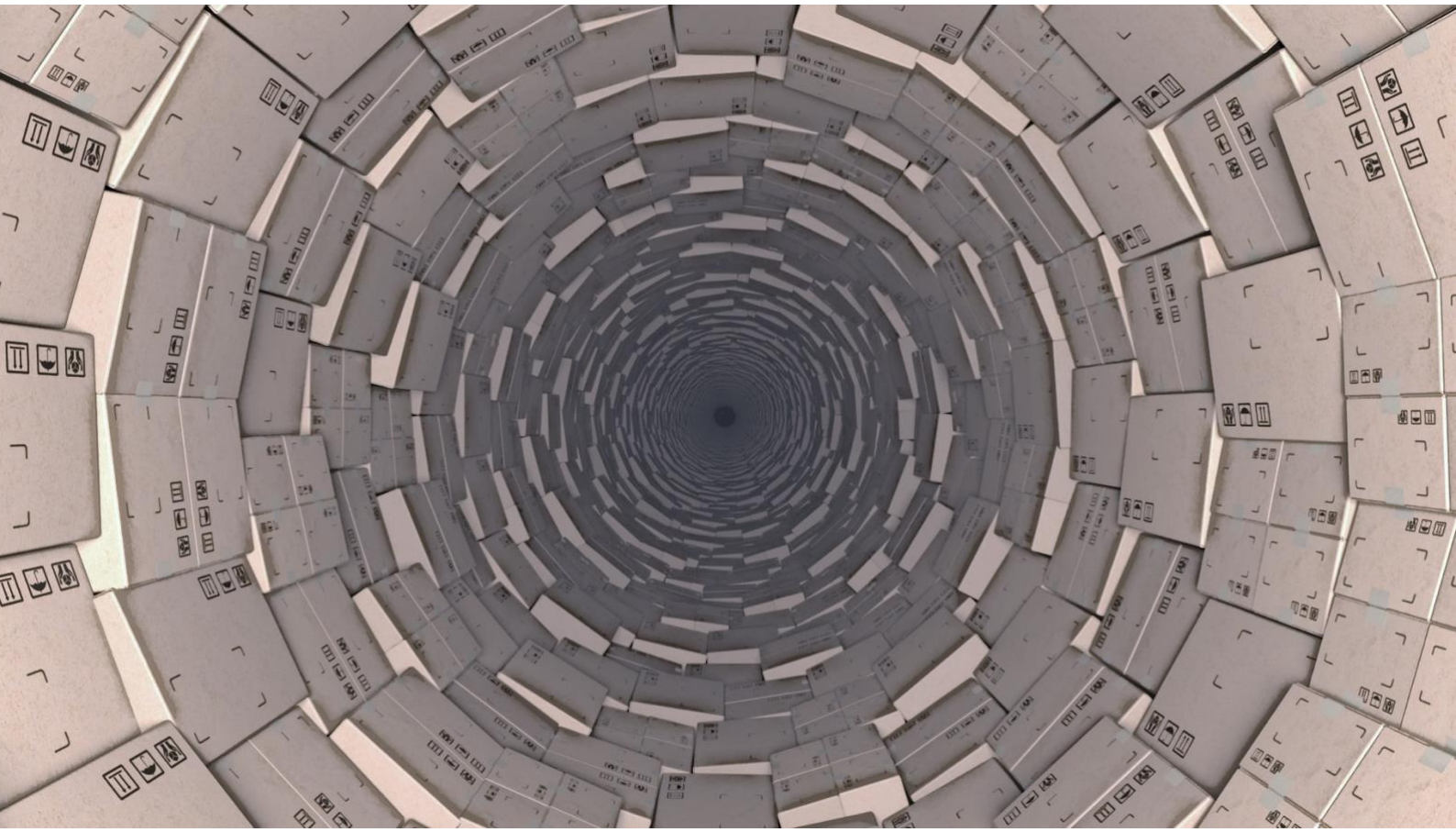

Final report

Business models and product groups for Product Service Systems (PSS) in the Nordics

PRODUCT SERVICE SYSTEMS IN THE NORDICS

September 2022

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EXECUTIVE SUMMARY

Product Service Systems (PSS) have significant potential for supporting circular and digital economy, improving societal sustainability and value creation. This project aims to demonstrate whether, when and how PSS can be economically and environmentally successful and contribute to the fulfilment of the Nordic Vision 'to become the most sustainable and integrated region in the world'.

This report presents the findings from the project's first two steps to create an overview of existing PSS models in the Nordics (step 1) and identify key product groups suitable for PSS (step 2). The report provides insight into existing PSS solutions applied in the Nordic Region, based on Arnold Tukker's three categories for PSS - Product-oriented, Use-oriented, and Result-oriented. The analysis is based on 275 cases of PSS found in the Nordic countries and categorised into nine product group clusters: Transportation, Packaging, Machinery and tools, Appliances, furniture and household products, Product for children, Clothing and accessories, Seasonal and special occasions, Electronic equipment and solutions, and 'Other'.

The survey shows that use-oriented PSS solutions are the most common in the Nordics, with 230 cases identified. Product-oriented PSS models are assessed to uphold the least environmental benefits of the three groups, and only the 40 most interesting cases of this type have been mapped in the project. Result-oriented PSS models are rare, and only a few cases are identified in Nordic countries.

Across the product groups, there is an overall focus on reducing CO2e emissions, increasing production utilisation, sustainable material sourcing, and reducing waste. Most of the product group clusters include models such as repair, refurbishment, and extended warranty, facilitating a prolonged lifespan of products and increased product durability. Based on consultations with PSS providers, the main attraction for consumers utilising PSS solutions is convenience, especially related to maintenance of the products offered. Increasing consumer awareness of product emissions and waste production has been identified as a focus for many PSS solutions.

Most consulted PSS provider experience challenges in competing with product-sales models, utilising cheap and unsustainable sourced materials for their products, and enabling low retail prices. For PSS providers utilising the use-oriented models, upkeeping an efficient stock to stay attractive to consumers has also proven challenging. Challenges with cultural lock-ins regarding product ownership and consumption patterns are experienced in all product group clusters, especially for providers utilising use-oriented business models targeting the B2C market. Many do, however, expect these tendencies to change over time.

CONTENT

1 INTRODUCTION

The Nordic Council of Ministers has set out a new Nordic Vision for 2030, addressed in the Action Plan for 2021 to 2024. The vision is that the Nordic Region will become the most sustainable and integrated region in the world, based on three dimensions: a green Nordic Region, a competitive Nordic Region, and a socially sustainable Nordic Region.

- A green Nordic Region will be achieved by promoting the green transition of the Nordic countries, working towards carbon neutrality, and pursuing a sustainable, circular, and bio-based economy.
- A competitive Nordic Region will be achieved by promoting growth in the Nordic Region based on knowledge, innovation, mobility, and digital integration.
- A socially sustainable Nordic Region will be achieved by promoting an inclusive, equal, and interconnected region with shared values and strengthened cultural exchanges and welfare[1].

As seen with sustainable development initiatives worldwide, business adaptation to disruptive changes often require new sustainable and innovative pathways. New services and business models are receiving increased attention as economically viable, innovative paths as alternative to technical and product-oriented development paths[2]. Models of producer ownership or Product Service Systems (PSS) do not offer a complete decoupling of products and environmental impact, but an added focus on services could enable economic growth without the same corresponding increases in environmental pressure as with product-sale models.

The vision of the Nordic Council of Ministers is related to a political debate on green growth and reshaping the windows of opportunity for industrial companies, defined by the fundamental transition to a Circular Economy. Circular business models and innovation pathways are key components, and not least PSS models are seen as supporting circular and digital economy with a potential to significantly improve societal sustainability and value-creation[3]. The development of innovative business models, such as PSS, can enable alternative value-creation opportunities and mechanisms as one way of implementing circular principles across industries[4]. PSS are seen to have emerged due to traditional manufacturing companies wanting to cope with the changing market forces and realising that linking services with products could lead to higher profits[5].

The concepts of Product Service Systems (PSS) can, in literature, be known as Producer Ownership Models (POM), with minor distinctions between the different concepts.

POM is characterised by producers/intermediaries not selling a product but the service a product is intended to offer. POM and PSS have significant similarities, with PSS having a broader definition, including POM in most models. This report uses PSS as its basis for a more holistic view of the

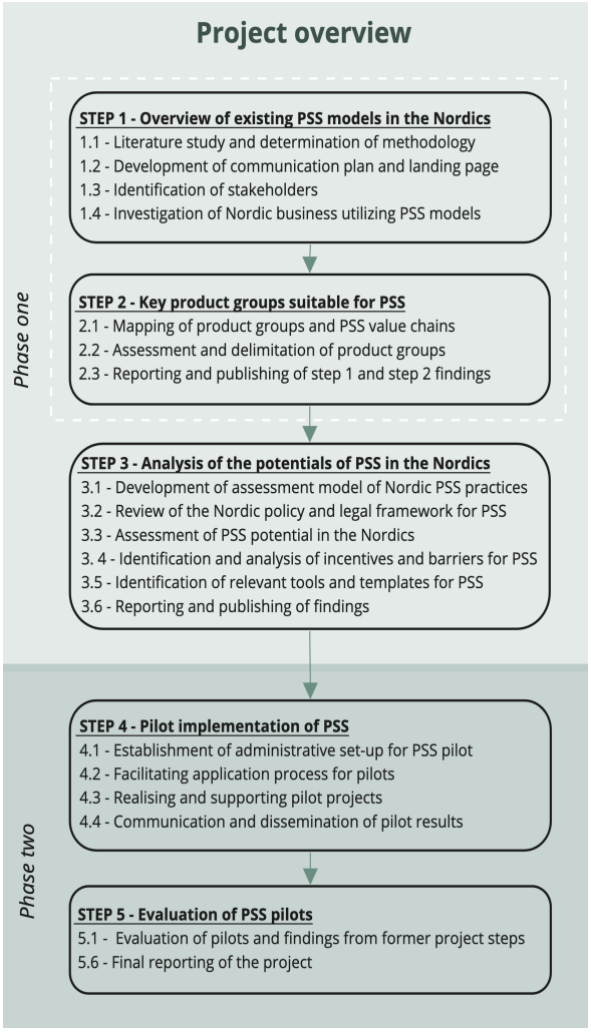
The penetration of PSS in the Nordics is understudied[6] and there is limited knowledge sharing on the subject among the Nordics countries and industries as well as sparse utilisation of collaboration opportunities. This project aims to demonstrate whether, when and how PSS and producer ownership models can be successful, i.e. be significantly more resource efficient and economically viable than traditional business models, hereby responding to international climate and environment ambitions. The first step in this process is to generate an overview of the PSS models currently used in the Nordics and identify which product groups are most suitable for further implementation. Existing and potential enablers and barriers for Nordic Product Service Systems will be assessed in relation to policies and regulations both at the EU level and in individual Nordic Countries.

