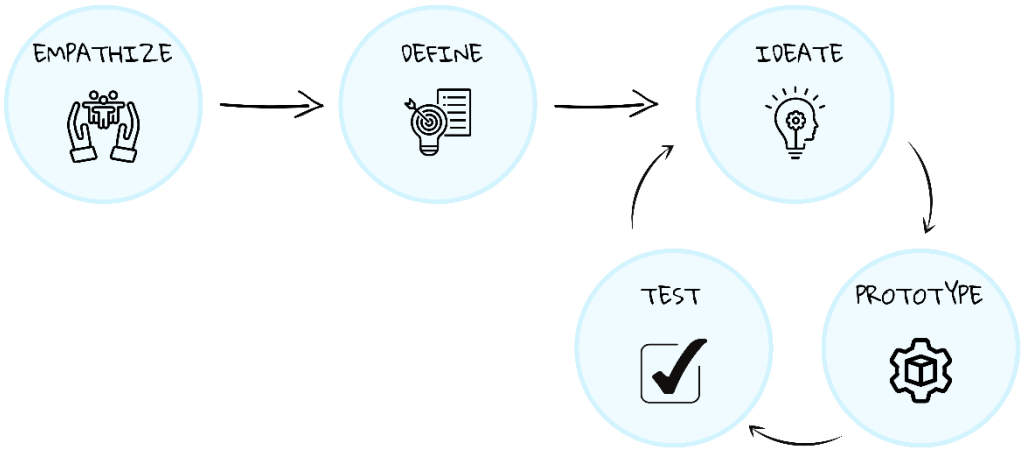

Figure 2. Basic steps of Design Thinking (adapted from Perspectives, 2021).

1.2 Research questions

CompanyCo is following figure 1's path of product servitisation (Baines et al., 2007) on a product and service basis, with current capabilities focused on hardware development and sales. It is undergoing a significant strategic transformation in support of its PSS offerings. CompanyCo is working to understand its current state and establish a framework for PSS innovation to support emerging offerings.

Research question 1:

What would be a suitable PSS innovation framework for CompanyCo's emergent offering?

Research question 2:

What is the current status of servitisation in CompanyCo's existing business?

The scope of the first research question is to develop a workable PSS innovation framework to support CompanyCo's emerging service offerings. The second question is intended to assist CompanyCo in identifying potential success factors and pitfalls associated with the transition to decision-supporting digital insights and result-driven service bundles.

1.3 Structure of the thesis

The thesis structure is constructed on four major phases; literature review, the current state of servitisation study, PSS innovation framework creation, and PSS innovation framework deployment on the B2B energy sector case. The thesis structure is presented in Figure 3.

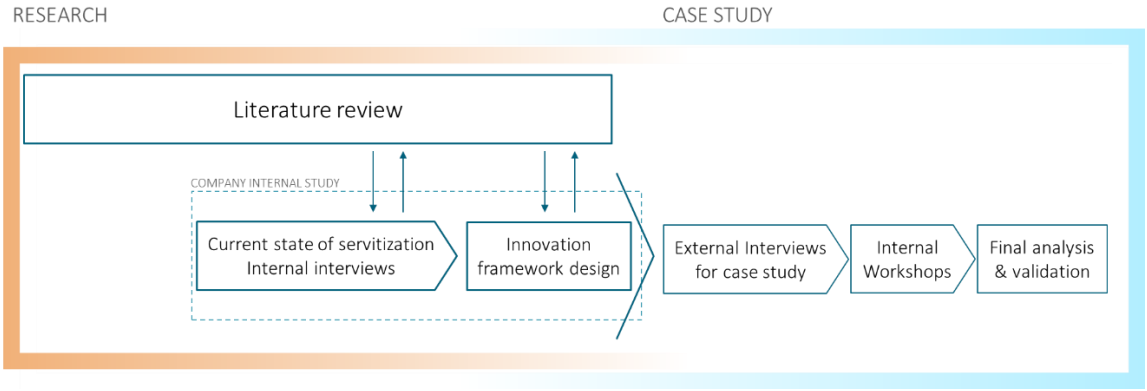

Figure 3. Thesis structure.

Literature review gives a comprehensive understanding of PSS concerning its relevant theoretical aspects of fundamentals and innovation. The review also studies modern Design Thinking innovation processes to understand innovation tools, customer-centric design, and rapid prototyping in the product development process. These theoretical frameworks will guide through the empirical part of the thesis.

Based on the theoretical frameworks, fundamental theories are used to form an interview deck for the *current state of servitisation research* to understand the capabilities of CompanyCo. Intensive case research aims to understand a unique case from the inside of the CompanyCo with expert interviews mapping CompanyCo's current capabilities and competencies. This provides a comprehensive, contextualised, and detailed description (Eriksson & Kovalainen, 2015). The current state study of this thesis aims to understand how CompanyCo's specific and unique organisational case works, combining theory to the status quo, CompanyCo's goals, and competencies.

PSS innovation framework creation forms and designs the PPS innovation process, combining PSS innovation fundamentals and Design Thinking processes. This process design is based on the literature review. The framework will use Liu's (2016) Design Thinking's double diamond as a baseline and attach Design Thinking procedures to PSS essentials.

The framework is tested and validated during the framework deployment phase on a B2B energy sector district heating case. In this phase of research, the framework is verified. The framework deployment illustrates the compatibility of the designed framework in a real-life context using external industry experts from chosen industries to form a case study. A case study is used in intensive design sprints as a form of workshop sessions. A Group of CompanyCo's experts is selected to achieve cross-organisational development knowledge to find innovational and unorthodox solutions to new customer segments. CompanyCo's current capabilities, strategic goals, and competencies need to be considered in the PSS solution design, making the transition to PSS and Design Thinking more efficient.

2 Theoretical framework

2.1 Design Thinking

According to Timo Brown, CEO of IDEO – leading design consultation and education company, "Design Thinking is a human-centred approach to innovation that draws from the designer's toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success" (IDEO, 2021). In simple words, Design Thinking is a discipline that matches customers' desires acknowledging technological feasibility, customer references and values, and what viable business strategy can renovate into the market opportunity (Björklund et al., 2019; Kimbell, 2011).

Design Thinking principles (Figure 4) are (IDEO, 2021; Kimbell, 2011);

- Desirability: What do people desire, understand, and honestly want?
- Feasibility: What is capable technically inside the tangible or probable future?
- Viability: What is the capability of developing a sustainable business model?

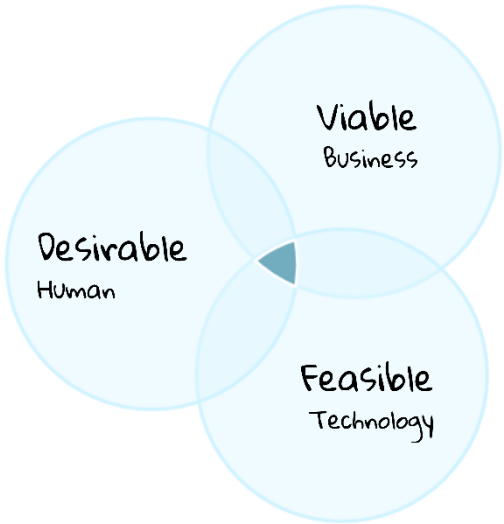

Figure 4. Design Thinking principles (adapted from IDEO, 2021).

Desirability, viability, and feasibility are achieved using the designer's sensibility and methods to understand customer needs and the solution domain. As the leading companies from Fortune 500 lists are nowadays also ranked in most innovative companies

listings, businesses are investigating ways to incorporate Design Thinking into each phase. (Brown & Wyatt, 2010; Forbes, 2018; Fortune, 2021). According to Rae (2016), when design principles are applied to strategy and innovation, the innovation success rate increases considerably. Apple, Pepsi, IBM, Nike, Procter & Gamble, and SAP have all outpaced the S&P 500 by an astounding 211 per cent during a ten-year period and are companies of desing-led status.

The majority of businesses are optimised to execute on a specified objective and resolve a stated problem. Creativity is about identifying a compelling problem to solve. Without a scalable creative framework, incremental innovation is favoured above disruptive innovation. To achieve disruptive innovation, businesses must develop ways to infuse and expand creativity throughout their organisations (Naiman, 2021; Pikover, 2017).

As industry titans such as IBM and GE recognise the critical role software plays in their organisations, they are also aware of the unprecedented amounts of complexity they must manage (Kolko, 2020). Simplifying and humanising requires the use of design thinking. It cannot be an add-on; it must be a core competency (Björklund et al., 2019).

"There is no longer a meaningful divide between business strategy and user experience design," Bridget van Kralingen, senior vice president of IBM Global Business Services.

Design thinking succeeds when it identifies ideal solutions that are based on real-world demands. Jon Kolko (2020) states on the design thinking evolution;

“People need their interactions with technologies and other complex systems to be simple, intuitive, and pleasurable. When done well, human-centred design enhances the user experience at every touch point and fuels the creation of products and services that deeply resonate with customers. Design is empathic, and thus implicitly drives a more thoughtful, human approach to business.”

2.1.1 Double diamond of Design Thinking

The Design Council (2005) introduced the classing baseline for Design Thinking driven processes with a diverge-converge pattern and four distinct phases; discover, define, develop and deliver. These stages give a template for different modes of thinking designers use. As the original framework emphasises developing and delivering phases without adding a comprehensive iteration loop, this thesis uses “The New Double Diamond Model of Design Thinking,” created and introduced by Jasper Liu (Liu, 2016).

Liu (2016) upgrades the double diamond to a more transparent and comprehensive iterative cycle (Figure 5) where the key takeaways are the following:

Finding the right problem is the first phase of the process. As Liu (2016) states, traditionally, projects start with objectives to boost conversion rates or develop a cloud solution. However, these objectives can be viewed as solutions without attachments to the key problem to solve. In Design Thinking, the designers need to step out of the outcome assumptions. The process begins by identifying the true nature of the issues, their underlying causes, and the current methods of addressing them.

The process behind the double diamond is ultimately the **diverge-converge thinking** process, wherein during the problem phase designer comes up with a series of research to determine the pain points and problems that people have and converge them to problem statements. Cross-disciplinary and multinational groups diverge the problem into solutions through brainstorming or other workshop activities in this solution phase. Through evaluation, comparison, consolidation, and other exercises, the solution phase is converged to a limited number of solutions to prototyping and testing (DC Design, 2017; Liu, 2016).

The Design Thinking double diamond also focuses on **iteration** in the progression during the whole design process lifecycle. As Liu (2016) states, there are no perfect solutions, only trade-offs. External and internal prototyping and testing illustrate the weaknesses

in the initial solution and enable the audience to redefine the problems. (DC Design, 2017; Liu, 2016).

In the centrum of Liu's double diamond is a **human-centred design**. The goal of human-centered design is to foster profound empathy for the customers whom it is created for. Empathy is achieved with close collaboration with customers, showing the process, and testing the prototypes. With tools like observing user behaviour and putting inventors into the customer's shoes, designers better understand the problems and behaviour of customer stages (DC Design, 2017; Liu, 2016).

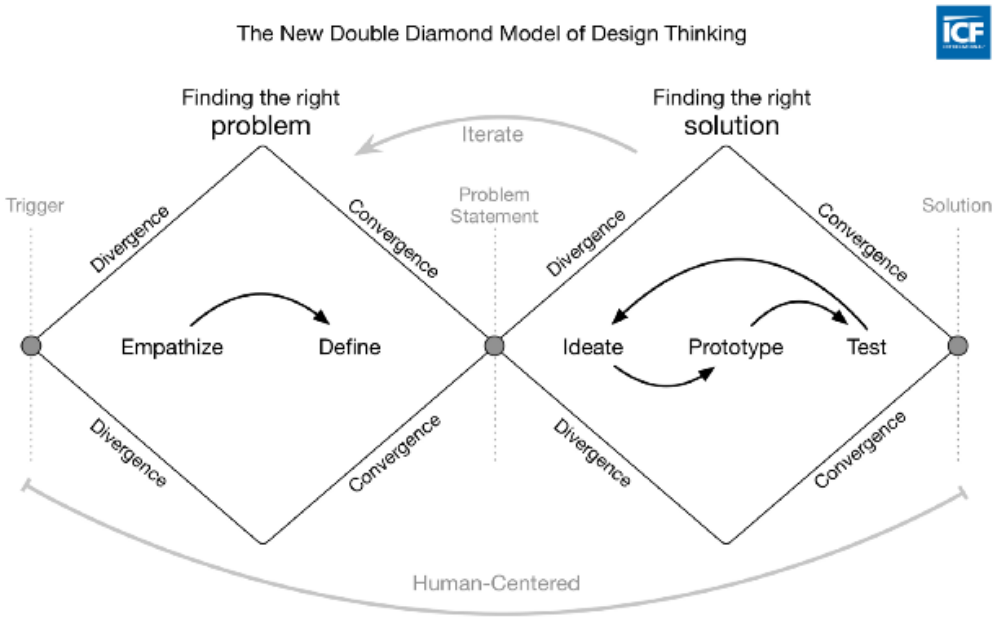

Figure 5. The New Double Diamond Model of Design Thinking (Liu, 2016).

2.1.2 Rapid prototyping

In the Design Thinking process, the role of prototyping is essential. Liu's (2016) double diamond includes the macro process of rapid prototyping inside the solution phase. The types of prototype levels can be seen illustrated in Figure 6. The goal of prototyping is to build a functional prototype for presentation to the tester and examine the function(s) that the project wants to validate (Björklund et al., 2019; Mattern, 2019). The projects

are large, and the prototypes need to validate different aspects or goals. Therefore, varying prototype processes can validate different clarity levels (diverge vs. converge) and functionalities (Schori, 2021).

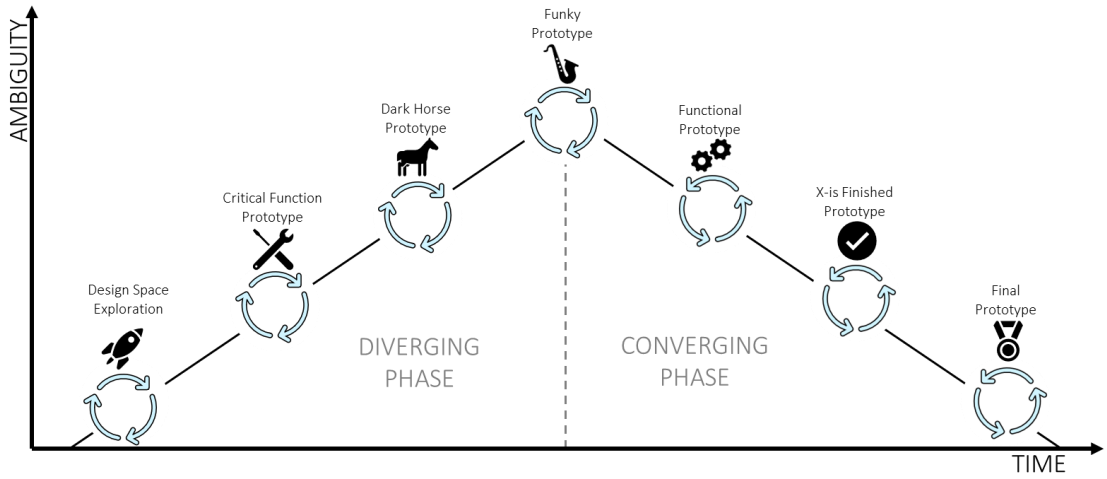

Figure 6. The Design Thinking macro process adapted from DT at HSG (University of St. Gallen, 2021).

Design space exploration phase includes the classical interviews and target group clarifications. With these interviews, open-ended questions are often asked to get familiar with the topic. The importance of these prototypes is to get to know the target group through clarifying prototypes such as personas and user journeys (Schori, 2021).

Critical function prototypes validate the minimum requirements for MVP products. For example, in this phase, customers may list and prioritise needed functions. Therefore, designers clarify minimum product requirements (Björklund et al., 2019; Mattern, 2019).

Darkhorse prototyping refers to using a mysterious black horse in horse racing to achieve an unexpected victory. In this prototyping process, designers can try the limits of unorthodox solutions “out there” to diverge the understanding of the solution phase (Mattern, 2019).

Funky prototype aims to combine and integrate promising elements ideated and explored previously. With duct tape and glue, or first functional sketches of UX, PowerPoint, customer experience cycle, or other rapid methods, designers can test the first iterations of solution combinations with customers. Funky prototypes aim to sharpen the vision of the solution journey (Brenner et al., 2016; Mattern, 2019; Schori, 2021).

Functional prototype explains vital elements of funky prototypes and provides a sneak peek at how the final prototype may look. This prototype serves as the initial convergent milestone for scoping out the final prototype. Prototypes define initial "feels like / appears to be / works like" experiences. The design team can use this prototype to elaborate on and clarify technical issues and develop a detailed development plan for the final prototype.

X-is-finished prototype has a specific goal to develop one key feature or functionality as it will be experienceable on the final prototype. The design team absorbs feedback to understand the key features, functionalities, and user experience (Brenner et al., 2016). This milestone also helps the design team understand key features and major technical issues that occur and need to be developed for the final prototype.

Final prototype is a high-resolution functional prototype in which previously validated key features are combined and integrated into the final prototype. This prototype encapsulates all necessary functions for delivering a complete customer experience. The final prototype develops and documents the essentials of critical functions for the solution's future implementation (Brenner et al., 2016).