[1] NCM (2020): The Nordic Region – towards being the most sustainable and integrated region in the world – Action Plan for 2021 to 2024.
[2] Ritzén & Sandström (2017): Barriers to the Circular Economy – integration of perspectives and domains.
[3] Braun et al. (2021): Everything-As-A-Service – XAAS - How Businesses can Thrive in the Age of Climate Change and Digitalization.
[4] Pieroni et al. (2018): Enabling circular strategies with different types of product/service-systems.
[5] Salwin & Kraslawski (2020): State-of-the-Art in Product-Service System Classification.
[6] Hernández (2017): Systems approach to the development of integrated solutions in the Nordic manufacturing industry.

The project will create a comprehensive knowledge base on models of producer ownership in a Nordic context and hereby serve as foundation for further policy development.

The project has the overall objectives to demonstrate models of producer ownership that are both economically successful and environmentally beneficial; to identify and promote framework conditions that can enable such models; and to ensure that relevant stakeholders are informed about the possibilities and challenges for POM in the Nordics. The project runs from November 2021 until December 2024.

This report is the first publication of the project with the purpose of providing insights into existing PSS solutions around the Nordics. The report includes an extensive mapping of product groups suitable for PSS solutions, paving the way for an in-depth understanding of environmental impact, social impact, and economic potentials of PSS in the Nordics. This will support the preparation of policy recommendations for Nordic decision-makers, ensuring that the most sustainable PSS solutions have good conditions for growth and stability.



1.1 This report

The project is divided into two phases with a total of total steps – as illustrated in the project overview. This report is based on the findings from step 1 and step 2 activities.

The first part of the report provides a theoretical clarification of PSS, elaborated through Nordic PSS case examples. The second part of the report presents findings from an extensive mapping of Nordic product groups relevant in a PSS context, an analysis of the tendencies in Nordic PSS business practices, and case examples illustrating the spectrum in where PSS business operates in the Nordics.

The report consists of three chapters covering findings from step 1 and step 2 of the project *PSS in the Nordics,* as illustrated in the figure below.

1 Introduction to the project 'PSS in the Nordics' methodology and the project context	The first part of the report introduces the context of the project '*PSS in the Nordics'* and the methodology of the project, providing an understanding of the context for the report structure and the overall project framework.
2 Introduction and review of the subject matter, theory and overarching analysis of the state of play for PSS in the Nordics	The second part of the report provides insights on the different models of PSS in the Nordics and introduces the theoretical context of which the collected data have been analysed.
3 Overview of Nordic market conditions for selected product groups, examples of PSS practice and findings from analysis	The third part of the report details the most relevant product groups used in PSS models in the Nordics. It exemplifies findings of tendencies in business practices and the overall Nordic market conditions.

1.2 Identification of product groups

The first part of this report contains an in-depth description of Tukker's (2004) eight archetypical models for PSS[7], one of the literature's most cited definitions of PSS and a starting point for understanding and delimitating PSS solutions in the Nordics. The identification of Nordic PSS solutions was initiated with a thorough literature study of academic publications to increase understanding of key concepts essential for PSS solutions. Commonly identified product groups include the following:

- Transportation
- Packaging
- Machinery and Tools
- Appliances and furniture – B2B
- Household products – B2C
- Products for children
- Clothes and accessories
- Seasonal and special events
- IT
- Other

A Nordic search for relevant PSS resulted in the identification of 275 PSS cases of interest.

The role of the provider and its position in the value chain can have important implications for the possibility of designing the product for sustainability and, thus, the solution's overall environmental potential. For the majority (152 cases), the 'provider' is a retailer or distributor, whereas for a minor share the 'provider' is a producer, manufacturer or designer.

As PSSs revolve around creating economic benefits for the provider and improved value for the customer, the survey also included mapping of the customer type – with an almost even division of cases targeting consumers (154) and businesses (124) and fewer targeting governments or public institutions (40).

One recent study (Borg et al. 2020) states that Use-oriented models have been mainly adopted in B2B markets, such as for office equipment, where their acceptance level and feasibility are relatively high but presence in the B2C markets is lagging. Most B2C examples focus on services substituting durable slow-moving products such as cars, or items that tend to be rented for single use, such as formal attire or party supplies[8].

Following the classification of Nordic PSS solutions, an assessment of the most relevant cases from each of the Nordic countries was conducted to ensure a deeper understanding of the current market conditions, the legal and regulatory frameworks, barriers and enablers, and actions to provide environmentally and socially sound product services. Cases were selected based on the capacity to address social, environmental, or economic challenges (including circular principles in their business model); the potential for replicability in more than one Nordic country; and the target market (B2B, B2C, and B2G). 35 cases were selected for in-depth interviews to spur an assessment of the environmental and socio-economic impacts, of how regulation affects Nordic PSS solutions, and of the actors' perception of challenges and enablers for PSS in the Nordics.

The product groups cluster and initial findings from the interviews were validated through interactive workshops in Norway, Sweden, Finland, and Denmark with PSS researchers, business owners, circular economy experts and scientist. The knowledge gained from the workshops has supported the final

[7] Tukker (2004): Eight Types of Product – Service System: Eight ways to sustainability? Experiences from Suspronet.
[8] Borg et al. (2020): Consumer Acceptance and Value in Use-Oriented Product-Service Systems

selection of product group clusters presented in the next chapter and the case examples provided in this report.

1.3 Environmental impact and potential benefits of PSS solutions

The ostensible purpose of PSS is to improve sustainability by developing and operating business models which lead to the more sustainable provision of product utility or function compared to a non-PSS alternative. In this study, the alternative is a conventional ownership model where a consumer acquires a physical product and gains utility from it through outright ownership over its lifetime.

The mere existence of a PSS-type activity does not ensure sustainability, and ideally, examples of PSS should be rigorously evaluated in accordance with a transparent and consistent methodology. The sustainability impacts often appear to largely be "assumed" rather than necessarily proven when a PSS activity is established. Rigorous evaluation of PSS implies calculating the costs associated with a product system - these being environmental and social "costs" as well as economic ones – and the product utility that derives from that system. Thus, the inclusion of any PSS case in this report serves to illustrate with width of the PSS concept but does not in any way constitute an endorsement or appraisal of the solution by the Nordic Council of Ministers or the consultant team.

The intention of PSS is to deliver product utility at a lower unit cost compared to the traditional buy and sell solutions. The lower unit costs could be either by reducing the total costs in the product system, for instance, by fostering more efficient design or end-of-life takeback and efficient recycling– or by increasing the product utility, for example, by encouraging reuse or product life extension. For the consumers, benefits include lower capital outlays, convenience and the benefit of only paying for the function of a product. Measuring product utility, in particular, requires a close focus on business model factors such as the frequency and extent of product reuse and the transfer of physical products between different users across its life cycle. The efficacy of PSS initiatives is strongly related to such factors.

Each case example highlighted throughout this report describes the PSS model types according to the Tukker scale's three main categories and an indication of the size of the company, market and Nordic countries covered. Furthermore, an initial assessment of the potential environmental effect of the PSS solution compared to the conventional product solution is highlighted. In the coming Step 3 of the project, the focus will be on establishing and developing a consistent approach to evaluating the environmental and socio-economic effects of PSS in more detail.

2 MODELS FOR PRODUCT SERVICE SYSTEMS

PSS models have drawn significant attention in recent years as drivers for business innovation and servitisation of manufacturing[9]. The PSS concept emerged in Scandinavia in 1999 [10] with the early definition "a marketable set of products and services capable of jointly fulfilling a user's need"[11]. The primary motivation behind this concept is that it - ideally - can provide additional benefits for producers, customers, and the environment.

Since then, the term has evolved and gained greater importance[12]. Several definitions of PSS have been proposed with noticeable similarities to the original terminology, where services, supporting networks and infrastructure are designed to satisfy customer needs and generate value[13]. One of the most cited definitions of PSS in literature is that given by Tukker (2014)[14], seeing PSSs as combinations of tangible products and intangible services designed for their joint capability of fulfilling specific needs. These fall into three main categories:

1. **Product-oriented** service models mainly focus on selling products but with additional services, e.g. maintenance, repair, take-back schemes, financing or consultancy.
2. **Use-oriented** service models focus on the product but do not entail a permanent transfer of ownership to the consumer. The product stays in ownership with the provider and is made available in a different form and sometimes even shared by several users. This incentivises the company to maximise the product's use and extend product and material lifespan.
3. **Result-oriented** service models, where the product is almost incidental; providers and clients reach an agreement for the function or result, which is achieved through some combination of services and products or even without the involvement of a product, e.g. the transportation of a customer instead of selling or leasing a car or offering laundered clothes instead of a washing machine[15]. This is the most radical and transformative PSS version.

Tukker elaborates these three categories into eight PSS archetypes, each with specific economic and environmental characteristics (figure 1). This more detailed categorisation allows for description and capturing the full range of complexity of different PSS business models, and the eight categories of PSS models constitute the basis for categorising PSS models in the present project.

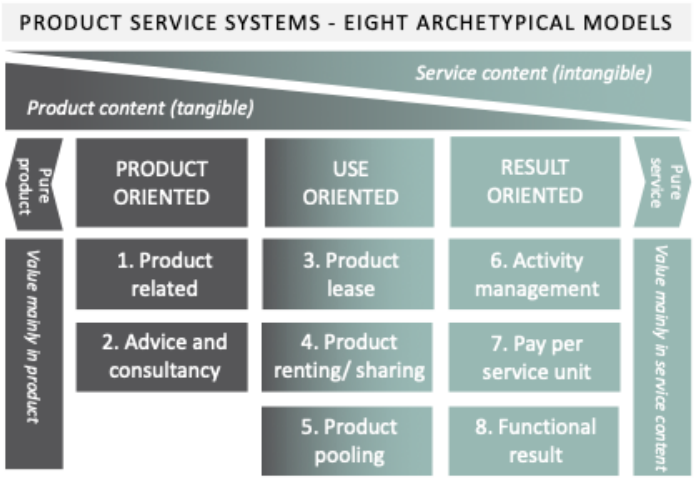


Figure 1: Eight archetypical models of Product Service Systems. Based on Tukker (2004)

Literature typically highlights either the opportunities that PSS can present to companies or the transformation process companies undergo from product providers to service providers. It is Furthermore, the PSS concepts often include the notion that a PSS should be more sustainable than the

[9] Kim (2020): A representation framework of product-service systems, in Design Science.
[10] Stahel (1997): The Functional Economy: Cultural and Organizational Change.
[11] Goedkoeb et al. (1999): Product Service Systems, Ecological and Economic Basics.
[12] Salwin, & Kraslawski (2020): State-of-the-Art in Product-Service-System Classification, in Advances in Design, Simulation and Manufacturing III.
[13] Kim (2020): A representation framework of product-service systems, in Design Science.
[14] Tukker (2004): Eight Types of Product – Service System: Eight ways to sustainability? Experiences from Suspronet.
[15] Beuren et al. (2012): Analysis of publications on product-service systems (PSS): towards a taxonomy and literature mapping.

competing product concept, e.g. provide a lower environmental impact than traditional business models[16,17]. The basic notion here is that PSS can act as a vehicle to help enhance competitiveness while at the same time fostering sustainability. Some PSS solutions have a high environmental potential, while others have a more shallow one. Even though PSS as a concept has the potential to improve social, economic, and environmental sustainability, the solution does not do this by default, why the environmental effects have to be verified on a case-by-case basis[18,19]. The following section will unfold the eight archetypes of PSS in a Nordic context.

2.1 Product-oriented PSS models

Product-oriented PSS models focus on the sale of products – services are seen as additional in relation to the products[20]. Providers typically deliver value to the customer through the product sale, but with extra added service(s). The property rights to the product are transferred to the customer upon payment and the PSS provider is responsible for delivering the agreed-upon services after property rights are transferred[21], e.g. offering take-back services of the product after use.

Since most product-oriented PSS models do not imply any change in the technological system or how the user operates it, they often imply only marginal environmental benefits. The provider has no strong incentive for considering life cycle costs in the design process – similarly to product-sales models[22], but there might be incremental efficiency improvements such as better maintenance and take-back schemes, leading to more intensive use of the product, prolonged life of capital goods, or reduced use of energy and consumables in the use phase.

The economic elements are not very substantial after the initial investment transaction. This, and the fact that this type of PSS is relatively similar to traditional product-sales models, makes the product-oriented PSS models the least problematic kind of PSS to introduce as a business model from an industry perspective[23]. From a societal perspective, product-oriented models constitute the least attractive PSS type since the models only challenge the status quo to a minimal extent.

40 product oriented cases have been investigated in this project, including different types and levels of services but with the service element being a minor part of the primary business model or revenue-generating mechanism. Within the product-oriented PSS category, two sub archetypes exist:

1. Product-related model
2. Advice and Consultancy model

2.1.1 Product-related model

In this type of PSS, the provider sells the products and offers complementary services that are needed during the use phase of the product[24]. Since product-related services often focus on the product itself, the services usually come in the form of embedded services provided by the supplier to help the customer manage the product during its lifetime. Specifically, maintenance contracts, supplying spare parts and

[16] Tukker (2015): Product services for a resource-efficient and circular economy – a review.
[17] Mont (2002): Clarifying the concept of Product-Service System.
[18] Ceschin (2014): Sustainable Product-Service Systems – Between Strategic Design and Transition Studies.
[19] Manzini & Vezzoli (2002): Product-service Systems and Sustainability: Opportunities for Sustainable Solutions.
[20] Tukker (2004): Eight Types of Product – Service System: Eight ways to sustainability? Experiences from Suspronet.
[21] Reim et al. (2015): Product-Service Systems (PSS) business models and tactics – a systematic literature review.
[22] Tukker (2004): Eight Types of Product – Service System: Eight ways to sustainability? Experiences from Suspronet.
[23] Tukker (2004): Eight Types of Product – Service System: Eight ways to sustainability? Experiences from Suspronet.
[24] Tukker (2004): Eight Types of Product – Service System: Eight ways to sustainability? Experiences from Suspronet.

consumables, product inspection, diagnosis and repair, transportation, on-site installation, refurbishing, cleaning, upgrades and return agreements at the end of life are all examples of product-related services[25].

The product-related services can be categorised into three different sub-forms based on the type and degree of interaction between the PSS provider and the customer:

1. Pure transactional services, where customer-specific requirements are provided, e.g. product transportation, installation, returns, on- and off-site repairs, spare parts, or delivery of consumables;
2. Extended warranties and preventive maintenance services, which include product repair and maintenance, are provided at the PSS provider's expense. This differs from pure transactional services in the payment contract. In this sub-form, there's generally only one payment covering a pre-defined period indicated in the contact between the PSS provider and the customer;
3. Condition-based maintenance is based on prognostic technology. These service solutions require strong involvement of the PSS provider and the collection and monitoring of product data and information. This is often combined with a pay-per-result formula, implying that the customer only pays the PSS provider if the service performance meets a pre-defined service level agreement[26].

Transactional services such as delivery, installation and returns are widespread in product-oriented business models across the Nordics. Repairs or service checks are common transactional services for most durable goods, and extended warranties and preventive or condition-based maintenance are often part of the sales contract for more expensive product groups. Take-back services are also well-known transactional services. It is, for example, utterly mainstream that a customer can sell back their car to the retailer when they purchase a new one. For other product groups, take-back services are rarer, but there are examples across product groups and the Nordic countries of companies experimenting with take-back solutions. For example, the Danish company Skagerak offers a buy-back guarantee on their furniture. Skagerak cleans and repairs the used furniture before reselling[27]. Within the fashion industry, Filippa K launched a collection program in 2015 that gave their customers store credit when bringing in pieces they no longer want[28]. However, this appears more similar to waste management schemes, e.g. EPR, than a service in terms of PSS. The solution's environmental benefits could be negligible, particularly if the take-back scheme does not guarantee proper end-of-life treatment of the product.

2.1.2 Advice and Consultancy model

In addition to the product-related services, the PSS provider may also give advice, training, and consulting services[29] pursuing efficient use of the product sold. This can include advice on the organisational structure of the team using the product, advice on proper maintenance practices, advice on extending the lifespan of a product, or advice on optimising the logistics in a factory where the product is used as a production unit[30]. Typical tasks include training for optimised product use, advice regarding product choice, and training for improving the skills and competencies needed to manage processes related to the products. As shown, the advice and consultancy model providers are often in close contact with the customer[31].

The advice and consultancy models are common, but they are seldom the primary PSS model nor the primary revenue generation mechanism in the identified Nordic cases. As the sub-forms of services related to the advice and consultancy model are one of the most common additional PSS models, it is difficult getting a clear picture of the prevalence of this model. Moreover, some tasks related to the help desk,

[25] Gaiardelli et. al (2014). A classification model for product-service offerings.
[26] Gaiardelli et. al (2014). A classification model for product-service offerings.
[27] Skagerak (n.d.): Reclassic.
[28] Filippa K (n.d.): Circularity.
[29] Gaiardelli et. al (2014). A classification model for product-service offerings.
[30] Tukker (2004): Eight Types of Product – Service System: Eight ways to sustainability? Experiences from Suspronet.
[31] Gaiardelli et. al (2014). A classification model for product-service offerings.

hotline and training services, such as advice regarding the customers' product choice, are seen as a standard business practice and are often not identified as a service by the businesses.

Product-related & Advice and Consultancy model example: Holmris B8[32]				
Holmris B8 is a furniture sales and design company which offers a wide range of product-related services. Holmris B8 can tailor solutions and furniture concepts to their clients' needs. They are specialised in Office, Learning, Care and Hospitality branches. Their range of services include delivery and assembly, cable management, storage and registration of furniture, repair and upgrades, service inspection, maintenance as well as take back solutions. Holmris B8 take back furniture to clean, repair and refurbish before reselling it. If the furniture is not suitable for resale, they will find a recipient who will take the furniture for recycling and pay shipping and handling costs. Holmris B8 is also a good example of the Advice and Consultancy model as they offer knowledge-based services such as well-documented data on the climate performance of each item of furniture, as well as advice on how to optimize floorspace through digital space management. With sensor technology they map, document, and analyse behaviour, movements patterns, user experience of air quality, temperature and indoor climate, which enable optimization.				
Product group: Furniture	Product ownership: Customer ownership	Nordic countries: DK	Targeted market: B2C, B2B & B2G	Revenue model: Sales

2.2 Use-oriented Product Service System models

With Use-oriented PSS models, the focus is on the product, but ownership of the product is not transferred to the consumer[33]. Instead of *selling* a physical product, the PSS provider rents or leases the product to the customer. The PSS provider guarantees the use or availability of a product for a certain period, for which the PSS provider is paid periodically. Since the ownership of the product is not transferred to the customer, the PSS provider holds both the risks and responsibilities of ownership[34]. We work with three categories within use-oriented PSS models:

3. Product lease
4. Product renting or sharing
5. Product pooling[35]

Use-oriented PSS solutions are pretty standard in the Nordics, with 230 cases identified across the Nordics, some of which are combined with product- and result-oriented models. Use-oriented PSS models are found in all the identified product groups and across all Nordic countries and the concepts of leasing and renting are highly normalised and standardised concepts. The terminology used to define the use-oriented PSS models is very similar to standard branding descriptions of the businesses promoting themselves, easing the identification of use-oriented PSS models significantly.