2.2 Product-Service Systems

2.2.1 Servitisation

The trend of servitisation means a shift from a product-oriented company to a product/service-oriented company. (Baines et al., 2007 ; Lightfoot et al., 2013) Traditionally, companies in the manufacturing industry develop and produce tangible products for selling to answer consumers' needs. In addition, companies may offer customers maintenance, training, and repair services to answer the essential requirements in case of malfunction and usage problems. These product-oriented services have not traditionally played an influential role in the company's strategy in the past (Lay et al., 2009). According to Neely et al. (2011), manufacturers primarily offer complex engineering products, implement servitisation strategies and note it in strategies.

Neely et al. (2011) encapsulate changes in strategies to five different trends: (1) from products to solutions, (2) elements to ecosystems, (3) outputs to outcomes, (4) suppliers to network partners, (5) transactions to relationships. (Figure 7).

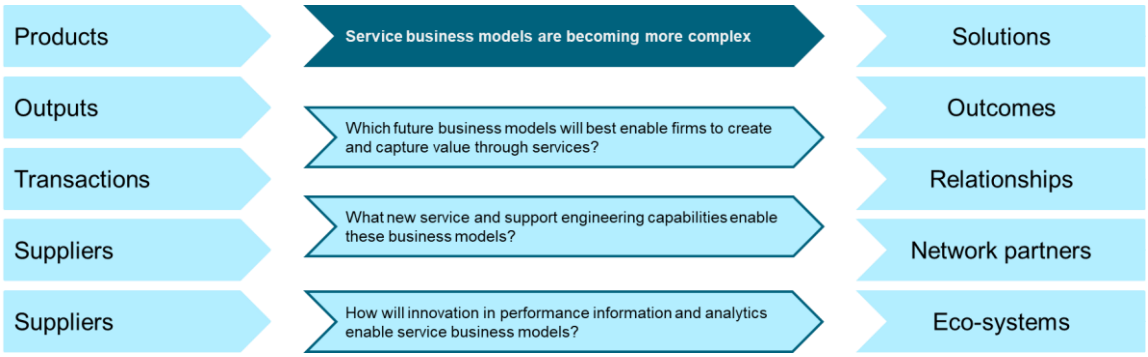

Figure 7. Elaboration of the change of services (Neely et al., 2011).

2.2.2 Concept of PSS

The product-service system, a subcategory of servitisation, emerged in the 1990s to define the PSS concept (Baines et al., 2007; Brax, 2005). The literature's definitions vary

considerably, particularly concerning the environmental factor. The definitions emphasise the importance of bundling the service and product as a complete system and customer-centricity. Although, even with the controversy, ecological benefits are desired while designing PSS.

As an original definition, according to Goedkoop et al. (1999), p.18, PPS, "a Product Service System is a marketable set of products and services capable of jointly fulfilling a user's need. The PSS system is provided either by a single company or by an alliance of companies. It can enclose products (or just one) and additional services. Furthermore, product and service can be equally important for the function fulfilment."

According to Bauren et al. (2013), the most cited definitions of PSS are by Baines et al. (2007) and Mont (2002) as presented below:

Baines et al. (2007) state: "A PSS is an integrated product and service offering that delivers value in use. A PSS offers the opportunity to decouple economic success from material consumption and hence reduces the environmental impact of economic activity." (p. 3)

Mont (2002) reasons that PPS should be defined as "A system of products, services, supporting networks and infrastructure that is designed to be: competitive, satisfy customer needs and have a lower environmental impact than traditional business models." (p. 239)

This research uses a definition highlighting three essential elements; products, services, and systems, based on Annarelli et al.'s (2019) modification of Goedkoop et al. (1999) definition:

> ***Product**:* Object or good conceived, designed and manufactured for selling to answer consumer's desires.

***Service**:* An act or activity designed to support the customer in performing a task. It has value-adding properties for customer work and has value to exchange on a commercial basis.

***System**:* A rudimentary combination that combines a set of interrelated elements and their relationships.

Combining these three elements (product, service & system) to functional rudiment brings towards the definition of PSS, a set of products and services connected to jointly fulfil customers' needs. (p. 1-2)

2.2.2.1 Terminology surrounding PSS

Many terms other than PSS is in use for businesses combining products and services to a functional system. Pawar et al. (2009) noted that different terms are often used for a seemingly identical concept. In the academic articles defining PSS (Boehm & Thomas, 2013; Park & Lee, 2009; Tan et al., 2006), multiple terms are listed with meanings similar to PSS. These terms can be seen as listed in Table 1. The similar terminology makes it more problematic to find all the necessary information around PSS.

Table 1. Terms used to describe concepts identical or similar to PSS (Park & Lee, 2009; Tan et al., 2006; Boehm & Thomas, 2013),

Service engineering	Service/product engineering
Servicification, servitization, servitisation	Hybrid product
Service package	Bundling
Integrated product and service offering	Hybrid value bundles
Functional sale	Systems Selling
Integrated product and service engineering	Hybrid value creation
Full-service	Functional product
Integrated solution	Industrial Product-Service System

Total care product	Servicing
Solution	Circular economy business models
Extended product	Servitisation
Eco-Efficient producer service	Post mass production paradigm
Covalent product	Integrated product service
[*Word here*] as a Service	

2.2.2.2 Classification

PSS's most used classification by Baines et al. (2007) and Tukker (2004) splits PSS's into three categories: product-oriented PSS, use-oriented PSS, and result-oriented PSS. The classification is on the orientation spectrum, from pure product to pure service, illustrated in Figure 8.

The first main category is product-oriented service. In this category, the company provides services required during the use of the merchandise provided by the company. According to Tukker (2004), these services can take the form of a maintenance contract, a financing arrangement, or a take-back agreement at the end of the product's lifecycle. According to Zhang et al. (2012), in product-oriented PSSs, provided products are traditionally sold, where product ownership is transferred. The service agreement is included as part of the product-service bundle to enhance and ensure the product's proper operation within the specified timeline.

Tukker (2004) defines three subcategories under the second category, use-oriented services: product lease, product renting/sharing, and product pooling. While the traditional product is central to this category, the business model is not focused on product sales. The product owner does not change and can be made available in a variety of forms. Multiple users can access the created product. The provider's objective is to maximize the product's required demand, extend the product's lifecycle, and improve the circularity of procurement materials (Baines et al., 2007).

The third category, result-oriented PSS, sells accessibility or outcome rather than the product. The consumer and provider agree on a result in this case, and no pre-determined product is involved (Tukker, 2004). The producer of the products retains ownership, and the customer pays only for the provision of the settled result.

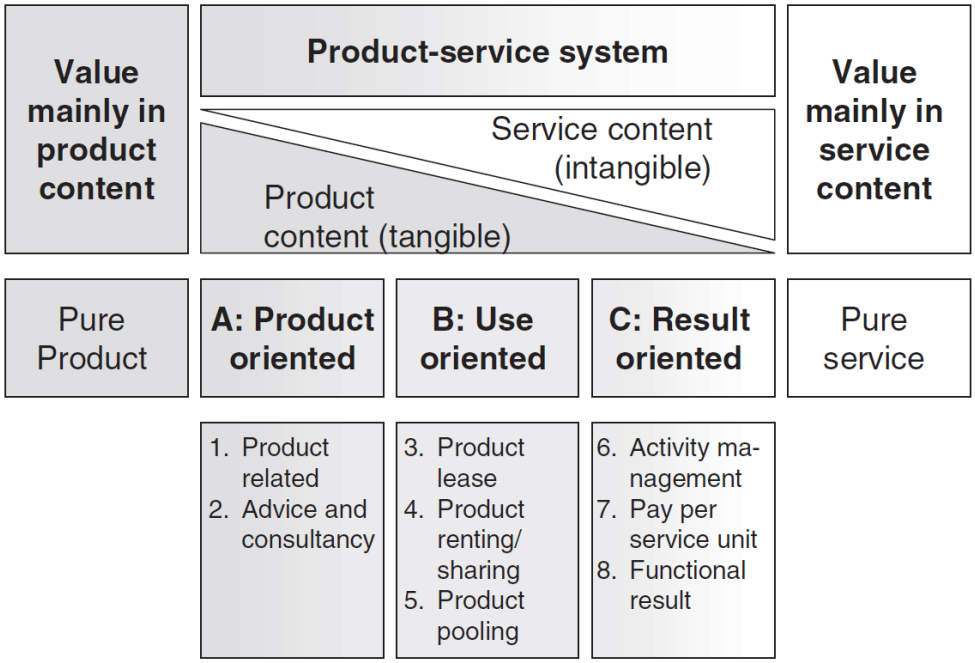

Figure 8. Main and subcategories of PSS (Tukker, 2004).

2.2.2.3 Morphology of PSS

Another degree of servitisation can be inspected to better characterise customer needs (Joachim, 2017). This degree is more "abstract" and focuses on freedom of action where the provider focuses on delivering the result. This characterising includes hidden difficulties in answering to abstract needs of the consumer (Annarelli et al., 2019)

Five main foundations can be used as a baseline when understanding the PSS business and related offerings (Figure 9). These PSS foundations are recommended to be taken into account in PSS innovation. The foundations are following:

1. *Ownership of the produced product or physical component*

The provider should carefully inspect and manage the ownership state since ownership might open new changes in the recycling, reuse, or remanufacturing of components. Ownership needs to be examined from two perspectives: state of ownership through and after the use phase. Leaving the ownership state to the customer during the use phase may cause an unwanted lack of performance and inconvenience (Lay et al., 2009).

Characteristic Features		Options			
Ownership	during phase of use	Equipment producer	Leasing bank	Operating joint venture	Customer
	after phase of use	Equipment producer	Leasing bank	Operating joint venture	Customer
Personnel	Manufacturing	Equipment producer	Operating joint venture	Customer	
	Maintenance	Equipment producer	Operating joint venture	Customer	
Location of operation		Equipment producer's establishment	Establishment "fence to fence" to the customer	Customer's establishment	
Single / multiple customer operation		In parallel operation for multiple customers	Operation for a single customer		
Payment model		pay per unit	pay for availability	fixed rate	pay for equipment

Figure 9. Morphological Box as a framework to describe new business concepts (Lay et al., 2009).

2. *Personnel*

The organisation structure of personnel should be considered on PSS characterization in the decision of manufacturing versus maintenance. . Organisations should be supporting cross-organisational innovation and development to achieve adaptive organisation. Human resources should be divided into manufacturing-focused and maintenance/service supply-focused when moving to the provision of services (Lay et al., 2009). The producer, an operating joint venture, or the customer may be responsible for personnel responsible for production (manufacturing-focused) and maintenance (maintenance/service supply-focused).

3. Location of operations

Location of operations is often considered a definitive resource in the manufacturing industry (Raddats et al., 2016), where products are usually produced in the company's faculty. PSS's location plays a role in PSS design, where production can be arranged in three different ways (Annarelli et al., 2019). Location varies from company to customer's establishments. The third way to allocate the operations is the so-called supply park, where the company establishes its facilities on the customer's side as "fence-to-fence."

4. The number of customers served

The number of customers may vary in different innovative business models for one to multiple customers. The number of customers served model is strongly dependent on the specific product to be produced and consumed in the product-service bundle (Annarelli et al., 2019).

5. Payment model

PSS innovation provides payment models as customer requirements vary (Raddats et al., 2016). The customer's traditional purchase model can be challenged, and more flexible payment models can be implemented. These payment models can be from payment for actual utilisation rate where the customer pays for availability or for time unit (ex. monthly, yearly) and units effectively produced (Annarelli et al., 2019).

2.2.3 Innovating and creating PSS

Rogers, 2002 defines innovation as an object, idea, or practice that an individual or alternative adoption unit considers new. In innovation, companies should utilise co-creation and collaboration with partners, suppliers, and customer resources. In traditional manufacturing companies, PSS innovation may involve conventional core competencies and solutions such as manufactured products offered to the customer in a new and innovative way (Kindström, 2010). According to Kindström (2010), companies may also focus the innovation on service-related innovation. The corporation can generate new

services and realise new service-based market positions using a service-related extended resource base.

In an article from Washington State University (2020) on the innovation of new PSS, five essential steps need to be considered:

Emphasise uniqueness and differentiating qualities: A business must differentiate itself from the competition to be successful. Subscription businesses must emphasise what sets them apart from pay-per-service providers and what they can do that a pay-per-service provider cannot. Two examples are product discovery (discovering new and intriguing products that consumers would not otherwise know) and reducing in-store visits. Make it clear to customers how this particular service is unique.

Emphasise convenience: Convenience is a significant plus factor in subscription services. They spare consumers time and make it even easier to discover items. Subscription services enable the possibility of an online consumer path to avoid human contact with the salespeople and make the upgrade and cancelling effortless. To help consumers understand the convenience, emphasise these "pluses."

Emphasise variety: A gaming service may offer subscribers a selection of thousands of games. A snack delivery service may send items that individuals would never consider trying on their own. A music streaming service may enable listeners to access any genre of music they desire at any time. This variety is a significant advantage of the subscription model that traditional retailers cannot match.

Emphasise simplicity: People prefer effortless solutions. A subscription service simplifies everyday tasks from razor ordering to movie renting and food ordering.

Use various subscription models: Use both pay-per-product and subscription. Designers do not have to adjust the innovation to one pricing model to offer to the customer. In

innovative pricing models, the consumer can pay in different methods and choose the inconvenient model.

2.2.3.1 Subscription economy

Since companies like Netflix and Spotify have long operated on a subscription-based model with a flat monthly fee, the subscription economy is one of the top emerging trends. Additionally, the shift away from capital expenditure-focused Thinking toward operational expenditure is routinely maintained by expanding the product offering toward performance- and lifecycle-based service products with a strong focus on results (Annarelli et al., 2019).

Financial results must be used to justify subscription services in an industrial business-to-business context (Fang et al., 2008; Gebauer et al., 2005). Capital and operating expenses are components of a broader total ownership cost (TOC) concept used to assess and comprehend the actual cost of doing business with a supplier that extends beyond pricing. As a result, TOC can be thought of as a purchasing tool and a philosophy (Ellram, 1993).

According to Lay (2014), CAPEX is frequently associated with significant investments in products, which are then recorded on the balance sheet and depreciated over the product's or asset's useful life (Annarelli et al., 2019). OPEX is shown on the profit and loss statement. In other words, these expenses are recurring daily.

The decision to invest in CAPEX or OPEX should be based on a thorough examination of the company's capital expenditure structure. CAPEX and OPEX decisions (for example, switching to a pay-as-you-go model) affect a business's cash flow. Often, companies elect to lease rather than purchase due to market or private lender restrictions on the amount of capital they can access. As a result, many businesses prefer to invest in revenue-generating operations, which translates into leasing rather than purchasing (Annarelli et al., 2019)

2.2.3.2 Pricing models

According to Kowalkowski and Kindström (2014), pricing is an essential part of designing and innovating the revenue model of PSS innovation. Lay (2014) defines pricing models into two categories, more traditional service pricing models (Table 2) and managed service provider (MSP) pricing models (Table 3). Kindström (2010) presents different A la carte pricing to MSP pricing model list, from Lay's (2014) list.

Table 2. Adapted from Lay (2014).

Service pricing models	Description
Cost-plus pricing	A.k.a adding a typical markup to the cost of a product to adjust the pricing. Current demand and competition are not taken into account in the model.
Target-return pricing	Over a set length of time to achieve a specific return on investment (ROI).
Competitive pricing	The present market structure and situation determine the price. Changing the price based on the market price — higher or lower.
Life cycle pricing	Pricing for market penetration — for market sectors where low prices drive expansion.
	Market skimming pricing is used for markets with high current demand and relatively cheap unit costs for manufacturing smaller quantities.
Experience curve pricing	Organisations modify their prices in response to cost dynamics, and buyers and sellers adjust to one another over time.
Value-based pricing	Cost adjustment is accomplished by adding a typical markup to the price of a product. The model makes no allowance for current demand or competition.

Table 3. Adapted from Lay (2014) and Kindström (2010).

MSP pricing model	Description
Monitoring only	MSP offers a network monitoring and alerting service.
Per device	Each device supported in a customer environment is billed on a per-device basis.
Per-user	Monthly invoices are sent to end-users for a fixed price covering support for all devices they utilise.

Tiered	Multiple bundled service packages, with each successively more costly package providing services to subscribers.
All you can eat	A highly customisable pricing plan covers all remote assistance, on-site support, and lab or bench time for an entire company for a single monthly cost.
SLA-based pricing	Pricing strategy based on the risk to MSP and what kind of risk is taken on behalf of the customer.
Value-based pricing	The pricing approach is determined by the risk to MSP and the risk taken on behalf of the customer.
A la carte pricing	A la carte pricing enables consumers to choose and pay for just the services they need. Additionally, they may combine several products to create a bespoke managed services bundle.

Value-based pricing is a pricing approach that bases prices mainly on the customer's perceived value of a product or service (Sakao & Lindahl, 2009). Value pricing is customer-focused pricing, which means that businesses price their products based on what the consumer thinks they are worth (Ross, 2021).

Furthermore, Value-based pricing is distinct from "cost-plus" pricing, which factors manufacturing costs when determining the price. Businesses that offer unique or highly valued features or services are more likely to benefit from the value pricing model than businesses that sell primarily commoditised goods (Sakao & Lindahl, 2009).