An interesting type of use-oriented PSS is deposit and refund. Growing concerns about single-use packaging are the motivation behind New Loop[36] working towards establishing a circular return system for takeaway packaging, and likewise for the company RE-ZIP[37] that has developed a deposit system for packaging for e-commerce. The deposit systems can be categorised as use-oriented because, although the ownership of the packaging is not transferred to the customers, the model builds on the presumption that the customer will bring it back after use.

[32] Holmris B8 (n.d.): The ultimate solution all in one place.
[33] Tukker (2004): Eight Types of Product – Service System: Eight ways to sustainability? Experiences from Suspronet.
[34] Reim et al. (2015): Product-Service Systems (PSS) business models and tactics – a systematic literature review.
[35] Tukker (2004): Eight Types of Product – Service System: Eight ways to sustainability? Experiences from Suspronet.
[36] New Loop (n.d.) Pantsystem til take away emballage.
[37] Re-zip (n.d.): Your sustainable choice.

Renting and leasing definitions

There are no universal definitions for the terms "rent" and "lease"; the terms are often used interchangeably and the use range varies across sectors. Both renting and leasing are contractual agreements between two parties, the lessor and the lessee, to let the lessee use an asset that the lessor has ownership of. Some differences between the concepts are outlined in the box[38]. In the long run, renting a product is often more expensive than leasing, but is also a more flexible agreement as the renting party is not bound to a fixed period[39].

Renting seems to be the preferred term for products used in the households and for textiles, while the IT sector tends to prefer the term leasing[40]. In general, the price is higher the more specialised the rented or leased product is, as it becomes more difficult to sell on the second-hand market.

Leasing – key elements

- Pre-defined commitment period, usually covering several months or years
- Often involves a buy-out option at the end of the leasing term
- Early determination of contract initiates fines
- At the lease expiration there is an option of upgrading to newer equipment
- Typically lower cost than long-term rent

Renting – key elements

- The party renting the asset is not responsible for maintenance
- In general covers a shorter time duration than leasing such as days, weeks or months

2.2.1 Product lease model

In lease agreements, the provider keeps ownership of the product and commits to responsibility for its maintenance, repair and control. The customer pays a regular fee for the use of the product and typically gains unlimited and individual access to the leased product[41].

The product lease model is the second most common use-oriented PSS model in the Nordic countries after renting and sharing and is found in all product groups (especially more expensive ones) and all Nordic countries.

The product lease model can be combined with most other PSS models but is often seen in conjunction with the product-oriented advice and consultancy model and the result-oriented functional result model.

Product lease model example: Parently[42]				
Parently is a Swedish company offering a wide range of children's products to rent or lease instead of having to buy. This use-oriented company aims to educate, inspire and be a driving force in the transition to a more circular way of family life. They provide subscription services and rental for children's things (i.e., strollers, carriers, bikes, cots). Private customers choose from multiple packages with various child-related products –and from different rental timeframes (1 day to 24 months, etc). Parently has two approaches. In some cases, ownership stays with the provider (Parently); in others, ownership stays with the brands (i.e., stroller company). All products are insured during the rental period through Parently's partner Omocom. Parently also works with brands to offer 'white-label' leasing services. These brands offer leasing services via their website, but Parently fulfils such orders.				
Product group: Children's products	Product ownership: Provider ownership	Nordic countries: SE	Targeted market: B2C	Revenue model: Renting and leasing subscriptions

2.2.2 Product renting or sharing model

The provider will often keep ownership of the product, and thereby the responsibility of maintenance, repair and control, as with Product lease models. The customer pays for the use of the product, but the customer does not get unlimited and individual access. Instead, the product in this model will be

[38] Educba (n.d.): Lease vs Rent.
[39] Jones (2016): Construction Equipment – Rent, Buy, or Lease?
[40] Glaser (2021): The Difference Between Office Equipment Rental and Leasing.
[41] Tukker (2004): Eight Types of Product – Service System: Eight ways to sustainability? Experiences from Suspronet.
[42] Parently (n.d.): Det här är Parently – pareting made easy.

sequentially used by different customers, which implies that the product might not be available at any given time[43].

The renting or sharing model is the most common PSS model in the Nordic countries, but barriers have been identified for specific product groups, such as clothing, where some businesses experience cultural difficulties.

Product renting or sharing can, in principle, be combined with most other PSS models but tend to be the primary business model. Most of the identified product renting or sharing models are seen in conjunction with the product-oriented advice and consultancy model and the result-oriented pay-per-service unit model.

Product renting model example: Beleco[44]				
Beleco is an innovative Swedish company with a pure use-oriented business model renting out office furniture to companies also for home office. Several complementary services are offered including interior design advice, delivery, carry in, assembly and pick up of furniture. The payment model is per day or per month and includes cheaper rental costs for longer binding time periods. Beleco is essentially a broker, service, and infrastructure provider since it does not buy products. The ownership of the furniture stays with the manufacturers and brands themselves who list their furniture on the website. This incentivises the creation of better products that last longer.				
Product group: Appliances, furniture, and household products	Product ownership: Provider ownership	Nordic countries: SE	Targeted market: B2C & B2B	Revenue model: Renting subscriptions

2.2.3 Product pooling model

As with the Product lease and renting models, in product pooling models, the PSS provider will often keep ownership of the product and responsibility for maintenance, repair and control. The customer pays for the use of the product, but does not get unlimited individual access. Instead, the product in this model is available *simultaneously* to all customers, so the product might not be available at any given time[45]. The Product pooling model promotes dedicated reuse of the products, as the business model entails shared access and multiple uses of a product, providing a greater product life-cycle efficiency in the use phase[46].

Although product pooling models frequently occur in the Nordic context, they are still the least common of the three use-oriented PSS models. Transportation is the main product group that utilises the product pooling model, as seen with the increasing presence of e-scooters, bikes and cars ready to use in the big cities of the Nordic countries. The product pooling model is not as prevalent in other product groups. This could be related to the extensive logistical overview needed to make the product pooling model profitable, as was also mentioned by Nordic PSS stakeholders throughout the interviews.

Product pooling model example: Omago[47]				
Omago is a Finnish mobility operator established in 2017. This SME operates currently in four cities in Finland (Espoo, Vantaa, Jyväskylä and Tampere). The company operates in both B2B, B2C and B2G interfaces and offers shared cars for citizen, tenants, companies and city employees in Finland. As in the case of many mobility PSS models, also the service model offered by Omago is use-oriented. The service can be purchased on an hourly, daily and monthly basis. Digitalization has an important role in the service, as it uses a digital platform, app, through which the cars can be rented.				
Product group:	Product ownership:	Nordic countries:	Targeted market:	Revenue model:

[43] Tukker (2004): Eight Types of Product – Service System: Eight ways to sustainability? Experiences from Suspronet.
[44] Beleco (n.d.): Hyr möbler och inred ditt kontor.
[45] Tukker (2004): Eight Types of Product – Service System: Eight ways to sustainability? Experiences from Suspronet.
[46] UNEP (2015): Using Product-Service Systems to Enhance Sustainable Public Procurement.
[47] Omago (n.d.): Huelton ja helppo tapa autoilla.

Transportation	Provider ownership	FI	B2C, B2B & B2G	Short-time rentals

2.3 Result-oriented Product Service System models

Result-oriented PSS models focus on the functional result achieved through some combination of services and products[48]. With the Result-oriented PSS models, the PSS provider agrees to deliver a particular result or outcome to the customer, and the service will often be of greater focus than the product. In some cases, no physical product is involved in the agreement between the PSS provider and the customer. Instead, the PSS provider gets paid for a result, for which the PSS provider is entirely responsible. The property rights stay with the PSS provider if a physical product is involved, and the customer only pays for the PSS provider's services when the agreed-upon result is delivered[49]. Tukker (2004) describes three categories of services, often related to Result-oriented PSS models:

6. Activity management
7. Pay per service unit model
8. Functional result model

The Result-oriented PSS models constitute the most promising models regarding the reduction of environmental impact. In theory, the result-oriented PSS has the potential to overcome all kinds of "split incentives" concerning the environment as it would be in the interest of both producer and consumer to minimise life-cycle costs, and hence the use of consumables in the use phase. However, there are some economic risks related to the Result-oriented PSS models. These models need attention concerning operationalisation since the providers' liabilities related to promised results are high, and threats of insufficient control can lead to unsatisfactory results, or high results costs[50].

Although there seems to be potential in result-oriented PSS models, there are only a handful of cases using this business model in Nordic countries. Only 50 cases have been identified, most of which are combined with product- and use-oriented models. Although the approach could be more widespread – it has been the most challenging to identify as the terminology used in PSS research is not yet normalised. Businesses using this model do not necessarily use this terminology or describe themselves in these terms.

2.3.1 Activity management or outsourcing model

Since outsourcing contracts often include performance indicators to control service quality, this model is classified as a result-oriented service[51]. During outsourcing, the PSS provider manages one or more activities on behalf of the customer. Still, the decision on how to perform and control these activities remains the responsibility of the customer[52]. Depending on the customer's preferences, a third party's control of activities will be executed, ensuring a non-biased evaluation of the PSS provider's performance. This model is widely applied in existing businesses, exemplified by outsourcing catering and office cleaning[53].