2.2.4 Customer

The following sub-sections focus on the new role of the customer in the context of PSS. This role is essential in the sector of servitisation, as Mont (2002) articulates in the PSS definition; customer satisfaction is one of PSS's primary objectives. Customer satisfaction is improved through a thorough knowledge of the customer, customer involvement, customer value, and customer as a resource.

2.2.4.1 Customer as a resource

There is raising understanding in research that the customer creates value to the customer (Heinonen et al., 2010). Tucker (2001) highlights the importance of understanding the critical problems and needs of the customers when designing new services or

business models. In his article, Tucker (2001) defines customers as prone to indicate when a company should change their service/product offering. Customers should be a source of feedback since they are the ones who consume the product. In an ideal situation, the customer feedback is looped back to trigger changes in the company to improve the offering for satisfying the customer. Despite the common realisation of this loopback dynamic, customers are not always listed as a resource in broader research (Plé et al., 2010). However, the competitive edge can be found based on the company's resources (Barney, 1986; Peteraf, 1993; Prahalad & Hamel, 1990; Reinartz & Ulaga, 2008).

The type of the customer's involvement and the degree of control over customer contact are two variables that influence customer integration as a resource (Joachim, 2017; Lay, 2014). Customers can participate as a resource, contributor, or direct resource. Input is important when consumers are resource contributors because it can be treated and analysed (Sakao & Lindahl, 2009).

2.2.4.2 Customer value

Customer value is a fundamental concept for PSS (Mont, 2002; Payne & Holt, 2002; Vargo & Lusch, 2004). Customer value is defined as benefits that the company can conduct to the customer. It may also consist of the reduction on the initial investment (possibility not to immobilise capital), operational cost decrease (maintenance, monitoring, upgrades, or limiting downtimes of operations), and decrement of customer responsibility (advances on end-of-life disposal and reduction on logistic cost) (Annarelli et al., 2019). These aspects are tangible elements; however, PSS implies strong customisation that improves the unique development of customer value to transit value. Therefore, value can be bought truly as operational services where customers enjoy interaction (Tukker, 2004).

One of the most widely accepted definitions of customer value is Holbrook's (1999) proposed work. He categorised the customer value into eight interrelated categories: efficiency, excellence, status, esteem, play, aesthetics, ethics, and spirituality. These

categories are designed for products, focus on practical value, and fully cover the service's hedonic value (Lee et al., 2015).

Table 4. Categories of customer value adopted from (Lee et al., 2015)

Categories of customer value	Description
Cost efficiency	Ability to accomplish something at a low cost without spending much money
Time efficiency	Ability to do a task quickly and efficiently without wasting much time
Convenience	Capacity to accomplish something with little or no effort (efficiency in the aspects of physical or mental effort)
Excellence	Capacity to execute a particular job effectively (quality of offering)
Status	By providing a service, image or reputation may be improved (including both self-recognition and recognition communicated to others via offering)
Play	Not only do customers want to have fun, they also want to feel at ease and relaxed, free of emotional tension, disappointment, and concern.
Aesthetics	Beauty of offering
Ethics	Virtue communicated to others via offering

Key elements to contribute to the creation of customer value are performance, customisation, "getting the job done," cost reduction, risk reduction, usability, and flexibility in contracts (Annarelli et al., 2019).

Table 5. Elements of the creation of customer value (Annarelli et al., 2019).

Element	The value
Performance	Increasing and guaranteeing high performance for the customer. The concept of performance varies in different customer segments.
Customisation	When integrating product and service, specific value can be customised for customer needs. The decision to customise the PSS to a broad audience and niche segment rather than a mass PSS is strategic for economies of scale.
"Getting job done"	Value can be built on solutions that reduce a client's effort in completing a task. Therefore company offers a solution to facilitate the work of others.
Cost reduction	Cost reduction is an attributor that customers follow closely, being tangible evidence. Communicating this to the customer can be a strategic decision.

Risk reduction	Customers also value reduction on risks. PSS providers can take share on responsibility when the customer can use the equipment without typical risk.
Usability	Ease of use from the beginning is valuable when the user can save money and time on training and orientation.
Flexibility in contracts	Companies can provide a package of solutions giving the specific customer or market segments. The company can offer flexibility with various contract offerings.

Operational customer value can also be looked at through lean methodology since various companies are trying to lean the operations. The lean method presents operational waste in the following categories: (1) overproduction, (2) excess inventory, (3) defects, (4) extra processing, (5) waiting, (6) motion, (7) transportation, (8) underutilising people, and (9) employee behaviour (Krajewski et al., 2016; Voehl et al., 2014). Understanding the customer's operational waste, PSS can be designed to answer customers' headaches.

3 Study methodology

This chapter introduced the study methodology used in the research. The objective of this chapter is to justify the research approach adopted to demonstrate that the study was made consciously.

3.1 Framework for evaluating Current state of service business

As shown in the Mourtzis et al., 2016 study, questionnaires are the most commonly used method to assess servitisation, and this study uses it as a baseline. Multiple academic studies on the PSS transformation have emphasised the critical nature of strategic alignment between the service transition strategy and the PSS structural elements (Adrodegari & Saccani, 2017; Gebauer et al., 2005; Kindström, 2010). However, it is hard to find a comprehensive framework that demonstrates the company's intention to align its current internal capabilities with its external threats (Baines et al., 2007; Meier et al., 2010). The framework proposed by Sholihah et al. (2019) incorporates these factors and results in a comprehensive questionnaire, which is therefore used in this study.

This study recreates Sholihah et al. (2019) proposed framework for evaluating drivers of servitisation in the manufacturing industry. The research formed a questionnaire set (see Appendix 1) to analyse the company's internal capabilities and external forces towards servitisation. The questionnaire set has been modified to reflect CompanyCo's terminology and methods of operations.

The suggested method extends the scope of the initial SWOT analysis by including essential competencies of the serviced business and the Business Model Environment framework to create structured assessment questions for internal and external analysis, respectively. The SWOT analysis is organised and measured to minimise uncertainty and misplaced direction. This tool compares the manufacturer's present business to the

desired capabilities of the serviced firm, allowing for the development of plans to address the serviced company's insufficiency capabilities.

The tool adapts the serviced company's critical capabilities (Table 7) and external forces identified from the literature (Table 6). Each capability or an external force is represented at least with one question, with the representation of answer range as scoring. Scoring means a condition of statement with values between 1 (minimum) and 10 (maximum). After overall scoring, a radar diagram is used to visualise dummy data of the current conditions in the manufacturing company.

Table 6. External forces identified by Sholihah et al. (2019)

External perspective	Identified external force
Industry forces	Competitor
	New entrants
	Substitute product or service
	Bargaining power of suppliers
	Bargaining power of buyers
Key trends	Technology trends
	Regulatory trends
	Megatrends
	Socioeconomic trends
Market forces	Market issues
	Market segments
	Needs and demands
	Switching cost
	Revenue attractiveness
Macroeconomic Forces	Global market conditions
	Capital markets
	Commodities and other resources
	Human resources
	Economic infrastructure

Table 7. Internal capabilities for servitisation identified by Sholihah et al. (2019)

Internal perspective	Category	Identified internal capability
Financial	Value-based pricing strategy	Shareholder value
		Revenue from product sale
		Additional revenue from service
		New revenue from new customer
	Efficient cost structure	Cost structure
		Operation cost
Customer	Customer intimacy	Value proposition
		Relationship with customer
		Company image

		Customer satisfaction
		Customer acquisition
Internal business	Product service co-creation with the customer	Product/service innovation
		Customer relationship
	Close collaboration with partner	Close collaboration with partners
		Distribution channel
	Efficient and effective distribution channel	Effective service provision
		Operation
Learning and Growth	Service-oriented personnel	Service capability
		Training
	Service-oriented ICT	Knowledge management
		CRM system
	Service-oriented performance measurement system	Service-oriented bonus structure
	Product service culture	Cross-functional team
		Organisation alignment

3.1.1 Execution of current state study

The number of interviewees was determined by the difficulties encountered in conducting the study during the Covid-19 pandemic. The questions are complex, and the internal experts capable of answering them are in high demand. However, the thesis employs a diverse range of responders to provoke a varied range of responses. According to DeJonckheere and Vaughn (2019) and Nguyen (2015), open field together with set of questions are a suitable method to (1) gather qualitative, open-ended data; (2) explore participant ideas, feelings, and beliefs about a particular topic; and (3) dive deeply into personal and occasionally sensitive, matters. This is why it is utilised to broaden the scope of the thesis, extending the Sholihah et al. (2019) framework.

Online survey were conducted for the "current state study": an online form created with the MS Forms tool. The survey was send via email to selected participants. Open field was also left for participants to explain the given answers.

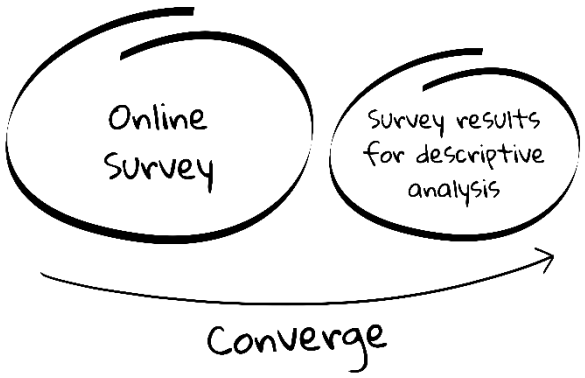

Figure 10. Execution pattern of current state study

Online survey:

The online survey has 14 respondents from CompanyCo's organization. Respondents have position variety from digital product & technology management, hardware product & technology management, sales management, services to the different higher-level expert positions in the company. The diversity of respondents aims to foster diversity in the responses, thereby extending the methodology of the project.

Table 8. Survey respondents for online survey

Role	Organisation
Product Manager	Product & Technologies
Product Area Orchestrator	Product & Technologies
Vice President, P&T	Product & Technologies
Offering Manager	Technology vertical
Segment Head	New Growth Markets
Product Manager	Technology vertical
Segment Head	New Growth Markets
Business Development Manager	Product & Technologies
Service Product Manager	Project and Customer Services
R&D Manager	Product & Technologies
Head of Portfolio	Product & Technologies
Head of Ground Transportation Strategy and Business Development.	Strategy & Business Development
Global Solution Manager	Platforms and API's
Projects and Customer Services, NOC Manager North America	Project and Customer Services

3.2 SWOT-analysis

SWOT analysis (strengths, weaknesses, opportunities, and threats) is a strategic planning tool used to evaluate a business's competitive position and formulate strategic strategies (Satta et al., 2021; The Art of Service - SWOT Analysis Publishing, 2020). The SWOT analysis takes into account both internal and external issues, as well as present and prospective opportunities. SWOT analyses are usually presented in a two-by-two table or matrix, with internal performance enhancers categorised as strengths and internal performance inhibitors as weaknesses, according to Leigh (2010). SWOT analysis is a flexible tool that may be applied to a range of situations, including appreciative inquiry, benchmarking, industry analysis, situation analysis, and scenario planning.

A SWOT analysis is designed to assist in conducting a realistic, fact-based, data-driven examination of an organisation's, initiative's, or industry's strengths and weaknesses (Leigh, 2010; Satta et al., 2021). The company must ensure accuracy by eliminating preconceived conceptions or grey zones in favour of real-world scenarios.

SWOT analysis is used in this thesis to structure and comprehend the current state conclusions with the goal of situation analysis. The problems are complex, real-life problems with various grey areas, so the frameworks present an excellent framework for the analysis.

3.3 Workshop sprints

The PSS innovation framework is validated through its execution in part during an intensive workshop sprint. A multidisciplinary team from product management, design, sales, and marketing participated in the workshop. Multidisciplinary teams foster a diversity of perspectives, resulting in positive conflict and improved outcomes. A design area was required to conduct the innovation workshops. The design area is specified through

external interviews with district heating industry professionals and internal discussions with the thesis steering group. The following workshops were held:

- Workshop 1 – Problem statement and problem area exploration
- Workshop 2 – Product vision and further ideation
- Workshop 3 – Prototype ideation + validation
- Workshop 4 – External prototype testing with customer
- Workshop 5 – Customer feedback-driven iteration

3.4 Energy sector case study

The energy sector case study is completed with external interviews in three energy supply companies, executing business on energy generation and district heating. Additionally, two providers for distributed energy resource (DER) optimisation software are conducted in the study. Companies are Scandinavia-based, representing the spearhead of the clean energy future in their sectors.

The case study is needed to conduct the validation during Innovation workshops of the PSS innovation process. The semi-structured interviews focused on forming a comprehensive design area for testing the PSS innovation framework, giving the thesis a more pragmatic point of view.

Table 9. Background of the participants for the external semi-structured interview

Role	Organisation
Data Scientist	Energy Company A
Digital Transformation Lead	Energy Company B
Production manager	Energy Company C
Senior Data Scientist	DER optimisation company A
Product Manager	DER optimisation company B
Head of Sales and Marketing	DER optimisation company B

4 Description of the case company

CompanyCo is a worldwide leader in deep-tech electronics manufacturing. The company is a global company providing a complete variety of innovative hardware equipment, both traditional and digital service and hosted solutions. Its products and solutions are reliable, accurate, and best in class, enabling enhanced decision-making, productivity, and increased safety and quality. CompanyCo is a purpose-driven company, helping to solve the most significant climate and sustainability challenges of our time. Company's strategy is to be "best in class" or "reference grade" on high-mix low-volume manufacturing.

The organization under inspection strategic objective for 2019-2023 published 2019, is to remain the undisputed world leader in it's own field of equipment manufacturing. The Business Area's strategy is built on four pillars: to provide industry-leading products , to strive for excellence in the delivery of large system projects, to leverage digital transformation and develop digital solutions for selected critical operations, and to selected fields leveraging selected megatrends.

CompanyCo updated its business objectives for 2021, increasing the target for growth and sharpening the vision. In the organisation's updated business objectives, CompanyCo's adjusted focus is to sustain long-term market leadership and expand to new markets with growth opportunities. Renewable energy, automotive, and smart cities are all examples of these megatrend-driven growth industries. New differentiation in this market comes from professional-grade (previously only reference grade) hardware to decision-supporting digital insights and combining these result-driven service bundles with a diverse hardware selection.

CompanyCo is transforming into a service company, and the strategic changes described appear in the organisation's day-to-day operations. The transformation to support recurring revenue business, platforms, services, and other critical functions are in transition and under development. These service aspects, including decision-supporting digital

insights, will necessitate the development of new skills and capabilities in servitisation, Product-Service Systems (PSS), and agile development methodologies such as Design Thinking. In this field, the current state and PSS innovation framework are desired.

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CompanyCo is traditionally a hardware-focused company where most of the services it provides are inextricably related to its hardware sales and could even be considered hardware features (e.g., calibration services, warranty). These services can be viewed as product-centric services. Additionally, CompanyCo provides customer value and profit-focused services on top of product-centric services, such as digital services (e.g., decision support services) and use-oriented services (e.g., remote monitoring). Services perform a relatively small part of the company, historically serving as a support function supporting hardware sales.

Nevertheless, CompanyCo’s strategy is to transform itself partly into a recurring revenue business, focused on supporting decision making, actionable insights, value-based solutions, and services with higher margins like monitoring services. CompanyCo's strategy also emphasises project services, encompassing all aspects of a project, for example, installation and acceptance testing. Consultative services include, but are not limited to, site surveys and training. CompanyCo's growing services with ambitious growth goals include continuous monitoring systems and maintenance contracts, and digital services, on which this thesis focuses.

5 Results analysis

5.1 Internal online survey

Radar diagrams and charts illustrate the deviation of internal capabilities and external forces of the responses. The radar diagrams include graphs divided into the area and topic basis. The charts show CompanyCo's identified internal capabilities results at the average question level. Standard deviation is also visualized to demonstrate differentiating opinions in the organisation. Figure 11 below illustrates the division into areas, topics, and questions. The average of the responses was 5.90 in internal capabilities, putting it slightly on the positive side of the scale. The average value for external force was 6.02.

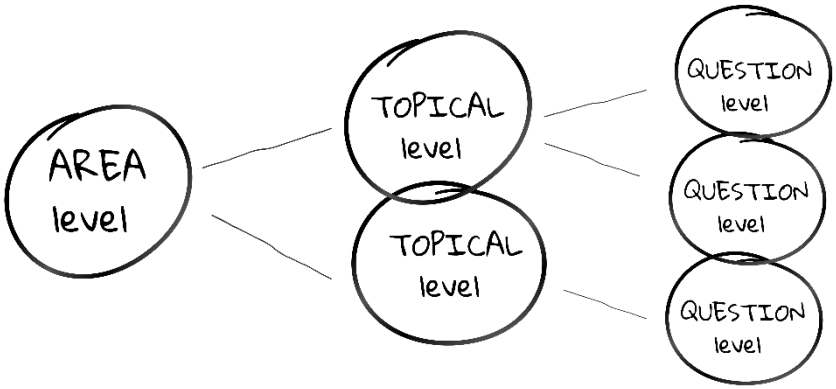

Figure 11. Questionnaire division

5.1.1 Internal capabilities

The final results of the internal capabilities online questionnaire are listed in Table 12, along with a breakdown by topic, area, and question. Scores are calculated by averaging the responses to the questions. After the final results, a descriptive analysis of the results is conducted.