The activity management or outsourcing model is one of the more underrepresented PSS models identified in the Nordics. However, it's expected that there are a relatively large number of unidentified solutions related to this PSS model since the model often offers services with less marketing efforts than the product being managed. Activity management and outsourcing are seen as common. They are one of the primary PSS solutions in some product groups, such as IT, where cloud-based activity management and outsourcing

[48] Tukker (2004): Eight Types of Product – Service System: Eight ways to sustainability? Experiences from Suspronet.
[49] Reim et al. (2015): Product-Service Systems (PSS) business models and tactics – a systematic literature review
[50] Tukker (2004): Eight Types of Product – Service System: Eight ways to sustainability? Experiences from Suspronet.
[51] Tukker (2004): Eight Types of Product – Service System: Eight ways to sustainability? Experiences from Suspronet.
[52] Gaiardelli et. al (2014). A classification model for product-service offerings.
[53] Tukker (2004): Eight Types of Product – Service System: Eight ways to sustainability? Experiences from Suspronet.

of data security are well represented. In product groups such as Heavy and light machinery and equipment, activity management is characterised by warehouse management.

Identified cases in the Nordics indicate that activity management or outsourcing is commonly offered in conjunction with product-oriented advice and consultancy, the use-oriented product renting and product leasing models, and the result-oriented pay-per-service unit model.

Activity management or outsourcing model example: NAPS Aurinkovoimala [54]				
Naps Aurinkovoimala is an energy company established in 2017. It is jointly owned by the Naps Solar Group and seven regional energy producers. The company offers a B2B photovoltaic service. Naps Aurinkovoimala or its owner companies are responsible for investing in solar power plants, which it builds on the roof of the customer company. The customer only purchases photovoltaic energy as a Service without any initial system investment. The power plant will be transferred to the customer at the end of the contract period. The service is marketed as a way to improve the customer's energy efficiency and responsibility and as a way to reduce investment costs for the customer by replacing them with operational costs.				
Product group: Appliances, furniture, & household products	Product ownership: Changing ownerships	Nordic countries: FI	Targeted market: B2B	Revenue model: Service agreements

2.3.2 Pay-per-service unit model

The provider delivers a reasonably standard product constituting the basis of the model, but the customer no longer buys the product. Instead, the customer pays for the output of the product according to the level of use[55]. However, the responsibility and the decision-making regarding the product use remain with the customer[56]. A typical example of this result-oriented model is the 'pay-per-print' formula, adopted by most copier producers[57].

The pay-per-service unit model is, in the business cases identified in the Nordics, one of the most normalised result-oriented PSS solutions. They are, however, not very visible. The pay-per-service (e.g., pay-per-print) is rarely the only service nor the primary service of a PSS provider. PSS providers offering pay-per-service-unit often also utilise traditional sales models or rental solutions. This makes identifying useful cases difficult. It's expected that additional pay-per-service unit cases will be identified through the national workshops through mutual discussion of the PSS models.

Identified cases in the Nordics indicate that the pay-per-service unit model is commonly offered in conjunction with the use-oriented product renting and product leasing models and the result-oriented activity management or outsourcing model.

Pay per service model example: Combi works[58]				
Combi Works is a small industrial manufacturing company based in Finland, that offers both products as well as manufacturing services. The company was established in 2005. The company has developed a business model called Factory as a Service. This subcontracting solution enables flexible and scalable manufacturing by simplifying and combining manufacturing, logistics and handling of wide scopes of manufacturing for its customers. Combi Works relies on existing global manufacturing capacity and does not have its own production. The model is based on selling scalable producing services. The revenue logic is based on invoicing per manufactured item (e.g., components). Digital tools have been one of the key enablers of this model. The service model supports the circular economy by bringing underutilized production resources into more efficient use. The more efficient production also helps lowering environmental footprint.				
Product group:	Product ownership:	Nordic countries:	Targeted market:	Revenue model:

[54] NAPS Aurinkovoimala (n.d.): Pienennä yrityksesi hiilijalanjälkeä ja säästä energiakustannuksissa.
[55] Tukker (2004): Eight Types of Product – Service System: Eight ways to sustainability? Experiences from Suspronet.
[56] Gaiardelli et. al (2014). A classification model for product-service offerings.
[57] Tukker (2004): Eight Types of Product – Service System: Eight ways to sustainability? Experiences from Suspronet.
[58] Combi Works (n.d.): The industrial manufacturing company - working in machine building and infra sectors.

Machinery & tools	Customer ownership	FI	B2B	Factory as a Service

2.3.3 Functional result model

The provider delivers a result to the customer rather than a service or product. In principle, the PSS provider is entirely free as to how to deliver the potentially abstract result, e.g. a comfortable temperature[59]. The functional result is, however, always specified in the contract between customer and PSS provider. In fact, the PSS provider is concurrently the product owner, the user, and the process decision maker[60].

The functional result model is currently one of the most underrepresented result-oriented models in the PSS model overview. Due to the abstract value delivered with the functional result model, identifying and mapping such PSS solutions has been difficult. In addition, some aspects of the functioning result model overlap with other PSS models, making categorising challenging. Identified business cases that utilise the functional result model mostly do so in combination with other PSS models, such as the use-oriented product renting model or the product leasing model. Often the functional result is an addition to other services or products offered, e.g. by providing workshops and courses in outdoor living and survival and a product renting model for hiking gear[61].

Functional result model example: DFDS[62]				
DFDS has been on the freight market for more than 150 years, offering ambient and temperature-controlled transport between multiple countries in Europe through two fully integrated divisions: DFDS Seaways and DFDS Logistics. DFDS owns their own facilities and means of transportation, making it possible to offer freight transport regardless of the amount needed to be shipped. DFDS offers fully integrated supply chain services, third and fourth-party contract management, and their services are flexible, so they can be adjusted to current marked trends. Premium solutions are also offered, in the form of express transport and high security transport. DFDS aims to continuously reduce their carbon footprint according to their website. They are currently working on reducing idle time for their different means of transportation, transitioning their fleet to become more fuel efficient and biofuel-based, and transitioning to environmentally friendly cooling containers.				
Product group: Transportation	Product ownership: No product	Nordic countries: DK	Targeted market: B2B	Revenue model: Functional result agreements

[59] Tukker (2004): Eight Types of Product – Service System: Eight ways to sustainability? Experiences from Suspronet.
[60] Gaiardelli et. al (2014). A classification model for product-service offerings.
[61] Østjysk Outdoor (n.d.): kurser i friluftsliv og vandring.
[62] DFDS (n.d.): Logistikløsninger.

3 PRODUCT GROUPS IN NORDIC PSS MODELS

During the project's first two steps, 275 different cases for PSS in the Nordics have been mapped through an extensive literature study and stakeholder engagement activities and divided into business model types according to the Tukker scale's three main categories. Throughout the following chapter, the highlighted cases PSS model will be marked indicated by an icon based on the previous chapter.

Product-oriented	Use-oriented	Result-oriented
The product is sold traditionally and some after-sale services may be included to guarantee functionality and durability of the product.	The producers maintain the ownership of the product, and the use, function or availability of the product is sold, e.g. renting/leasing, sharing.	The producers sell the capability or the result that the customers want instead of the product. The customers are charged for the provision of the agreed results, the ownership still remains with the producers.

The following product group clusters have been assessed to have the most significant potential for replication across the Nordic Region, considering material consumption, market size, innovation, Nordic distribution, social impact, and environmental impact. This has been done through consolidation with Nordic market actors and scientists specialising in PSS and circular economy.

The following section will describe all eight product group clusters, including the entailed product types. Each product group cluster section will be initiated will an overall picture of the Nordic conditions of the sector.

3.1 Transportation

Transportation plays an essential role in society and the economy, affecting efficiency and accessibility, all while being the key source of environmental pressure, responsible for approximately 25% of all global greenhouse gas (GHG) emissions[63] and consuming one-third of all final energy in the European Union. Besides contributing to climate change, air pollution and noise, transportation takes up large strips of land, contributing to the fragmentation of habitats and urban sprawl[64]. Current tendencies in the global transportation market revolve around privatisation, income diversification, utilising public-private

[63] Salvucci et al. (2019): Energy Scenario Analysis in the Nordic Transport Sector: A Critical Review.
[64] EEA (2020): Transport.

partnership mechanisms, infrastructure, and agglomerated approaches to business model formation[65]. Mobility as a Service has gained more focus[66,67], indicating that PSS solutions in transportation have a window of opportunity to achieve stability in the market.

3.1.1 Nordic conditions

Transforming transportation is a crucial energy challenge in the Nordic region to achieve the climate targets set by the Nordic governments[68]. The transportation sector represents a significant source of GHG emissions in the Nordic region, accounting for almost 40% of total CO_2 emissions. At the same time, each of the Nordic countries is considered a pioneer in deploying sustainable energy technologies relevant to the transportation sector, with some of the Nordic capitals considered global leaders in sustainable urban transportation (e.g. Copenhagen's bike lanes, Oslo's electromobility and Stockholm's public transportation)[69]. In 2019, Finland, Sweden, Denmark, and Iceland signed a declaration to collectively work toward carbon neutrality, further increasing the attention on decarbonising the transportation sector in the Nordics[70].

Path-creation policies are predominant in the Nordic policy mixes on transportation. Policies focusing on transportation in the Nordics often rely on creating new policy pathways for mobility, but transport regime sustaining policies are also standard due to public and market pressure. Therefore, Nordic policy actions for mobility are developed in a push-pull environment, resulting in, at times, internal paradoxes in mobility-related actions[71]. The Nordic region can become a frontrunner in solving climate challenges related to the transportation sector. Still, the deployment rate of low-carbon technologies and fuels needs to be accelerated for this to be achieved. Improved policy measures are essential to decarbonise areas such as freight transportation in the Nordics[72].