Table 10. Final results of internal capabilities in the online survey

Area	Avg. value	Topic	Avg. value	Question	
Financial	5.27	Value-based pricing strategy	5.54	Shareholder value	5.21
				Revenue from product sale	6.36
				Additional revenue from service	5.36
				New revenue from new customer	5.21
		Efficient cost structure	4.75	Cost structure	4.21

				Operation cost	5.29
Customer	6.37	Customer intimacy	6.37	Value proposition	6.21
				Relationship with customer	6.93
				Company image	5.00
				Customer satisfaction	7.79
				Customer acquisition	5.93
Internal business	6.25	Product service co-creation with the customer	6.32	Product/service innovation	5.29
				Customer relationship	7.36
		Close collaboration with partner	6.39	Close collaboration with partners	6.21
				Distribution channel	6.57
		Efficient and effective distribution channel	6.04	Effective service provision	5.43
				Operation	6.64
Learning and Growth	5.82	Service-oriented personnel	6.61	Service capability	6.43
				Training	6.79
		Service-oriented ICT	5.54	Knowledge management	4.57
				CRM system	6.50
		Service-oriented performance measurement system	4.57	Service-oriented bonus structure	4.57
		Product service culture	5.93	Cross-functional team	5.93
				Organisation alignment	5.93

Area level:

According to respondents at the area level (figure 12), CompanyCo's customer orientation (6.37) was the top-rated area of internal servitisation capabilities. Following that is internal business (6.25), accompanied by learning and growth (5.82). Financial aspects (5.27) were estimated to be CompanyCo's biggest pitfall by respondents.

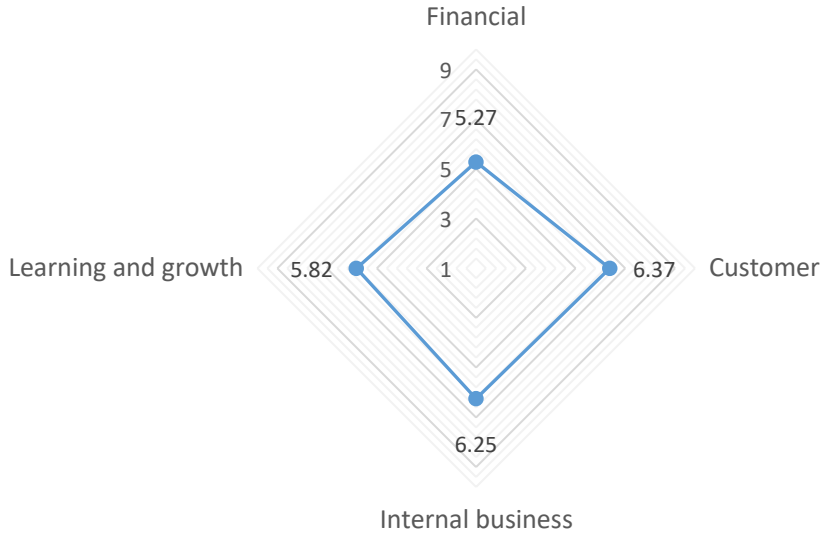

Figure 12. Internal capabilities average results, categorised by area

Topical level:

Internal business area can be classified into three categories on a topical level (Figure 13); product service co-creation with the customer (6.32), close collaboration with the customer (6.39), and an efficient and effective distribution channel (6.04). The financial area contains a value-based pricing strategy (5.54) and an efficient cost structure (4.75).

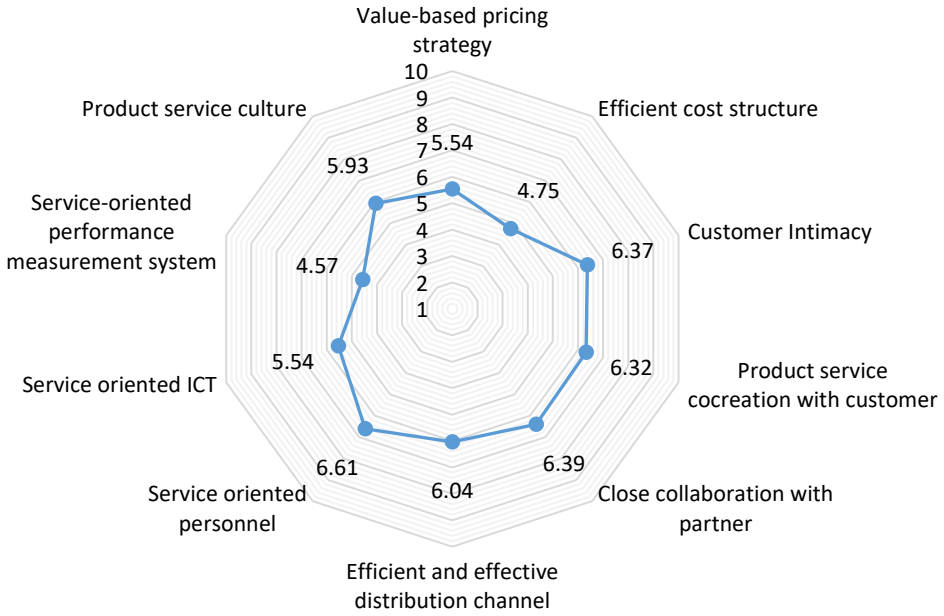

Figure 13. Internal capabilities average results, categorised by topic

The lowest-scoring internal capability toward servitisation is the service-oriented performance measurement system (4.57). The highest scoring results are service-oriented personnel (6.61) and customer intimacy (6.37).

Question level:

The internal business can be divided into question-level subcategories (Figure 14); product/service innovation, customer relationship, close collaboration with partners, distribution channel, adequate service provision, and operation cost. Interestingly, the product/service innovation, where the question focused on innovation and co-creation with the customer, is significantly lower (5.29) with a higher standard deviation (2.30) than other customer-related topics. CompanyCo's relationship with the customer (7.36), customer satisfaction (7.79), and customer satisfaction management (6.93) is understood

as a strength towards servitisation. Strong customer relationships reinforce CompanyCo's long associations with the customers, going back over 50 years.

The financial area's status is in detail at the subcategory level (Figure 14); shareholder value is relatively low compared to our offering capabilities (5.21). Additionally, the cost structure received the lowest score in the survey (4.21).

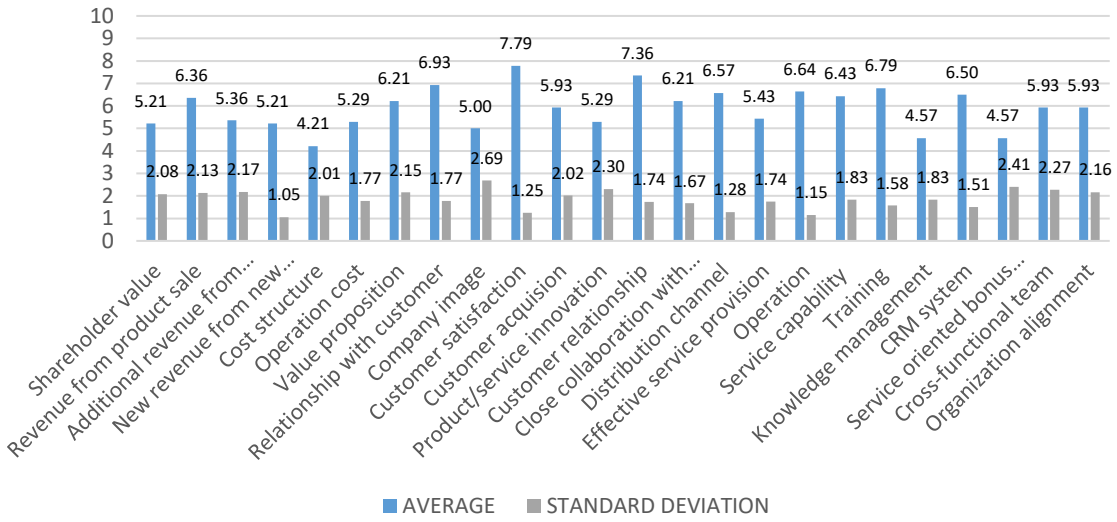

Figure 14. Internal capabilities average and standard deviation results, categorised by question

Answers reflecting CompanyCo's culture as a hardware manufacturer, a product-service transformation company, contain a service-oriented bonus structure (4.57) and knowledge management (4.57). These factors have been identified as potential stumbling blocks. Respondents also experience that CompanyCo does not have an image as a solid PSS provider (company image: 5.00).

The notable result in the learning and growth area is knowledge management (4.57), indicating that CompanyCo does not have a knowledge management system or there is uncertainty around it.

5.1.2 External forces

The external forces online questionnaire's final results are listed in Table 13, along with a breakdown by area and question. The average of the responses to questions is used to calculate the scores. After the final results are obtained, a descriptive analysis of the data is performed.

Table 11. Final results of external forces in the online survey

Area	Avg value	Question	Avg value
Industry forces	6.23	Competitor	5.64
		New entrants	7.00
		Substitute product or service	6.21
		Bargaining power of suppliers	5.57
		Bargaining power of buyers	6.71
Key trends	7.00	Technology trends	6.36
		Regulatory trends	7.36
		Megatrends	7.64
		Socioeconomic trends	6.64
Market forces	5.82	Market issues	5.15
		Market segments	6.21
		Needs and demands	5.14
		Switching cost	7.07
		Revenue attractiveness	5.50
Macroeconomic Forces	5.25	Global market conditions	4.71
		Capital markets	5.79
		Commodities and other resources	4.54
		Human resources	5.08
		Economic infrastructure	6.14

Area level:

According to respondents at the area level (figure 15), the top-rated area of external forces toward servitisation was key trends (7.00). It adheres to CompanyCo's strategic perspective of anticipating megatrends. Following previous, the external forces are industry forces (6.23) and market forces (5.82). According to respondents, the most prominent external threat to CompanyCo’s business is macroeconomic forces (5.25).

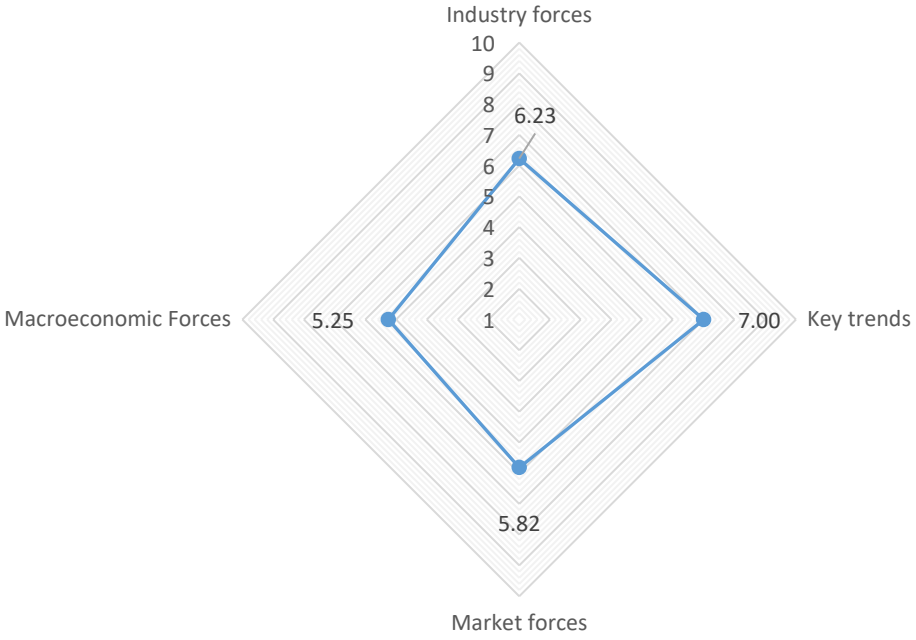

Figure 15. External forces average results, categorised by area

Question level:

According to respondents, the current market status of CompanyCo's critical resources is more harmful than beneficial (Commodities and other resources (4.54), see Figure 16). This could occur due to the current time period characterised by resource supply issues related to Covid-19. Additionally, the global economic environment (4.71) was viewed as a threat. Furthermore, respondents expressed concern that we may face difficulties acquiring new human resources (5.08). Following that, opinions about needs and demands (5.14) and market issues (5.15) are expressed.

Respondents believe that current megatrends (7.64) benefit CompanyCo as a company. The second most significant external force was our customers' strong loyalty to CompanyCo as a company, evidenced by a high retention rate and a high switching cost (7.07). According to the survey, respondents identified new entrants (7.07), buyer bargaining power (6.71), and socioeconomic trends as positive forces (6.64). Respondents indicated that CompanyCo's value proposition is difficult to replicate by a new player, that we have

strong bargaining power with our partners, and that major socioeconomic trends (e.g., income distribution, spending patterns) favour CompanyCo as a company significantly.

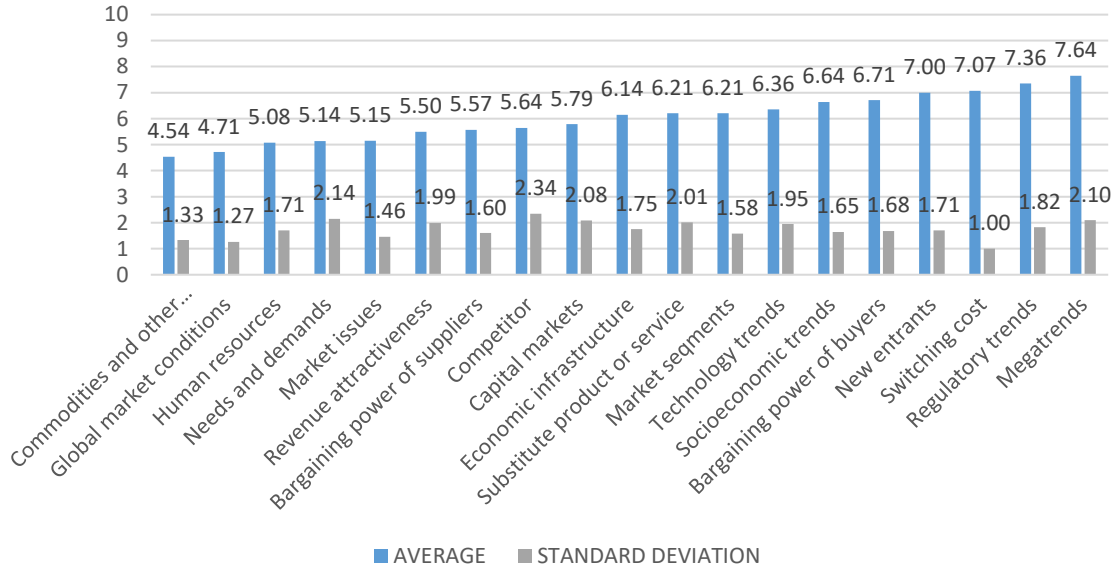

Figure 16. External forces average and standard deviation results, categorised by questions

5.2 Energy sector case study

The energy sector case study is based on interviews with energy businesses that generate and distribute district heating. The case study aims to form a comprehensive understanding of customer needs for future design area scoping and future innovation.

The district energy use varies broadly across the countries. Climate, urban density, and energy sources available at the moment all contribute to the variety. Diversity in regulatory frameworks (e.g., building traditions and energy policies) increases complexity and explains substantial dissimilarity. According to Euroheat & Power, in Europe, there are approximately 6000 district heating systems (Figure 22), covering 12 percent of Europe's heating demand. Heating demand divided to country-level can be seen in figure 23.

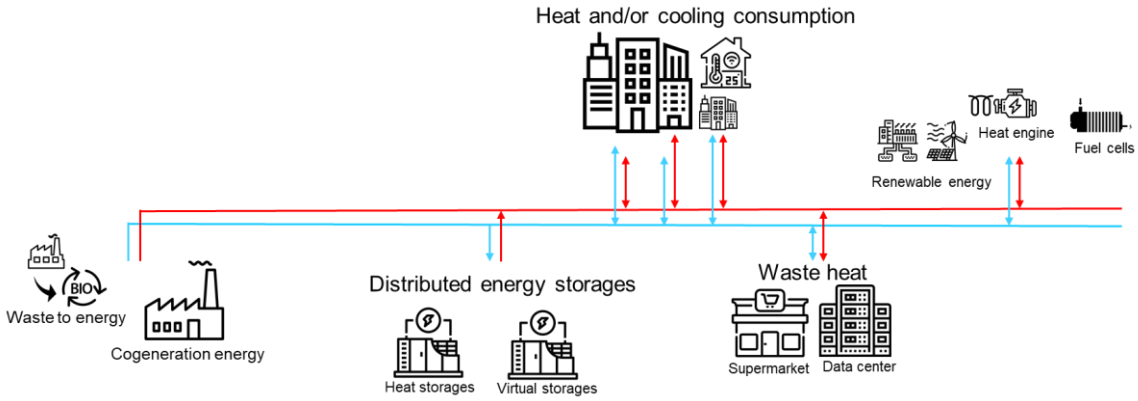

Figure 17. Basic functionality of district heating system (adapted from Jie et al., 2012)

The demand for cooling is higher than for heating from the global perspective. District cooling is expected to replace individual cooling practices (each building, each room) in high-density areas (International Energy Agency, 2020). District cooling works with the same principles as district heating, granting better energy efficiency, free spaces in urban areas, and is easier to operate than at the individual level. The market for district cooling is currently smaller than for district heating, although it is already snowballing in temperate countries and even faster in warmer countries (U.S. Department of Energy, 2002).

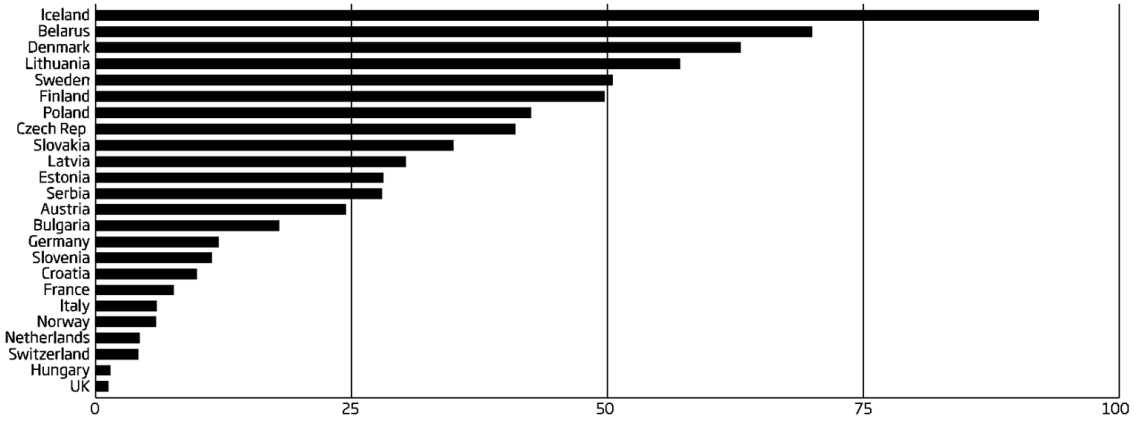

Figure 18. Share of citizens served by district heating in percent (Euroheat & Power “2017 Country by Country")

5.2.1 Distributed energy resources

The new district heating and cooling generation lean towards distributed energy resources (DER), leveraging local energy sources. DER's are small and modular energy generation and storage technologies that can provide energy or electric capacity where it is needed (Figure 24) (U.S. Department of Energy, 2002). The objectives of efficiency, green transition, and emerging technologies all serve as drivers toward DERs. These drivers are committed to maximising the use of all available energy sources, including waste heat from data centres. Table 14 contains additional drivers elaborating DER's new generation advancements and implementations.

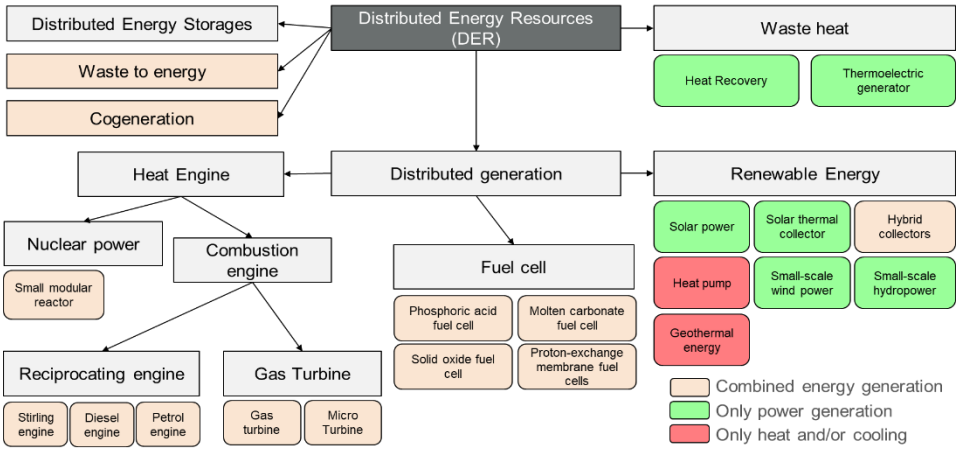

Figure 19. Forms of Distributed Energy Resources (adapted from Araner, 2021)

Table 12. Circular economy drivers (Araner, 2021)

Drivers	Form
Low-grade heat dissipation in industrial or domestic heat sources.	Waste heat
Encourage the use of sewage water—or waste heat from a water treatment plant—as a source of energy.	Waste heat
Increase overall dependence on waste energy.	Waste heat
Encourage the use of locally produced biomass.	Waste to energy
Wherever feasible, include low-grade geothermal energy.	Renewable energy
Increase solar thermal energy as a component of a comprehensive district heating network.	Renewable energy
Combine wind energy with solar photovoltaic energy in heating.	Renewable energy
Increase the use of thermal energy storage to balance grid energy use.	Grid optimisation
Promote the new role of consumers where the consumer may also become producers.	Consumption optimisation

5.2.2 District heating grid trends

The most obvious trend in DH is an increase in production based on renewable energy sources and a decrease in production based on fossil fuels (Paardekooper et. al., 2018). This trend is a natural outcome of international and national targets, such as the Finnish government's goal of zero-emission electricity and heat production by the end of the 2030s (Finnish Government, 2019).

Heating is increasingly being provided by electricity-based systems, such as heat pumps. This process is known as electrification. Nonetheless, 90 percent of the DH produced in Finland in 2018 came from the combustion of fossil fuels (Finnish Energy, 2019). Since electricity production's emissions have been successfully reduced, thanks to Nordic hydro and, more recently, wind power, electricity is regarded as one of the best energy sources for sustainable heating (Eurelectric, 2018; Paardekooper et. al., 2018).

As a result of the difficulty in obtaining sufficient sustainable heating sources, there is significant potential for improving the energy efficiency of buildings, distribution, and generation, all of which are constantly evolving. As a result, the heating demand for district heated homes has been cut in half from 1970 to 2018 (Paardekooper et. al., 2018).

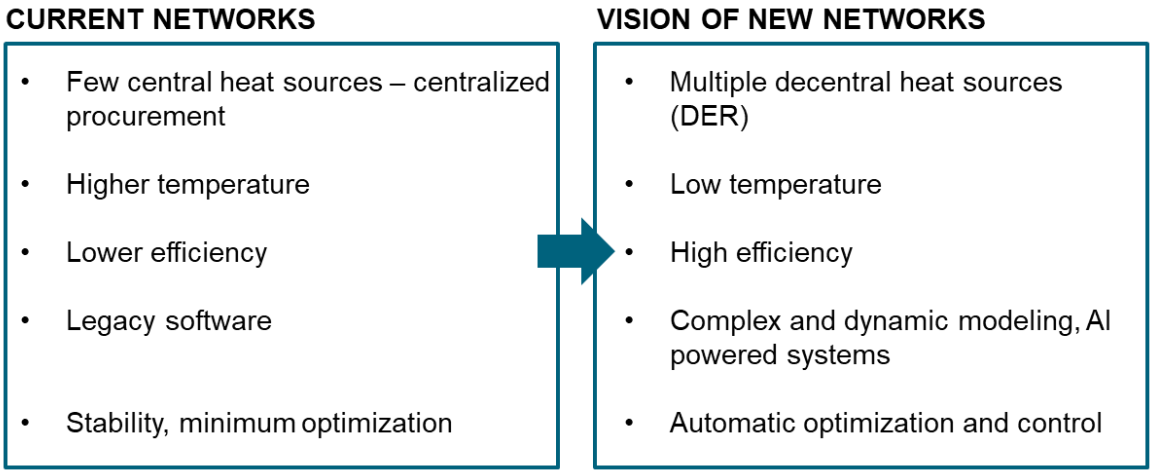

Figure 20. Network differentness (Gradyent, 2021)

A district heating system's production fleet is shifting toward decentralised production. Historically, particularly in areas with high DH consumption, production has been centralised in a few large production units. Thus, by transitioning primarily from combustion to heat pumps that utilise distributed excess heat sources, the future production fleet may be highly distributed (Paardekooper et. al., 2018).

New distributed energy solutions and carbon neutrality goals drive energy companies to improve on more profound understanding and controllability of the grid functionalities such as grid optimisation, energy supply optimisation, demand forecasting, and energy generation forecasting. Grid profile simulation is currently a solution businesses use to understand their heating plant and grid performance better. The simulation paints a vivid picture of what is happening on the distribution network and enables companies to make improvements and decisions based on this information. Simulation can also be described as “digital twin” or “virtual prototyping.” These simulations can be used as a foundation for the heating design and decision-making solutions.

One of the key factors, or a data source, of energy fields control systems and grid simulation is district heating load forecasting. The controller and simulation must be aware of the following: (1) how much energy is used in the future, (2) where it is used, and (3) when it will be used. According to energy sector experts, heating load forecasting is the most accuracy-dependent case in the energy sector. Therefore, it is inspected more thoroughly. Other weather-dependent sectors are roughly listed in Table 15. The table does not include all data sources and may contain inaccuracies due to the topic's confidentiality.

Table 13. Energy companies weather data use cases, adopted from expert interviews

Use area	What	Factors	Weather relevancy
District heating & cooling	Grid load forecasting	Domestic hot water use	Behavioural factors; historical DH data, weekdays, public holidays…
		Building heating & ventilation need	Weather observations and forecast, behavioural factors
	Grid control optimisation		Grid load forecasting, real-time measurements, historical data
	DH distribution operating		Weather observations and forecast, behavioural factors, grid load forecasting, real-time measurements
	DER optimisation		Grid load forecasting, real-time measurements
	Heat generation optimisation		Grid load forecasting, real-time measurements
Control room	Power generation plan		Grid load forecasting, real-time measurements
	Weather visualisation		To understand the area changeability, weather visualisation is used
	Grid remote controlling		
Smart building automation	Peak power controlling		
	Virtual energy storage & generation		
	Energy use optimisation		
Electricity	Renewable energy generation		Weather observations and forecast
	Electricity generation optimisation		Weather observations and forecast
Predictive maintenance	DHC grid maintenance		Weather observations and forecast
	Electricity grid maintenance		

Among other data sources, grid load forecasting uses historical district heating usage data, weather observation data (real-time & historical), and weather forecast data (real-time & historical). According to expert interviews, the weather is the most important factor in grip load forecasting—weather effects on building heating, ventilation, and other HVAC-related functions. The weather and environmental parameters are listed in Table 16.

Table 14. Weather parameters

Weather parameter	Comment
Temperature	The most common and effective parameter. Utilised by all inspected companies.
Solar radiation	Heat builds up in infrastructure, significant effect in the spring and autumn. Utilised as the second most critical factor.
Wind speed	Utilised by emerging algorithmic, artificial intelligence, and model-based systems
Wind direction	Utilised by emerging algorithmic, artificial intelligence, and model-based systems
Rainfall	Utilised by emerging algorithmic, artificial intelligence, and model-based systems
Atmospheric pressure	Utilised by emerging algorithmic, artificial intelligence, and model-based systems
Humidity	Utilised by emerging algorithmic, artificial intelligence, and model-based systems
Lightning	Parameter mainly for predictive maintenance

Grid load forecasting is a data source for various solutions in energy companies, as district heating demand is inextricably linked to district heating operational functions. As the company's expert B, stated;

“The need for district heating in “country” is closely linked to the weather. Because of that, weather data is a central part of our forecasting and price setting. The better the weather forecast is, the more accurate is the outcome from our models.” (Company B Interview)

If demand forecasting is improved, companies can save money in two ways: (1) through primary energy savings achieved across operational improvements and (2) via electricity savings at the SPOT-market volatility in heat and power generation plants.

5.3 Designing Product-Service System Framework

This chapter focuses on research question 1; What would be a suitable PSS innovation framework for CompanyCo's emergent offering? The framework is based on Design Thinking principles and PSS characteristics and was field-tested in part using Design Thinking tools during workshop sprints. The framework can be used in conjunction with other toolsets and various product phases.

5.3.1 Designing a suitable PSS innovation framework

The PSS innovation framework (Figure 26), designed for this thesis, is based on The New Double Diamond Model of Design Thinking (Liu, 2016), the Design Thinking macro process (University of St. Gallen, 2021), and PSS characteristics (Baines et al., 2007; Kindström, 2010; Lay, 2014; Lay et al., 2009). Other PSS essentials are used, introduced in the theoretical framework.

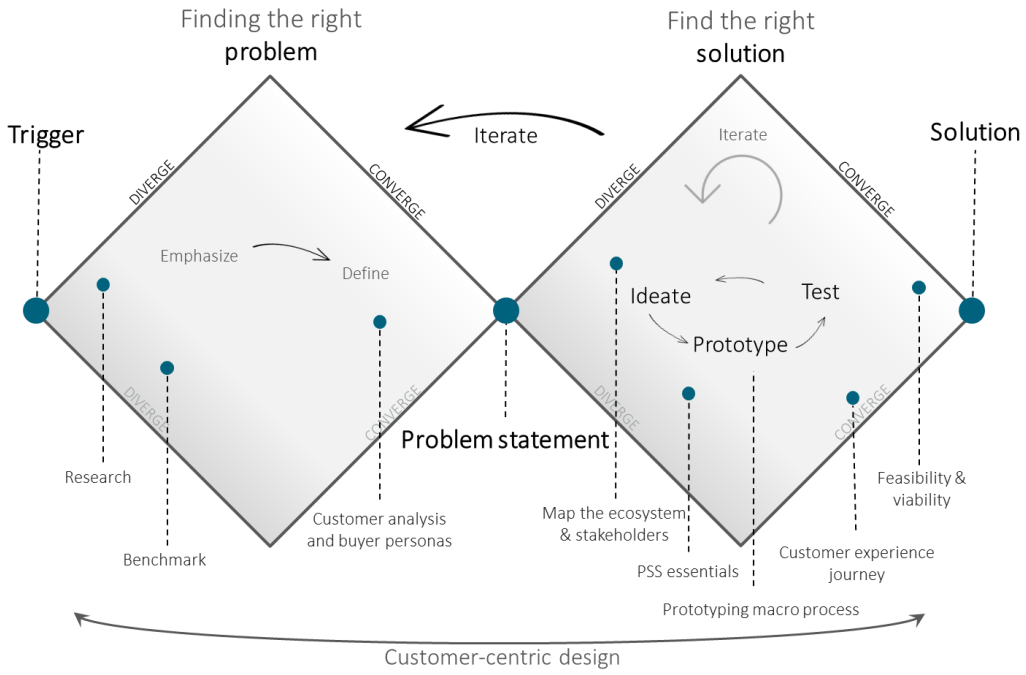

Figure 21. PSS innovation framework

A concept, idea, vision, or objective for a new product, service, or feature triggers the process. While the result may vary, it should be a viable, feasible, and desirable **solution**.

More precisely, the **trigger** requires the organisation to begin mentally associating the technologies, systems, techniques, and processes that are feasible or accessible with how they can be used to address unmet customer requirements.

5.3.1.1 Finding the right problem

The "find the right problem" phase highlights the issue and better understands the customer's pain points and experiences. This phase is designed to foster an empathic understanding of the subject or situation at hand. Empathy is critical to a human-centred design process because it enables designers to put their personal beliefs and assumptions aside to gain insight into customer functions and needs. Through a variety of customer-centric activities, it is possible to gain an understanding of the fundamental issue. Illustrated activities in Figure 26 supports defining the problem, such as research, benchmarking, customer analysis, and buyer personas. The process's emphasis and definition must be developed in close collaboration with the customer to ensure a customer-centric understanding of the need. This first diamond's objective is to have 1-3 problem statements that the design group understands and agrees on.

5.3.1.2 Finding the right solution

When the problem statement is defined, the design team enters to “finding the right solutions” phase. However, iteration allows for the constant transformation of the problem statement, if necessary. This phase is based on innovation, ideation, gaining detailed knowledge, hands-on prototyping, and iteration.

Map the ecosystem & stakeholders phase directs the design team to understand relevant stakeholders for the design problem. The ecosystem mapping focused on understanding the stakeholders and deepening understanding of what the ecosystem members can provide back to the stakeholders. PSS innovation is centred on collaboration, with each

ecosystem member contributing their unique strengths. The design can leverage this shared knowledge base to improve the solution design.

PSS essentials introduce critical capabilities to the solution phase, bringing the PSS innovation perspective within the scope of the designer. The essentials include a PSS cheat sheet (Figure 27), which details the framework's ownership, personnel, customer operations, and location of operations and equipment. The subscription economy enables businesses to experiment with new pricing models. Pricing cards (figure 28) detail the pricing options available in the subscription and service economies.

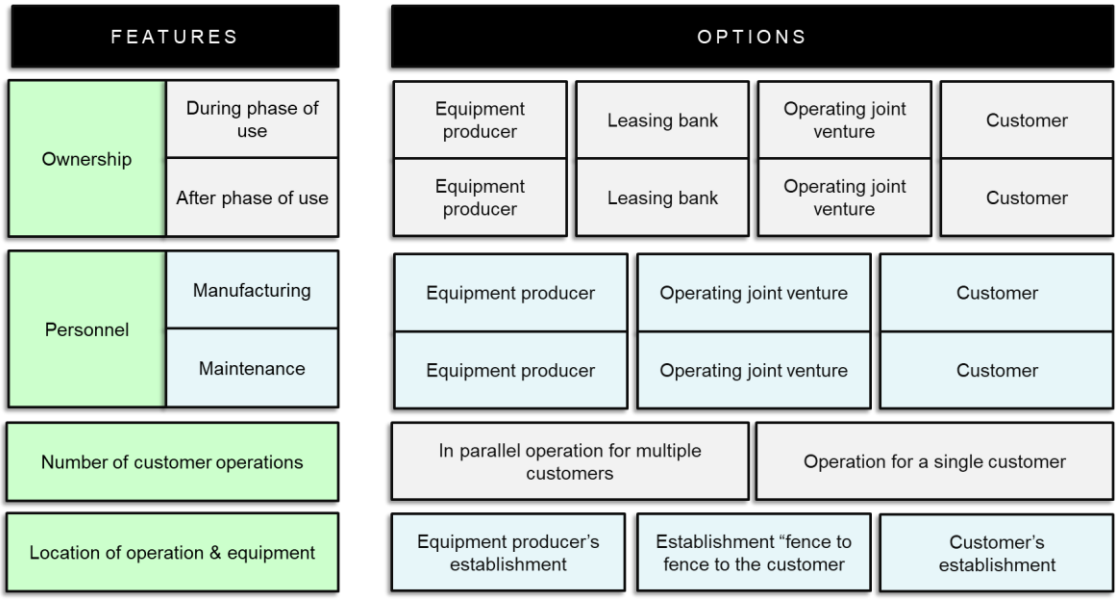

Figure 22. PSS cheat sheet (adapted from Lay et al., 2009).