The Nordic countries have explored several transport innovations and are currently regarded as international pioneers in areas such as electric vehicles, electrified roads, and Mobility as a Service model. A transnational study on sustainable future transportation in the Nordics concluded that attention should be given to ways in which key innovations can be commercialised and deployed and that there is a need to increase the understanding of the role of new business model innovation in supporting transport innovation[73]. Despite some successes, the overall picture indicates many ongoing opportunities, with initiatives often being superficial, for example, not extending beyond the coordinated provision of information. There is also evidence of weak coordination and duplication of effort, for instance, between public transport authorities (local, municipal, regional). At the last-mile level, the emergence of e-scooters has probably been the most visible move in the personal mobility market over the past few years. However, the steep upward trend in e-scooter use has stalled somewhat due to increasing safety and nuisance concerns.

The need for sustainable mobility solutions is continually on the rise. PSS solutions can integrate sustainable principles in the use and design phase of passenger transportation[74], as well as new opportunities in the logistic management and supply chain configurations[75], as seen with the Nordic freight transport consisting almost solely of PSS solutions. This is, however, not the default for the PSS solutions, and the sustainability is highly dependent on the approach utilised by the provider. The following section

[65] Vinichenko (2021): Critical Tendencies in the Transport Industry and Factors that Determine them.
[66] Wolters Kluwer (2021): 2021 transportation industry trends to help grow your business.
[67] Alexiou (2021): 'Mobility As A Service' Concept Promises To Revolutionize Transport Accessibility.
[68] Hansson et al. (2019): Sustainable Horizons in Future Transport – with a Nordic focus.
[69] Salvucci et al. (2019): Energy Scenario Analysis in the Nordic Transport Sector: A Critical Review.
[70] Mordor Intelligence (2021a): Nordic bike sharing market – Growth, trends, COVID-19 impact and forecasts (2022-2027).
[71] Kotilainen et al. (2019): From path dependence to policy mixes for the Nordic electric mobility: Lessons for accelerating future transport transitions.
[72] Hansson et al. (2019): Sustainable Horizons in Future Transport – with a Nordic focus.
[73] Hansson et al. (2019): Sustainable Horizons in future Transport – with a Nordic Focus.
[74] Beella et al. (2010): Product Service Systems and Sustainable Mobility: An electric vehicle introduction case.
[75] Pan (2019): Opportunities of Product-Service System in Physical Internet.

will give more detailed insights into existing PSS solutions for transportation within the product types: Bicycles, cars, scooters, and boats.

3.1.2 Bicycles

Cycling is one of the Nordic countries best solutions for greener urban transport. PSS solutions for bicycles have been introduced in more than 700 cities globally[76]. They are widely recognised as a way of reducing car use and fuel consumption, promoting green travel and improving traffic efficiency. Indirect effects of sharing solutions for bicycles include improvement of societal mobility equality, health benefits and economic growth potential. However, if the distribution of PSS solutions for bikes is unstructured, it can also aggravate resource consumption. Some studies highlight how PSS solutions for bicycles have resulted in massive investments, unreasonable distribution of bicycles, and significant disruption and stress to urban governance, due to "bicycle cemeteries" and immature technologies for recycling the waste from these cemeteries[77]. Bicycle cemeteries have become a common phenomenon following the implementation of PSS solutions, indicating socio-environmental challenges, which could result from the users not having ownership and thus not feeling responsible for the bicycles.

Most Nordic countries have well-implemented urban bicycle infrastructure, reaching almost all age groups. In the Nordic region, use-oriented models for bicycle-sharing are predominant. The market is fragmented, with several regional players active in each country. To provide a more convenient experience for commuters, major bicycle-rental service providers are expanding their market reach and adding more advanced features to their bicycle fleets[78]. Some PSS providers offer short-term rental services, as seen in the tourism industry. In contrast, others provide leasing services which often include some type of maintenance of the bicycles and insurance in case of theft.

Renting- and leasing models for electric bicycles are also becoming more regular, enabling access to more expensive high-quality products for the average consumer. This enables PSS providers to compete with car ownership and services in urban areas due to the convenience and economic savings related to parking and fuel. To what extent the bikes substitute travel by car varies, as shown by a comparative study of the reductions of pooling models for e-bicycles in Melbourne, Minneapolis, Washington D.C., and London, where the utilisation of motor vehicles and the distance reduced were assessed. The study showed vast reductions in car kilometres (90.000, 243.291, and 632.841, respectively). However, in London, the study further detected an increase in the use of motorised operation vehicles by 766,341 kilometres, indicating that external factors, such as the infrastructure available and people's behaviour, have a significant impact on whether the pooling model for e-bicycles can be counted as a sustainable alternative to travel by private car[79].

Liisabike	**PSS model:**
Liisabike offers a leasing service of electric urban cargo bikes through a subscription service. The motivation behind the PSS solution was to enable more commuters to utilise electrified cargo bikes in Copenhagen since many customers were struggling to pay the price of a new cargo bike. Liisabikes' PSS solution includes maintenance and repair of the bikes and an option for insurance through the company. Ownership of the cargo bikes stays with Liisabike. However, they offer their customers the opportunity to buy the bikes at a reduced price when they are no longer in sufficient condition for further leasing. Liisabike has collaborated with PowUnity to develop an IoT solution to track bicycles, to counteract theft.	

Potential benefits of PSS solution:	Countries:	Market:	Size:
Currently Liisabike has 375 cargo bikes on the streets of Copenhagen. By providing the users with repair and maintenance as well as their important anti-theft protection the solution can	DK	B2C	SME

[76] EC (2014): Science for Environment Policy – Bike share programmes reduce car use in cities, but benefits are less strong in London.
[77] Jie et al. (2020): A sustainability-oriented optimal allocation strategy of sharing bicycles: Evidence from ofo usage in Shanghai.
[78] Mordor Intelligence (2021a): Nordic bike sharing market – Growth, trends, COVID-19 impact, and forecasts (2022-2027).
[79] Fishman et al. (2014): Bike share's impact on car use: Evidence from the United States, Great Britain, and Australia.

incite users to lease a cargo bike instead of a car – particularly in dense cities. Liisabike has calculated this CO_2 saving to a reduction of 115,380 kg CO_2 from the cargo bikes in use as an alternative to cars.			

3.1.3 Cars

The Nordic countries have, in recent years, detected a decline in sales of new cars. Iceland, Sweden, Finland, and Denmark have seen decreases of 22%-11%, whereas Norway recorded a drop of only 2% in 2019-2020. All numbers are lower than the EU average fall of registered passenger cars by 23.7%[80]. The consumption decrease has likely been affected by lockdowns associated with the COVID-19 pandemic.

The Nordic countries have different levels of integration of PSS car solutions; however, most countries have significant challenges. Mobility as a Service development requires effective collaboration between public and private actors due to infrastructural planning and data sharing agreements[81]. Use-oriented PSS models are predominant in the Nordics, with car-pooling as the most common product service provided. All identified PSS car solutions utilising an application for smartphones as an access point, providing their customers with easy accessibility.

Pay-as-you-go services are common, often combined with an option for subscription or pre-paid minutes packages providing reduced customer costs. Most of the Nordic PSS solutions are oriented toward the B2C and B2B markets; however, some have the option of special agreements for the B2G market. The PSS car solutions are primarily available in the larger cities in the Nordics, making the solutions very urban-centred. However, many providers are expanding their reach gradually. With the urban-centred approach and parking zone restricted to primarily urban areas, the PSS car-pooling solutions mainly reduce short-ranged car transportation. Thereby, current car-pooling solutions reduce urban car ownership and not necessarily the number of kilometres driven. The same cannot be said for car leasing or renting solutions.

Whether PSS solutions for cars impose significant environmental impact reductions, e.g. by reducing the number of cars overall, has been questioned[82]. A challenge with carpooling solutions is the number of vehicles required to provide efficient services, as significant improvements in resource efficiency can only be achieved by significant changes in consumption patterns[83]. As most customers expect a specific availability of the services, PSS providers might contribute to a slight increase in consumption of cars, especially if private consumption patterns are unchanged and most consumers still own a car at home. With carpooling solutions utilising electric vehicles, a positive impact on the transition of the infrastructure of charging stations is also present. Companies providing the PSS services create an incentive for expanding the availability of charging stations and parking saved for shared- and electric cars[84]. Product leasing models for a car might even contribute to greater consumption, making the frequent exchange of vehicles more accessible. This way, the PSS solutions could even contribute to higher waste production, depending on the lifecycle perspective in the PSS model. Recent studies even indicate that the additional greenhouse gas emissions resulting by a shift from both privately owned vehicles and public transport to car sharing schemes outweigh the greenhouse gas reduction as a result of unpurchased or unproduced vehicles. Electric vehicles did, however, show greater potential than gasoline or diesel-fuelled vehicles[85].

One of the most significant challenges with PSS solutions for cars is the risk of replacing public transport, which to some extent is electrified in the Nordics. Such replacement would not only be less sustainable, but over time this could even result in public transportation systems becoming less economically viable. In the worst case, a broad and successful implementation of PSS solutions for cars could collapse well-established public transport systems, leading to increased mobility inequality. The PSS solution can, on the

[80] Refsgaard et al. (2020): Change in new registered cars 2019-2020.
[81] The Swedish Energy Agency (2019): Mobility as a Service – experiences from the Nordic countries.
[82] E.g.: Ceschin & Vezzoli (2010); Kuntzky et al. (2013); Teles et al. (2018); Williams (2007).
[83] Williams (2007): Product service systems in the automobile industry: contribution to system innovation?
[84] Jung & Koo (2018): Anlyzing the Effects of Car Sharing Services on the Reduction of Greenhouse Gas (GHG) Emissions.
[85] Jung & Koo (2018): Anlyzing the Effects of Car Sharing Services on the Reduction of Greenhouse Gas (GHG) Emissions.

other hand, also increase mobility equality, as consumers who cannot afford a car have greater access to one due to the PSS.