Figure 23. Pricing cards (Kindström, 2010; Lay, 2014).

The PSS should include close collaboration with the customer throughout the customer experience journey (Figure 29). CompanyCo's current capabilities encourage innovative thinking when recurring revenue models are pursued in the strategy. Companies should pursue innovation in every step of the customer experience journey to understand PSS's new challenges. While CompanyCo's current capabilities include product-oriented services, adding a result-oriented customer value (Figure 29) and value-based offerings presents difficulties during the servitisation's mindset shift. This is why the framework emphasises it.

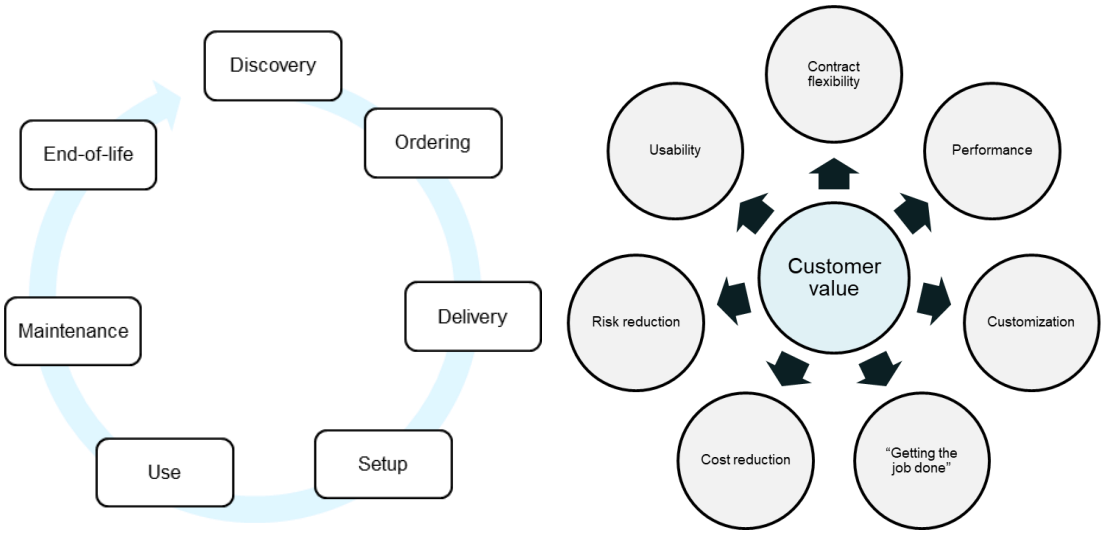

Figure 24. Customer experience journey (left) & customer value (right) (Annarelli et al., 2019; Lee et al., 2015)

The framework emphasises prototyping, being in the middle of the diamond. The prototyping is based on **Prototyping macro-processes,** where the design team can use the prototypes to create or make choices (Figure 30). The purpose of prototyping is to deepen the knowledge of customer requirements and pain points and create something that can be transformed into a product, feature, or solution. The design team should seek out human perspective as early as possible through customer contacts and interviews.

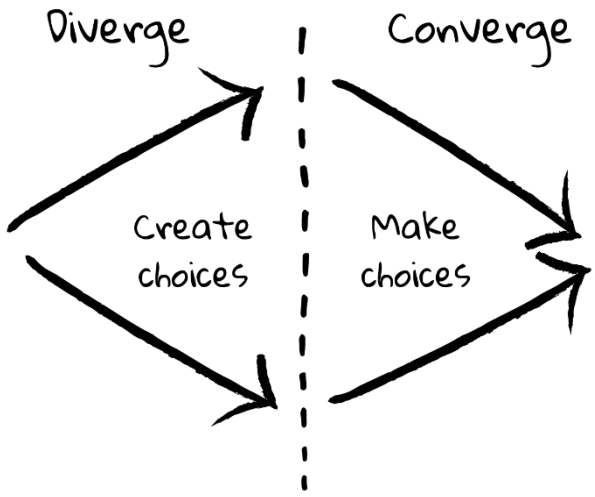

Figure 25. Diverge and converge (Björklund et al., 2019)

The fundamentals of Design Thinking begin with desirability, feasibility, and viability. Customer-centricity is critical in this framework, and therefore the process starts with customer desirability – what the customer truly needs. There may be inconsistencies between what the customer states they require and what they require. Technical feasibility and economic viability are also critical considerations. While the solution phase should consider these as well, feasibility and viability may become irrelevant if customer value is not realised.

5.3.2 Learnings from workshops

Testing and validation of the proposed innovation framework were performed with a design sprint in workshops. The first workshop began with an overview of the PSS innovation and design area. The design area was researched and defined at external interviews and covered the PSS innovation framework's first phase, “finding the right problem.” The design area is following:

1. Weather station detecting the key present weather parameters
2. Hyper-local weather and environment forecasts (APIs)
3. Ability of improving the hyper-local forecasting with local weather stations
4. SaaS platform – User Interface

Figure 26. Map of measurement instruments in Helsinki area

Figure 31 contributes to the environmental site of PSS thinking by recommending that solutions be sought to leverage the installed base of measurement networks. The design

area did not complete the first group activity of the workshops, which was to create a problem statement.

5.3.2.1 Workshop 1 – Problem statement and problem area exploration

The problem statement aims to form together agreed and understood reality. The problem statement was written in the following format: How might we [what: goal] so that [who: stakeholder] can [why: need/insight]? The design group came up with the following HMW-question: **HMW provides local observation data (& forecast) without the customer being afraid of making a stupid investment?**

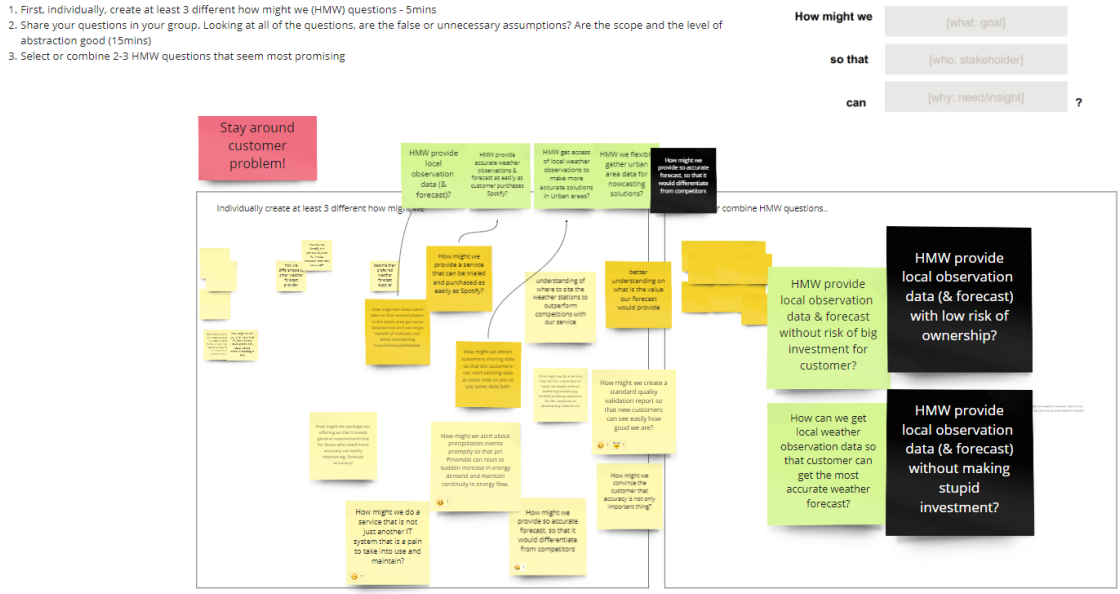

Figure 27. Problem statement formation

To broaden the understanding, the design group illustrated the current condition of customer experience (Appendix 2.). This exercise aimed to identify areas for improvement to design new PSSs instead of separate services and hardware. The journey reveals the complexity of the current offering. Additionally, as illustrated in figure 32, the design group mapped ecosystem members.

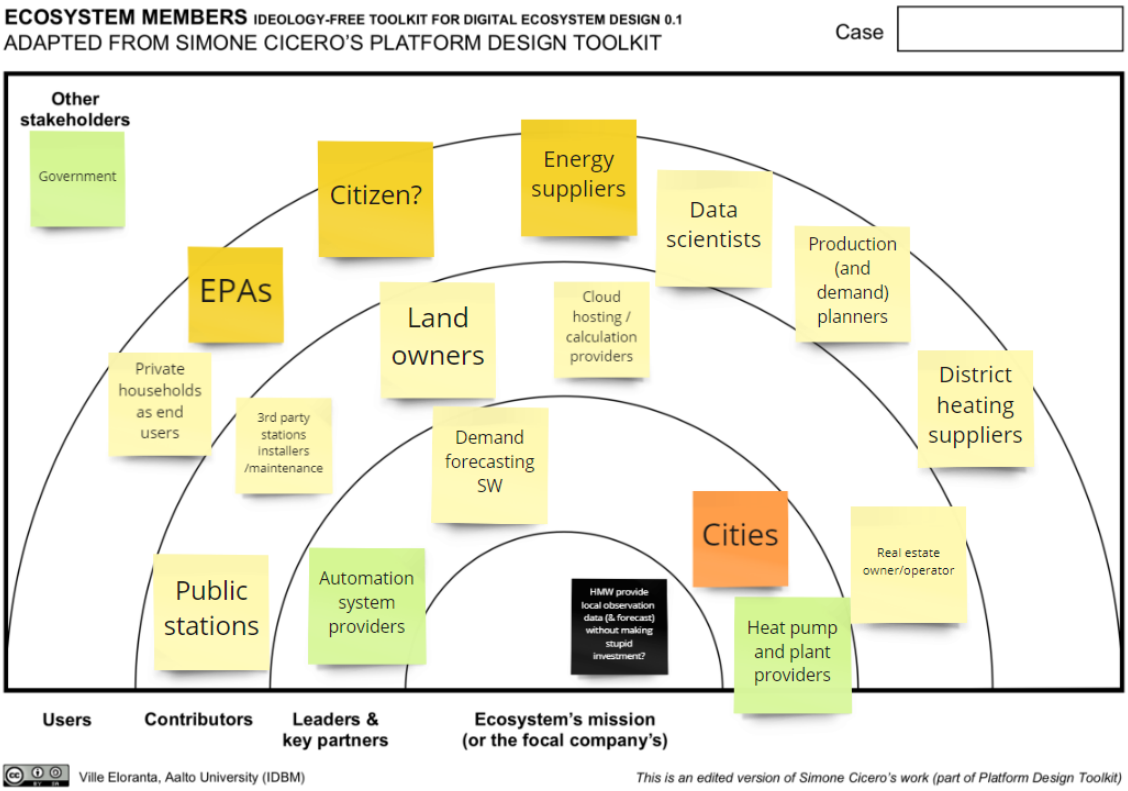

Figure 28. Ecosystem members

After ecosystem mapping, the design group shifted to the first round of ideation by brainstorming new ideas using a tool called "reverse brainstorming." The objective of "reverse brainstorming" is to generate as many ideas as possible without knowledging the quantity over quality of the ideas. Reverse brainstorming works by utilising the previously formed HMW-question and determining how to escalate the problem. In other words, how to make customer problems even bigger. Finally, negative ideas generated are transformed into positive ones, resulting in ideas that add value to the customer and generate customer value. The tool and the resulting image are depicted in Figure 34.

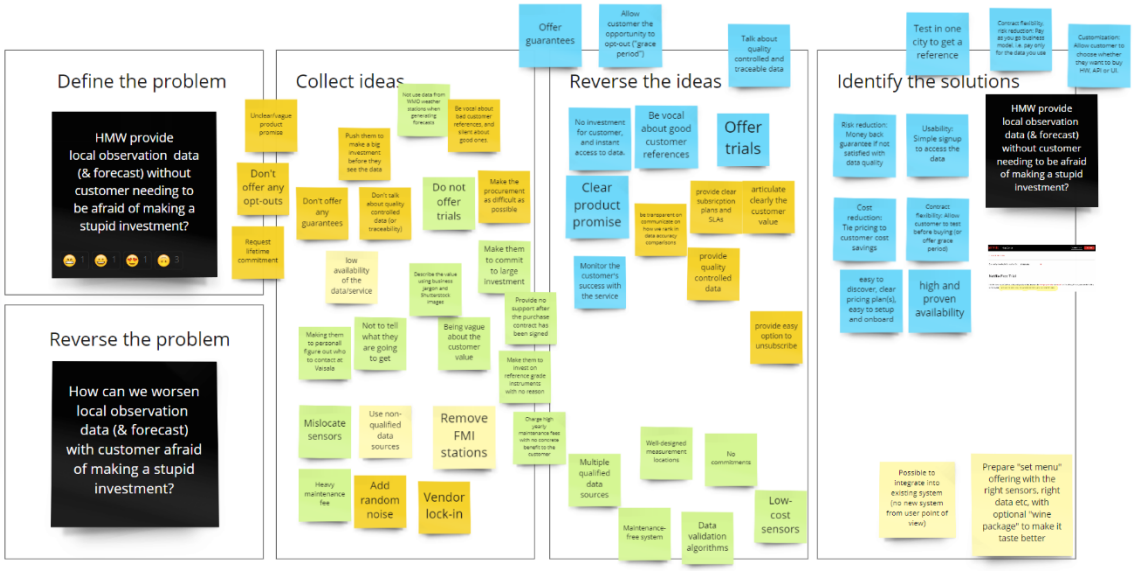

Figure 29. Ideation tool: reverse brainstorming

5.3.2.2 Workshop 2 – Product vision and further ideation

During the second workshop, the design group formed a product vision to converge the idea further, establish common ground, and agree on a prototype concept. Product vision is at form: For [target customer] who [statement of need or opportunity] the [product name] is a [product category] that [key benefit, reason to buy] unlike [primary competitive alternative] our product [statement of primary differentiation]. Figure 35 illustrates the design group's product vision.

For For person responsible of demand forecasting in district heating company
Who need the most accurate weather observations, forecasts & probability (?)
The (pr NEW PSS **is a** (hydrid of HaaS and DaaS upgradable to SaaS
That improved weather forecast easily available for any desired location
Unlike generic weather forecasts
Our product can improve forecasts with local observation in any location with easy quick access

Figure 30. Product vision formed in the second workshop

The ideation process continues in PSS essentials in the following step from the PSS innovation framework. During this phase, the design team is pressured to reorganise their

thinking around the PSS fundamentals by using a PSS cheat sheet, PSS cards, and forms of customer value (Figure 36.). The group determined the following parameters;

- Ownership during the phase of use: equipment manufacturer
- Ownership after phase of use: equipment manufacture
- Personnel to manufacture the equipment: CompanyCo
- Personnel to maintenance the equipment: CompanyCo or operating joint venture (3rd party)
- Operation is a parallel operation for multiple customers
- Location of operation is at customer's establishment (customer provides the location for instruments)
- Pricing is a combination of tiered pricing and per device pricing
- Packages are divided into (1) weather API, including the historical data, (2) Web Application, and (3) Forecast enhanced.
- Key customer value is; enhanced accuracy in local settings, instant access, and maintenance-free service
- KPI's are focused on data quality and availability
- SLA's are customisable
- Trial has graze period for cancelling

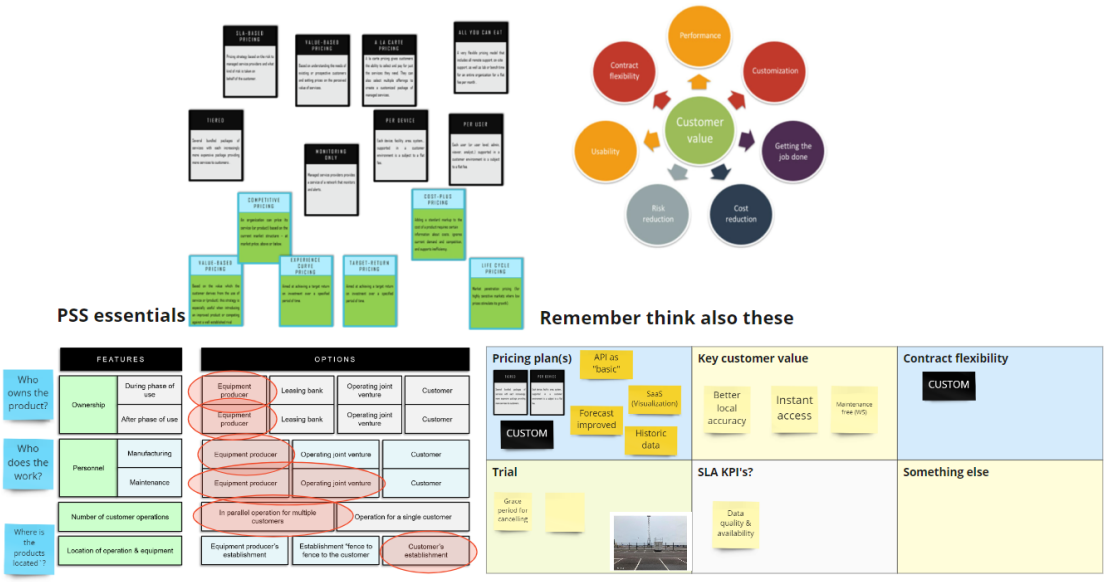

Figure 31. Ideation using PSS essentials

5.3.2.3 Introduction to prototype

The prototype is designed as a cartoon sketch that illustrates each stage of the customer experience journey (Figure 29). The design group chose from the Design Thinking macrocycles (Figure 6, University of St. Gallen, 2021) the porotype to be in the form of a "critical function prototype." The prototyping process is represented in Figure 37, from diverging prototype concepts to broad customer journeys to converging on critical assumptions and creating a final prototype for testing. The design team iterates to establish a shared understanding of the concept and essential functions of the prototype.

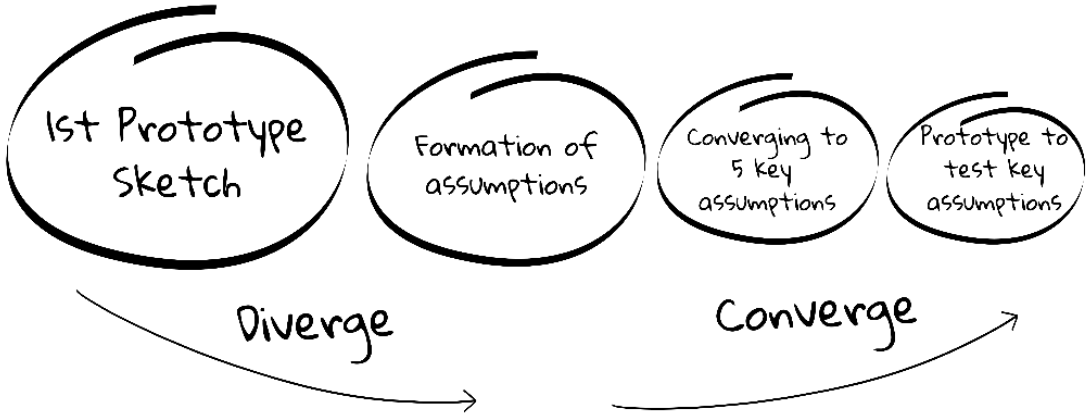

Figure 32. Prototyping journey

The team created a prototype sketch (Appendix 2 B.) to help form the opening set of assumptions (Table 17.). The deck of assumptions is scored to focus the prototype on the topics that need more attention. The “x” marks the five chosen assumptions in Table 17. The final prototype (Figure 38.) tests these five key assumptions with an energy sector Customer. As an example, the use phase of the customer journey is portrayed in Figure 39, which includes a "cartoon panel" and an attached assumption.

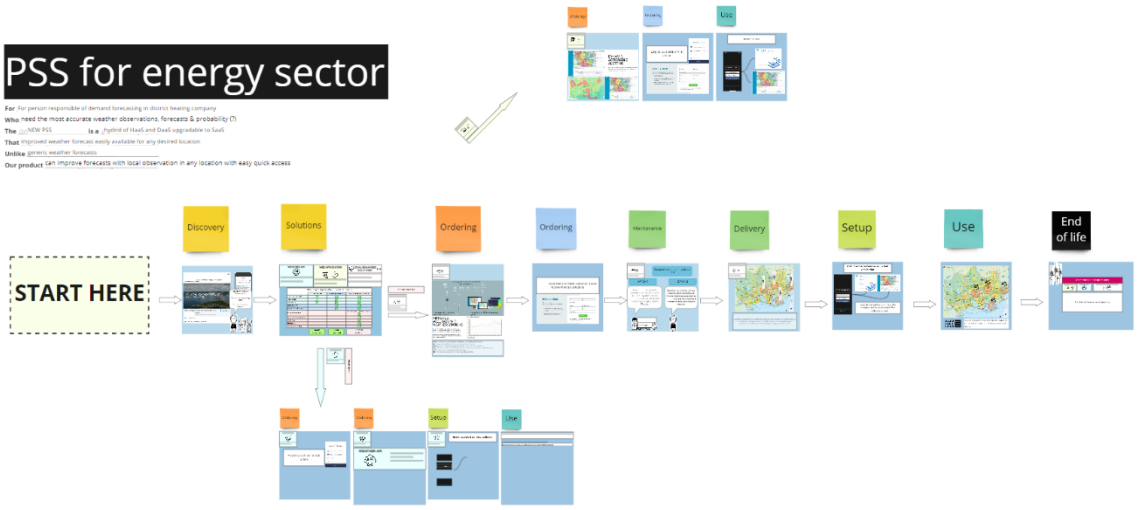

Figure 33. PSS prototype for the energy sector

Table 15. Prototypes assumptions

	Assumption	Key's
A1	When we offer APIs, "Web Application," and "Local Enhanced Solution," the customer is interested in the last one.	X
A2	Target customer searches this type of solutions via web and "forecasting accuracy" or "demand forecasting weather" is what gets their attention.	
A3	15% of accuracy improvement (in RMSE) matters.	X
A4	The customer believes in the cost savings/value represented by CompanyCo's calculators.	
A5	Customers can provide an installation site that is suited for gathering data through the product lifecycle.	X
A6	The customer wants CompanyCo to handle the installation to make sure right functionality.	X
A7	There is a team that needs to identify the need for this service jointly.	
A8	CompanyCo has access to data and can use it to improve its services.	X
A9	There is a need for probabilistic weather data	
A10	Dynamic, actionable alerting is something customers would be interested in.	
A11	No maintenance is something customer values.	

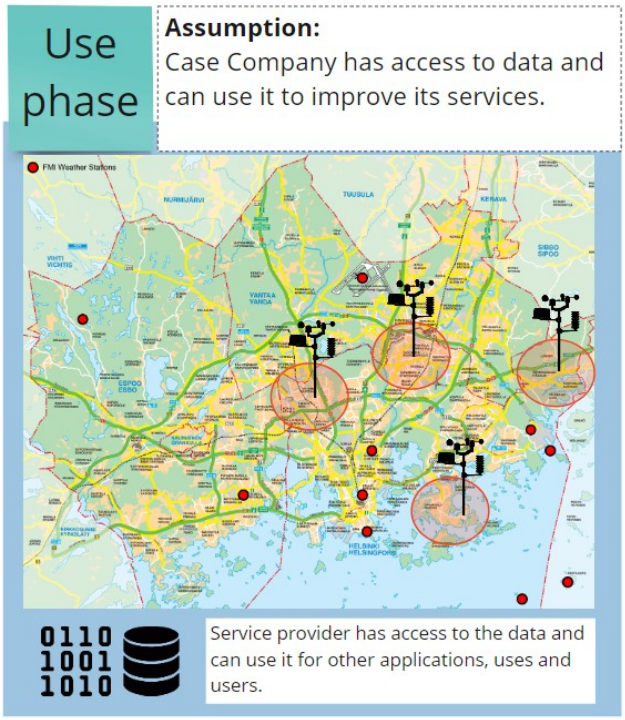

Figure 34. Example of prototype "cartoon panel" and the related assumption

5.3.3 Learnings from customer

The introduced prototype was validated with a customer from a company that generates energy and distributes district heating. The company representative observed the prototype phase by phase and openly commented on anything that resonated with him. The test was conducted via Zoom. In the beginning, the following instructions were given:

"I will share my screen and show on a frame by frame the customer journey for a new CompanyCo offering. The prototype is aimed at district heating customers. Please think aloud as much as possible. What you see, the thoughts and questions that arise. In general, state whatever comes to mind as plainly as possible. There is no right or wrong in this case."

The following feedback was gathered to help us better understand the customer (Table 18). In the beginning, the customer concentrated on the location where relevant data should be shared. They mentioned that LinkedIn postings generate the majority of the

company's technology leads. Because the company uses Weather APIs in their solutions already, the "Local Enhanced Solutions" stimulate their interest primarily.

The customer stated that accuracy is the primary value they base their business on district heating solutions. The customer would be interested in reading a white paper or something similar in advance about improving forecasting accuracy. If pricing were based on some form of value-based pricing or risk sharing, the customer would have an easier time making a purchase decision. Additionally, some form of agile trialling would help spark interest. The trial should focus on the length of the heating season to validate the potential for improvement.

The test subject was uncertain whether our company could deliver the facilities/location to the equipment but was more secure about wanting CompanyCo to handle the installation and maintenance. While data ownership is something to discuss further, the participant does not see it as a barrier to progressing at the moment.

Table 16. Customer insights from the prototype

Assumption	Customer feedback
When we offer APIs, “Web Application,” and “Local Enhanced Solution,” the customer is interested in the last one.	When I read this, the first thing that struck me was the column on the far right (Local Enhanced Solutions). It seems to be something new. Especially exciting topics are; enhanced forecast, local observations, and maintenance-free. On the left, the API is "business as usual” and seems to be a traditional API, like the one we use currently. The web application does not resonate directly, is not particularly relevant. Control and production optimisation work automatically with the power of machines. Nice, but not essential.
15% of accuracy improvement (in RMSE) matters.	Accuracy is a key-value on which value is built in such solutions—taking the local difference into account more closely in load forecasting, optimising production, and running the grid benefits an energy company has in mind when hearing such stuff. In detail, we are trying to achieve a smaller RMSE. If we achieve a 15% improvement in the RMSE, we are talking about saving a 6-figure sum per year in a city the size of ours. The prototype does not answer that is the new solution is model-based or another kind of forecast. The graph would need definitions, such as time horizon. I would like to have a white paper about the accuracy and relevant topics, maybe an example from a similar city as ours.

Customers can provide an installation site that is suited for gathering data through the product lifecycle.	I cannot say directly whether our company can deliver the facilities/location to the device. However, our company has many properties all over the city. It may be possible, not at all against the idea, but it should be clarified. It is preferable to plan the matter collaboratively, where the service provider would provide specific information on which physical locations are optimal for obtaining the desired installation conditions.
The customer wants CompanyCo to handle the installation to make sure right functionality.	We would want CompanyCo to install the equipment. These are the things for which 101% percent confidence is desired. We want the highest possible confidence in forecasts and measurements.
CompanyCo has access to data and can use it to improve its services.	In that sense, we probably do not mind that the weather data is developing something else for someone other. The equipment would be, after all, CompanyCo's stations. District heating is local, so there is no direct benefit against competitors in the improved forecast. In principle, the electricity side would have the advantage of having better weather forecasts than competitors.

5.3.4 Workshop 4 - Customer feedback-driven iteration

In the next step, iteration of the idea begins (Figure 40). The prototyping results were shared and analysed in the design group to further develop the new PSS concept.

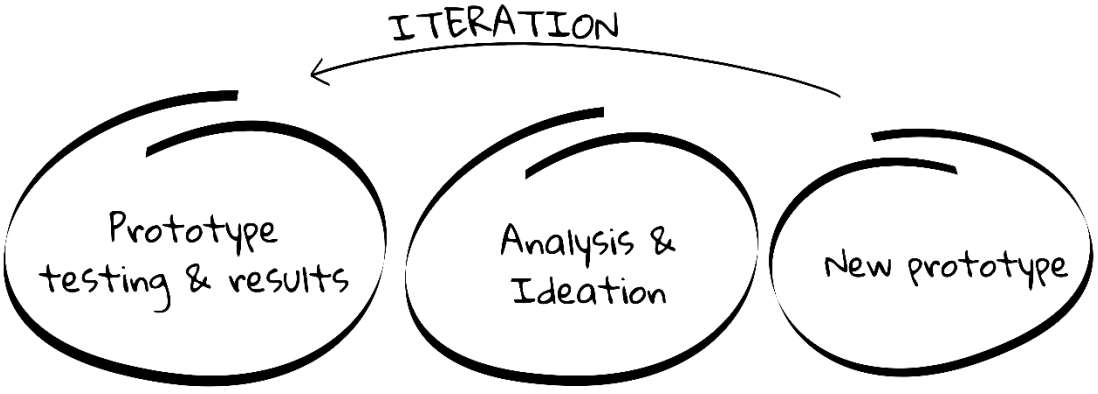

Figure 35. Customer feedback

During the interview, the customer raised the topic of result-oriented pricing and agile trialling. Brainwriting was used to improve presented topics in the prototype. Brainwriting is a technique that reinforces brainstorming. It is a technique for rapidly generating ideas and layering them on top of one another. Each participant jots down their responses to a question or problem. When they are finished, they pass their topic to the next person, who reviews and expands on the ideas. This thesis does not analyse the iteration results (Appendix 2C), but the central message is to remember to iterate, fail, and fail forward. The next step after iteration would be new prototypes.

6 Discussions, conclusions, and future works

The purpose of this study was to design a PSS innovation framework for CompanyCo's emergent business and get a thorough knowledge of internal and external capabilities towards servitisation to assist CompanyCo in determining how to improve capabilities to develop new services that would generate demand and prosper.

Research question 1:

What would be a suitable PSS innovation framework for CompanyCo's emergent offering?

This study demonstrated that the suitable PSS innovation framework for CompanyCo's emergent offering could be based on The New Double Diamond Model of Design Thinking (Liu, 2016), the Design Thinking macro process (University of St. Gallen, 2021), and PSS characteristics (Baines et al., 2007; Kindström, 2010; Lay, 2014; Lay et al., 2009). The framework process starts with a concept, idea, vision, or goal for a new product, service, or feature. The solution is intended to be viable, feasible, and desirable. The process triggers the organisation to conceptually link the available technology, systems, techniques, and procedures to unmeet customer needs.

The purpose of the "find the right problem" phase is to draw attention to the issue and better understand the customer's pain points and experiences. The "finding the right solution" phase involves ideation, brainstorming, acquiring extensive knowledge, prototyping hand-on methods, and iteration.

In conclusion to the discussion, a new PSS innovation framework is presented that integrates the empirical findings with the prior literature on PSS and Design Thinking. District heating load forecasting, as the case study, demonstrated its applicability in the manufacturing business context. The new framework is intended to be a generic framework that can be applied to any business that requires integrating tangible elements and service bundles. The primary benefit of the new framework is that it is universally applicable,

despite its origins in the manufacturing business, while still providing a better understanding of PSS innovation in the service business context. The outcome revealed that the organisation could use a systematic technique to innovate and design new PSSs in a complex environment by utilising the built framework. Throughout the innovation process, Design Thinking tools are employed, and assumptions are validated with the client.

Research question 2:

What is the current status of servitisation in CompanyCo's existing business?

Manufacturing firms diversify their offerings with services to differentiate themselves from competitors, achieve financial benefits, and increase customer intimacy. The transition to services is rarely straightforward and might provide producers with several obstacles. Numerous critical success elements and barriers associated with servitisation are related to the shifting roles of customers, product development, and salespeople.

The "current status" online survey results indicated that CompanyCo's business's external forces somewhat favourably support servitization. Internal capabilities in CompanyCo's existing internal business were examined in greater detail in the study, with the following topics covered; KPI's and organisational alignment, value-based pricing strategy, product-service culture, customer-centric product-service co-creation, knowledge management, and efficient cost structure. The results indicate that CompanyCo is committed to transforming itself into a more service-oriented organisation. The data indicate that CompanyCo is committed to organisational change in the direction of a service-oriented business, corroborating the indications of a new company strategy.

The results indicated that the strengths to leverage (Figure 41) in the direction of servitisation are CompanyCo's professional and dedicated people, as well as the strong transformation forces that support strategic changes. Employees appear to be enthusiastic about driving a clear vision for cross-organisational development and PSS's. CompanyCo's product portfolio is well-positioned due to its end-to-end capabilities, scientific

innovation, and value-adding products with a tangible component of value. The value that CompanyCo's hardware generates is an exceptional opportunity to capitalize on potential value-adding pricing and communication opportunities.