M[86]	**PSS model:**
Established in 2018, M is a spin-off company of Volvo that offers smart car sharing according to a user-oriented business model. M aims to provide free movement in a meaningful and environmentally improving way. B2C and B2B customers can search, book, and pay for the car service via the M smartphone application. The B2C model has two payment methods: pay-as-you-go and subscription model. The carpool is available in hundreds of stations in major cities in Sweden. For B2C, the package offers depend on the monthly hours of driving and, for the B2B market, on the organisation's size. The packages include fuel, congestion tax and insurance, and 24/7 support.	

Potential benefits of PSS solution:	Countries:	Market:	Size:
M has documented its environmental performance in a sustainability report by Capgemini. Highlights include the reduction of cars in the streets, which has provided more public space, CO_2 reduction, and participation in UN-approved golden standard carbon offsetting projects.	SE	B2C & B2B	LE

3.1.4 Scooters

E-scooters have become increasingly predominant in Nordic urban areas as a B2C last-mile solution in recent years. While PSS models for electric scooters have been recognised as a needed last-mile solution, the fast appearance on the streets of the Nordic cities resulted in an overrun of the urban infrastructures and a lack of regulation until bans and limits were implemented. Several issues have been discussed regarding this newly established PSS scooter model. Many residents in the urban areas find the large number of scooters parked everywhere a nuisance, restricting the mobility of pedestrians and cyclists[87].

In the last years, the PSS solutions for e-scooters are even considered a danger for the public in the Nordics due to many injuries and one account of death in Sweden[88]. The risks associated with the PSS solutions for e-scooters have resulted in multiple regulatory interventions in the Nordics. Doctors at Helsinki University Hospital called for a ban on using electric scooters in the city on weekend nights since the e-scooters are overrepresented in accident statistics in the Helsinki and Uusimaa hospital district. A prohibition on weekend nights was recommended since 80% of electric scooter-related accidents happened at night, and the patients were intoxicated[89]. In Oslo, a ban has been put on rental solutions between 23:00-05:00, and a limit has been set on the number of e-scooters available[90]. In Stockholm, councillors have voted to cut the number of e-scooters in half, allowing only three operators to provide their product service with a cap of 4000 devices each[91]. In Copenhagen, a complete ban on e-scooters was implemented in 2020 but later overturned and replaced with a limit of 800 scooters per provider[92]. PSS providers with electric scooter solutions, such as Tier, have supported limitations and regulations of the market and call for tenders to enable parking infrastructure and accessibility, as seen in Paris, London, and New York[93].

The environmental impact of e-scooters has also been widely debated, as they are advertised as a green alternative to other urban transportation options[94]. Even though e-scooters are emission-free at the point of use, the production, collection and charging of the scooters dominate the scooters' environmental impact[95]. Thus, the environmental impact of the PSS models for e-scooters is highly dependent on the energy source of the operational vehicles picking up e-scooters, the lifespan of the e-scooters and what

[86] M (n.d.): Cars in your back pocket
[87] Meaker (2021): E-scooters are everywhere in Europe. So are grisly accidents.
[88] Ibid.
[89] YLE (2021): Most Helsinki e-scooter injuries at night and while drunk; doctors call for weekend night-time ban.
[90] Modijefsky (2021): Oslo adopts restrictions on e-scooters.
[91] Dodds (2021a): Stockholm councillors vote to cut the e-scooter number by half.
[92] Dodds (2021b): Copenhagen overturns ban on e-scooters, shared fleets to relaunch.
[93] Dodds (2021a): Stockholm councillors vote to cut e-scooter number by half.
[94] Tier (n.d.): Change mobility for good.
[95] Perry (2020): Why we have a love-hate relationship with electric scooters.

mode of transport they replace. According to an LCA study from 2019[96], the manufacturing of e-scooters represents about 50% of the scooters' total greenhouse gas emissions, mainly due to the materials used in the production, such as aluminium and raw materials for batteries[97]. The user phase emits about 47% of the total impact, mainly due to the collection of the e-scooters in fossil-driven vehicles, charging and short lifespan of shared scooters, in some cases due to vandalism[98].

A 2019 North Carolina State University study suggests that e-scooters produce more emissions per passenger mile than standard buses, e-bicycles, and regular bicycles. The e-scooters are, however, a more sustainable alternative to a short car trip. Data from French cities shows that e-scooters typically replace walking or public transport (in total 74% of the uses), while they seldom replace the use of a personal car, car shares or taxis (only 8% of the uses)[99].

However, other studies still see e-scooters as a less polluting alternative to other urban transportation options, including public transport[100]. If the collection, charging and lifespan of scooters are optimised, they can reduce emissions if they replace personal car travel[101]. However, e-scooters also replace walking, cycling, and public transport, where reduction of greenhouse gas emissions is not likely. The environmental benefits of e-scooters can thus be further discussed, even though the scooters are emission-free at the point of use.

Joe Scooter[102]		**PSS model:**	
JOE Scooter is a Finnish micromobility start-up. The company offers shared, e-scooters in 12 Finnish small to medium size cities (Hämeenlinna, Imatra, Kalajoki, Kotka, Kouvola, Lappeenranta, Mikkeli, Pori, Rauma, Rovaniemi, Savonlinna, Seinäjoki). Their service model is use-oriented, meaning that the users pay per minute of use. The shared, free-floating e-scooters are rented through an app.			
Potential benefits of PSS solution: Most of their e-scooters were previously used by another shared e-scooter operator. JOE Scooter refurbishes these end-of-life e-scooters in Finland, thus improving resource efficiency and reducing waste. Furthermore, the e-scooters contribute to fossil-free mobility.	Countries: FI	Market: B2C	Size: SME

3.1.5 Boats

All the Nordic countries are either islands, coastal states, or both. Therefore, the Nordic countries are very dependent on maritime transportation, regarding the transportation of passengers, imports and exports of goods, and commodities[103]. Maritime PSS solutions are very diverse, from leisure trips to personal transport of infrastructural importance, reflecting the general maritime character of the Nordic countries. While transportation by boat has been provided as a service for centuries in the Nordics, day trips on small boats for celebration or enjoyment for the B2C and B2B markets are appearing in the Nordic harbours and canals. These types of PSS solutions are mostly use-oriented models and are predominantly found to be rental or pooling solutions. Sometimes, a membership is needed to access the rental or pooling solutions.

Regarding the environmental impact of PSS solutions providing boat trips for enjoyment, the question of whether the PSS solutions actually replace any production and purchases of boats arises as with the other transportation models. The PSS solutions for boat trips for leisure could add to the consumption of materials and energy since the boat trips become available to a broader consumer group that would

[96] Hollingsworth et al. (2019): Are e-scooters polluters? The environmental impacts of shared dockless electric scooters.
[97] Moreau et a. (2020): Dockless E-Scooter: A Green Solution for Mobility? Comparative Case Study between Dockless E-Scooters, Displaced Transport, and Personal E-Scooters.
[98] Hollingsworth et al. (2019): Are e-scooters polluters? The environmental impacts of shared dockless electric scooters.
[99] Perry (2020): Why we have a love-hate relationship with electric scooters.
[100] Severingiz et al. (2020). Assessing the Environmental Impact of Novel Mobility Services using Shared Electric Scooters as an Example.
[101] Hollingsworth et al. (2019): Are e-scooters polluters? The environmental impacts of shared dockless electric scooters.
[102] Joe (n.d.): Enjoe the ride.
[103] Placek (2022): Maritime ports in the Nordic region – statistics & facts.

otherwise not have the means to access a boat. While this provides more equality in consumption patterns, the overall material and fuel consumption could increase. On the other hand, the boats produced are more likely to have a greater utilisation with PSS business models, with more significant value creation. Depending on the PSS provider's approach to the acquisition of the boats, the design phase and maintenance and energy source of the boats, environmentally sound solutions can be provided for "enjoyment" boating. Still, the opposite can be just as likely.

GoBoat[104]	**PSS model:**
GoBoat offers a rental solution of small boats for birthday celebrations, family outings, joyful times with friends, or an alternative way to experience the many outdoor concerts and events in multiple Danish harbours. Different PSS solutions are offered by GoBoat –for instance, rent-by-the-hour solutions and three types of membership providing reduced prices. The membership entails some extra advantages, such as pre-sales on events, free catering baskets, and exclusive access to night sailing.	

Potential benefits of PSS solution:	Countries:	Market:	Size:
GoBoats aims to limit their environmental footprint, according to their website. Therefore all boats are powered by solar cells on the boats. Their pavilion, docks, and tables are made from sustainably sourced wood, and only organic snacks and drinks are available through GoBoat. Additionally, GoBoat has created the concept Garbage Pirate, which equips children with a fishing net they can use to fish garbage out of the water. As a thank you for their efforts, they get a liquorice treat when they return on land[105].	DK	B2C & B2B	SME

3.1.6 Mobility as a Service (MaaS)

Mobility as a Service (Maas) is a relatively recent concept in mobility, and it has gained increasing interest in the Nordics. The model is based on the integration of different modes of public and private transport and transport-related services to offer on-demand mobility. The transport modes can entail, for example, public transport, active modes like walking and cycling, car-, bicycle-, and e-scooter-sharing schemes, and taxis. In general, these PSS models rely on existing urban mobility services. MaaS solutions are also highly dependent on digital platforms through which the customers can plan, book, and pay for their trips and get real-time information regarding the journey[106]. There are different types of MaaS depending on the level of service integration. In the most integrated type of MaaS, the entire service is offered by bundling mobility services to provide a seamless trip. As an example of a lower level of service - just booking and payments for single trips are included.