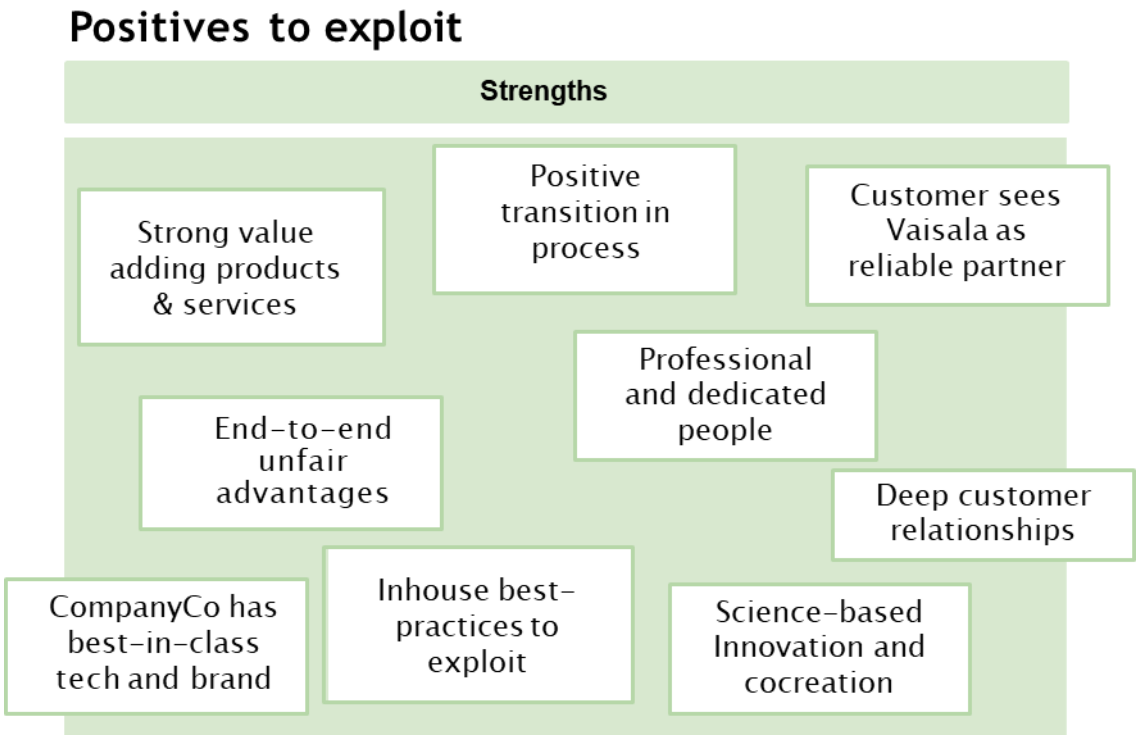

Figure 36. Summary of internal positives to exploit towards servitisation

According to the research, the pitfalls (Figure 42) in servitisation are CompanyCo's unclear processes for customer information, which can be stored in multiple locations. Daily customer information flow is perceived to be on the shoulders of project managers, and the information process can be cloudy. The transparency of cost structure in service offering is work in process but a possible pitfall towards servitisation. Consistency in PSS solutions is a challenge, as is marketing, producing, and selling customised bundles. The findings indicate that hardware manufacturing traditions haunt the transition, manifesting themselves in the company’s tooling and as caution on early prototypes.

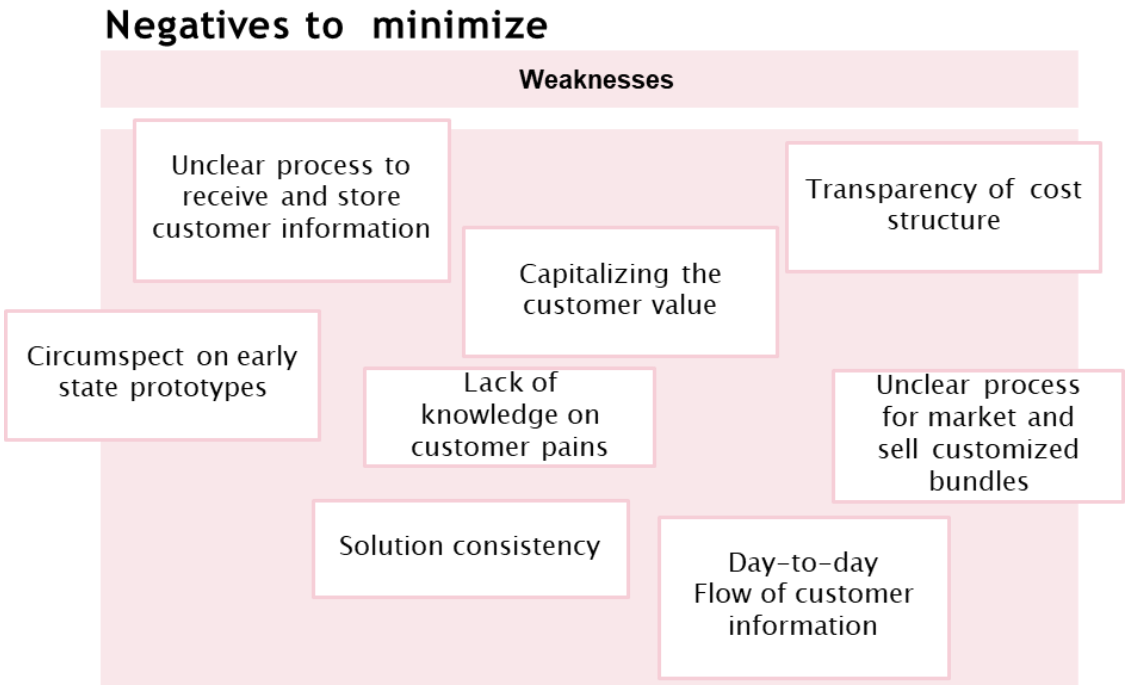

Figure 37. Summary of internal positives to exploit towards servitisation

6.1 Contributions and implications for future research

This work makes two practical contributions. First, it illustrates the approach practitioners may use to develop a PSS or the elements they should consider using Design Thinking methodologies. Second, it provides critical information about the types of challenges that other organisations may face during this process, allowing them to prepare accordingly.

In the future, it will be necessary to conduct comprehensive research on the PSS innovation process. Multiple previous studies have focused on either PSS innovation or Design Thinking, but none have examined the combination of PSS fundamentals and Design Thinking methodology. As a result, the thesis's objective is to develop a framework for PSS innovation that is iterative in nature and customer-centric. This work is something that can be improved. It provides only a partial picture because the process was only partially tested; thus, it is necessary to obtain a larger view and determine the nature of

the problems and challenges in the remainder of the process to facilitate further innovation and implementation of new PSSs.

6.2 Limitations

The current study sheds some light on potential future research directions on the current state of servitisation and the PSS innovation framework, but it does have some limitations. First, this research is being conducted in the Finnish measurement equipment industry, a highly specialised sector. Additionally, this is a qualitative study conducted by interviewing experts from a single organisation's division. As a result, the results may be context-dependent. Therefore, caution should be exercised when extrapolating the findings to other industries (Yin, 2003).

Second, this is a case study. Thus, the theoretical framework's applicability is determined solely based on the research company. Multiple companies should have been studied to determine whether the theoretical framework (PSS innovation) is generally applicable. Moreover, to demonstrate the theoretical framework's applicability, the sample of cases should span the entire width of the manufacturing industry.

Thirdly, the PSS innovation framework focuses on the Design Thinking innovation process, limiting PSS innovation frameworks in a minor role. The thesis approached the topic in a specific direction (iterative, customer-centric procedures), and other points of view could have been considered.

Case studies as a method can be highly subjective, increasing the possibility of researcher and interpreter errors. Additionally, semi-structured interviews with nine participants and an online survey with fourteen respondents were conducted. The number of interviews could have been higher to achieve a broader profile of answers. The number of interviews may have been increased to obtain a more diverse profile of responses. Interviews and surveys are also prone to subjectivity on both the interviewer's and

interviewee's sides. The interviewee could have misunderstood the question or the phenomena in their context, or the interviewer may have misunderstood something expressed by the interviewee, misinterpreting the results.

The word "PSS" is employed inconsistently throughout the studied literature, and there is ambiguity around its related concepts. As a result, the literature evaluation may contain inconsistent offers for which the term PSS was retained. Additionally, fewer academic sources were employed in the literature review when discussing Design Thinking, weakening the study's reliability.

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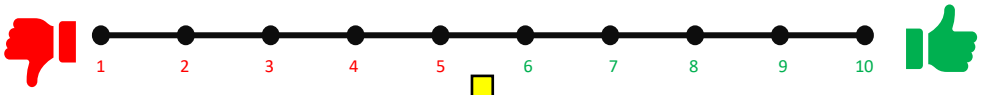
Appendix 1. Survey questions, adapted from Sholihah et al. (2019)

Current state survey

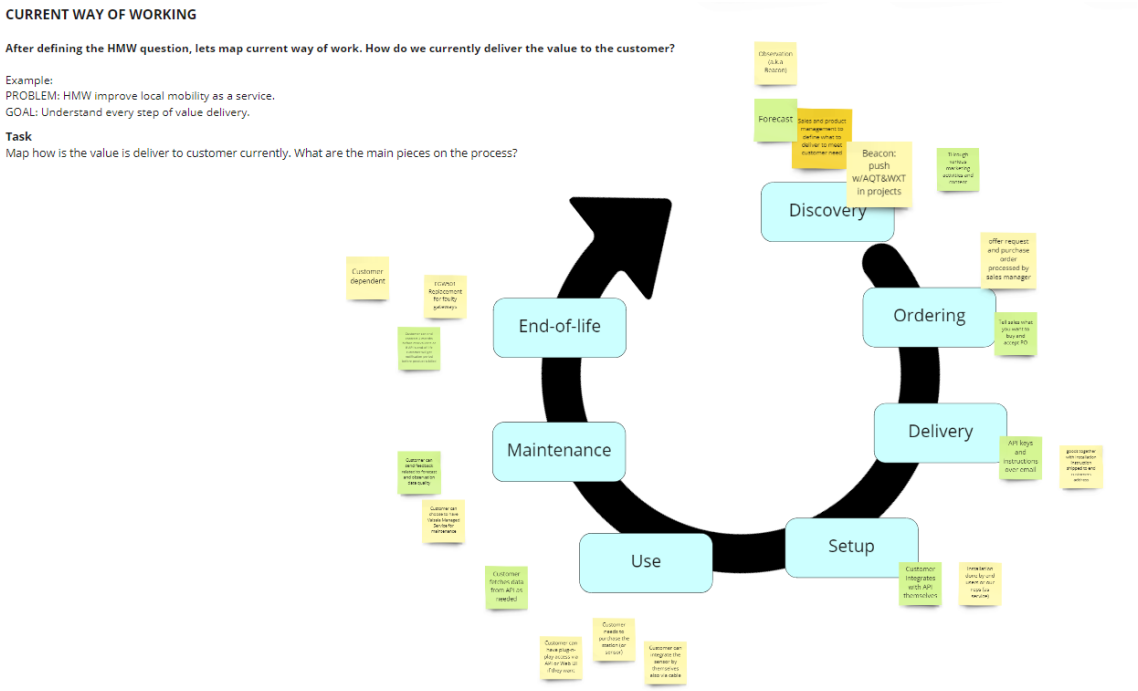


Area	Topic		Question	Assumption 1		Assumption 2
INTERNAL CAPABILITES	Financial	Value-based pricing strategy	Q1 Shareholder value	Our shareholder value is low compared to our offering capabilities		We have high shareholder value matching to our company capabilities
			Q2 Revenue from product sale	Our revenue sustainability from product sales is questionable		Our revenue stream from the product sale is sustainable
			Q3 Additional revenue from service	Service provision in our offering does not give any additional revenues		We get significant additional revenue because of service provision in our offering
			Q4 New revenue from new customer	We do not have any new continuous revenue stream from new customer		We benefit new continuous revenue stream from new customer
		Efficient cost structure	Q5 Cost structure	Our cost structure is insufficient with the cross organisational offering (PSS)		Our cost structure is effectively suitable for our cross organisational offering (PSS)
			Q6 Operation cost	We do not have cost-efficient operations		We have cost-efficient operations
	Customer	Customer Intimacy	Q7 Value proposition	Our value proposition is not aligned with customer needs (value-based pricing strategy)		Our value proposition is well aligned with customer needs (value-based pricing strategy)
			Q8 Relationship with customer	Our relationship with the customer is weak (e.g., no co-creation, relationship management, or deep relationships)		We have a strong relationship with the customer (e.g., co-creation, relationship management, and deep understanding of customer needs)
			Q9 Company image	Our company does not have an image as a PSS provider		We have a strong company image as a PSS provider
			Q10 Customer satisfaction	Our customers are not satisfied		Our customers are very satisfied
			Q11 Customer acquisition	We cannot acquire new customers		We continuously acquire new customers

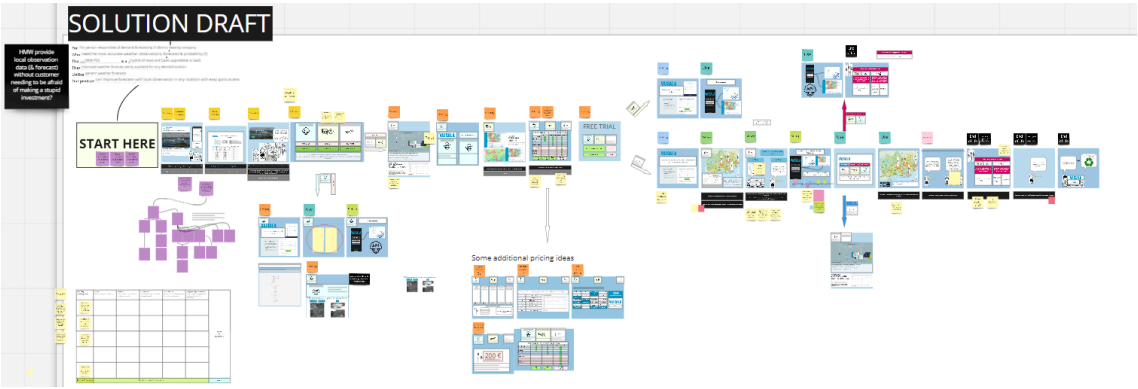
	Internal business	Product service co-creation with the customer	Q12	Product/service innovation	Innovation and co-creation with the customer are not our focus		We actively innovate our product and service offering by co-creation with the customer
			Q13	Customer relationship	Our customer relationship management is ineffective		We highly value customer relationships and maintain them with effective customer relationship management
		Close collaboration with partner	Q14	Close collaboration with partners	Our collaboration with partners is weak		We have strong and close collaboration with partners (suppliers and/or service partners)
		Efficient and effective distribution channel	Q15	Distribution channel	We have inefficient and ineffective distribution channels for our products and services		We have efficient and effective distribution channels for our products and services
			Q16	Effective service provision	Our service provider does not contribute to the increase of the value of our offering		We provide effective services to increase the value of our offering
			Q17	Operation	Our operations in production and service provision are inefficient		We have efficient operations in production and service provision
	Learning and Growth	Service-oriented personnel	Q18	Service capability	Our company capabilities are far from the high-quality service provider		We have capabilities to provide high-quality services to the customer
			Q19	Training	There is no training to increase employees service capabilities in our company		We train our employees to be service-oriented people
		Service-oriented ICT	Q20	Knowledge management	Our company does not have a knowledge management system		We have an effective knowledge management system
			Q21	CRM system	Our company does not manage customer relationships by CRM system/customer relationship unit in the organisation		We have effective customer relationship management (CRM) system/customer relationship unit in the organisation
		Service-oriented performance measurement system	Q22	Service-oriented bonus structure	We do not have a service-oriented bonus structure		We have a service-oriented bonus structure
		Product service culture	Q23	Cross-functional team	A cross-functional team is practically difficult in our company		Working well in a cross-functional team is our company culture
			Q24	Organisation alignment	Our company does not have strategic alignment		Our company is strategically well aligned
EXTERNAL FORCES	Industry forces		Q25	Competitor	Our competitors within the industry are strongly threatening our position		We have a strong position over our competitors (e.g., product/service value, supply chain) within the industry
			Q26	New entrants	Our value proposition is easy to be imitated by a new player		Our value proposition is difficult to be imitated by a new player
			Q27	Substitute product or service	Our offering is easily substituted by other products and/or services		Our offering is difficult to be substituted by other products and/or services
			Q28	Bargaining power of suppliers	We have weak bargaining power with our partners and are in danger to lose them		We have strong bargaining power with our partners
			Q29	Bargaining power of buyers	Our customer can easily switch to another PSS provider or products/services provider		We have high customer retention
	Key trends		Q30	Technology trends	Our offering is severely threatened by technology		Technology developments positively affect our company and our PSS offering
			Q31	Regulatory trends	Regulations are threatening our company and offers		Regulations positively affect our company and offer

		Q32	Megatrends	Megatrends are threatening our company and offers		Current megatrends positively affect our company
		Q33	Socioeconomic trends	Demographic trends are threatening our company and offers		Major socio-economic trends (e.g., income distribution, spending patterns) greatly support our company
	Market forces	Q34	Market issues	Current market issues are threatening our company and offerings		Current market issues strongly support our company and offerings
		Q35	Market segments	Our current market segment is declining		Our current market segment is growing. There is a new potential market segment
		Q36	Needs and demands	We have a significant portion of unsatisfied demand		We have satisfied all our customers' demand
		Q37	Switching cost	Our customers can easily find and switch to another provider with similar or substitutional offerings		Our customers are strongly loyal to our company with a high retention rate
		Q38	Revenue attractiveness	Our customers can easily find and purchase cheaper products/services		Our customers are not price-sensitive and willing to pay our offering
	Macroeconomic Forces	Q39	Global market conditions	Current global market conditions (e.g., GDP rate, international economic crisis, unemployment rate) are threatening our company		Current global market conditions (e.g., GDP rate, international economic crisis, unemployment rate) are positively affecting our company
		Q40	Capital markets	Current capital markets are threatening our company		Current capital markets greatly support our company's capital needs
		Q41	Commodities and other resources	Current market status of our essential resources is threatening our company		Current market status of our important resources is incredibly beneficial for our company
		Q42	Human resources	We have problems acquiring new human resources		It is easy for us to acquire the best human resources
		Q42	Economic infrastructure	The public infrastructures do not support our company's business		The public infrastructures greatly support our company's business (e.g., transportation, corporate taxes)

Appendix 2A. Workshop: Current ways of working



Appendix 2B. Workshop: First iteration of workshops



Appendix 2C. Workshop: iteration based on customer feedback