MaaS is often seen as an innovation that could reduce the use of fossil fuel-based transportation. However, the evidence on positive environmental impacts is still controversial, and the effects depend on which transport modes are being replaced and with what[107]. MaaS primarily offers greater convenience for consumers and could actually have a negative environmental impact by encouraging consumers to use a vehicle instead of walking.

Whim[108]	**PSS model:**
MaaS Global is a Finnish mobility start-up established in 2015. The company offers mobility as a Service through its Whim service. A customer can use various modes of mobility, including public transportation and shared mobility, such as carsharing, ridesharing, bike-sharing and micro-mobility, like e-scooters, by purchasing a season or serial ticket through the Whim app. In this result-oriented model, the MaaS operator acts as a broker/service aggregator, while the product ownership stays with individual transport service provider. Besides two cities in Finland (Helsinki and Turku), the service is available in Belgium, Austria, Switzerland, Japan, and the UK.	

[104] GoBoat (n.d.): GoBoat-Ånden.
[105] Bernsen (2021): Sustainability on land, at sea, and in the air: Companies incorporate climate friendly solutions in their businesses.
[106] Jittrapirom et al. (2017): Mobility as a Service: A Critical Review of Definitions, Assessment of Schemes, and Key Challenges.
[107] Jang et al. (2021): Does MaaS contribute to sustainable transportation? A mode choice perspective.
[108] Whim (n.d.): We offer freedom of mobility.

Potential benefits of PSS solution:	Countries:	Market:	Size:
The company aims to reduce dependency on private cars, thereby reducing CO_2 emissions. Furthermore, with this model, the company seeks to have a positive impact on health and wellbeing by making active transport, i.e., walking and cycling, combined with public transport, more attractive for consumers.	FI	B2C	SME

3.2 Packaging

Recently, the focus on overcoming environmental issues concerning packaging waste has increased, especially in single-use plastic packaging. In March 2020, the European Commission published the new Circular Economy Action Plan, with initiatives along the entire life cycle of products, targeting their design, promoting circular economy processes, fostering sustainable consumption, and aiming to ensure that the resources used are kept in the EU economy for as long as possible. One of the objectives of the new action plan is to reduce plastic packaging waste and plastic litter and to implement the Directive on single-use plastics[109] aiming to minimise the negative impacts on the environment of certain plastic products with a limited lifespan.

3.2.1 Nordic conditions

Packaging is ubiquitous in our day-to-day lives. It has many functions, from protecting products to minimising food waste. However, the widespread use of packaging has resulted in heavy environmental impacts[110]. Steadily increasing packaging volumes, especially single-use plastic packaging, have led to serious problems, particularly the plastic packaging's impacts on marine environments.

The Nordic countries' most common approach to dealing with packaging waste is separate collection and recycling, but the many different packaging types complicate citizens' household sorting. In Denmark, a voluntary pictogram system for waste, including plastic fractions, was developed in 2016 with uniform colouring, terminology, and symbols. Now 90% of Danish municipalities use pictograms in recycling centres, recycling stations and residential areas. The pictograms are also being implemented in Finland, Norway, and Sweden, creating a uniform waste communication throughout the Nordics[111].

Finland, Iceland, Norway, and Denmark have packaging taxes or deposit refund systems in place in some form, primarily focusing on beverage packaging. Recycling of all packaging in the Nordics variate depending on the country. The registered recycling rate is relatively high in Finland and Denmark, lower in the other Nordic countries[112].

The consumption of disposable packaging from food consumption is growing because of lifestyle changes, where convenient meal solutions and takeaways are part of the experience economy. With increasing e-commerce and consumption of takeaway, packaging consumption is expected to continue to rise.

The growing consumption of packaging causes environmental impacts and inefficient use of resources. Single-use services, e.g. cups and food boxes, are among the most common plastic items in nature. They are used on the go and are often in lightweight materials that easily blow away[113]. When companies choose the packaging solution for their products, a unique design is often in higher demand than recyclability or reusability[114]. However, much packaging can be reused, and more and more providers use PSS models to facilitate packaging reuse and to face future EPR regulations.

[109] EP (2019): Directive (EU) 2019/904 of the European Parliament and the Council of 5 June 2019 on reduction of the impact of certain plastic products on the environment.
[110] Berg et al. (2020): The drive toward sustainability in packaging – beyond the quick wins.
[111] Siebert (2021): Labelling of packaging in Scandinavia.
[112] Eurostat (2022): Recycling rate of packaging waste by type of packaging.
[113] Oceana (2021): Engangsplast og emballage: Hvordan udvidet producentansvar kan mindske plastikforurening.
[114] Mouritsen et al. (2021): Fra engangsemballage til genbrug.

The beverage packaging system is so well established in many Nordic countries that this type of PSS solution will not be included in this overview that focus on plastic packaging, web shop packaging, and freight packaging.

3.2.2 Plastic and single-use packaging

The need to reduce our vast plastic use is evident today – in particular, single-use plastic has gained focus in recent years. Ellen MacArthur Foundation's extensive study on the potential of reusing plastic packaging shows that replacing just 20% of single-use plastic packaging with reusable alternatives offers an opportunity worth at least USD 10 billion[115]. PSS solutions could be one way of reducing single-use plastic packaging, providing convenient services for the customer and reducing material use for the providers.

Multiple PSS solutions for plastic and single-use packaging are forming in the Nordics, and product-, use- and result-oriented solutions are all represented. In Finland and Denmark, deposit schemes on takeaway food packaging are available for consumers. Reusing packaging is a common theme among the providers offering PSS solutions for packaging, aiming at reducing the waste production. The PSS providers most commonly offer their product services to the B2C and B2B market; some focus on engaging private consumers in the reuse process, and others focus on manufacturing and distributing reusable packaging to businesses. To ensure that the consumers are incentivised to reuse in the B2C market, digital-coins-for-return concepts have been created for some PSS solutions, which can be used to redeem new packaging. In the B2B market, the incentive for businesses is mostly branding-oriented. Therefore, PSS providers cooperate closely with their B2B customers to develop and distribute solutions.

As most identified PSS solutions for plastic and packaging are based on circular principles, the product-services offer reductions in production, consumption, and waste. The schemes create consumer awareness, and most PSS models identified are similar to EPR schemes. There are some cultural lock-ins related to the convenience of disposable packaging since the inconvenience of reuse and recycling by consumers is still a challenge to overcome.

Påfyll[116]	**PSS model:**		
Påfyll is a new reusable packaging concept for home and personal care products established by Orkla, a large consumer goods conglomerate in Norway. Whilst the operator is a large-scale enterprise; the concept presently operates at pilot scale encompassing a small fraction of their total market. In this use-oriented PSS, the consumer borrows the (plastic) packaging in which the product is delivered to their home to return the packaging for collection, cleaning, refilling and reuse. The concept is a full-service solution, including doorstep delivery of products and collection of the used packaging. It is established as part of a circular shopping platform with online ordering and account management via app/website, with the potential for data-driven smart semi-automated reordering. A basic proof of concept and a more detailed environmental impact study (details confidential) have demonstrated a clear environmental advantage over traditional one-way packaging alternatives.			
Potential benefits of PSS solution: Reduce consumption of plastic through the reuse of plastic packaging.	Countries: NO	Market: B2C	Size: LE

3.2.3 E-commerce packaging

E-commerce is taking a more and more prominent spot in the retail market, resulting in a stable market for e-commerce packaging. This was further strengthened during the COVID-19 pandemic, where the retail e-commerce packaging market saw a significant boost, and forecasts predict that e-commerce will continue increasing and various boxes will dominate the market in the coming years[117]. Studies show that customers trust green companies that support closed-loop value chains. This trust makes it possible to

[115] EMF (2020): Reuse – Rethinking packaging.
[116] Påfyll (n.d.): Produktene du trenger i beholdere som varer
[117] ResearchandMarkets (2021): Global Retail e-Commerce Packaging Market Report 2021: Innovation by Packaging Manufactures to Make Packaging Attractive and Protean.

ensure the return and further reuse or recycling of retrieved items, indicating that the market is ready for PSS solutions relying on collaboration between manufacturers and providers of PSS packaging solutions[118].

Nordic PSS solutions can be found aiming at both the B2C and B2B markets, with an incentive structure like those described in section 3.2.2. (Plastic and single-use packaging). For the B2C market, convenience is perceived as one of the most critical enablers for reusable e-commerce packing. Therefore, some PSS providers collaborate with national postal services, enabling private consumers to resend packaging free of charge. The primary incentive for the B2B market is often reduced costs and environmental branding. As with PSS solutions for plastic and packaging, most identified PSS solutions for e-commerce are based on circular principles. Some of the identified PSS providers have made agreements with local postal services, enabling easy and convenient return systems for e-commerce packaging. However, whether or not these services provide enough benefits to compensate for the extra transportation through postal services is still unclear.

Repack[119]	**PSS model:**
RePack is an SME offering reusable and returnable transport packaging for online retailers with both product- and use-oriented models. The services are targeted particularly to B2B customers, with some B2C elements. Currently, the company offers three types of packaging services: 1) RePack for e-commerce, 2) RePack for re-commerce, and 3) RePack for closed loop. In the e-commerce service, the retailers pay a cycle fee, which covers reusable plastic packaging (a pouch) and cleaning the packaging after use. The consumers can return the packaging, free of charge, via postal service to RePack, which inspects and cleans the packaging before the next use cycle. As a reward for returning the packaging, consumers get a discount for their next purchase and access to RePack platform, where all participating online stores are listed. In the re-commerce service, the customer rents the RePack bags for a monthly fee, exchanges the parcels within the re-commerce operations and is responsible for controlling shipments, reverse logistics and cleaning. The role of RePack is to ensure that the customer has a sufficient amount of packaging for their needs. The closed loop service is similar to the re-commerce service but is intended for each customer company's internal shipments.	

Potential benefits of PSS solution:	Countries:	Market:	Size:
The environmental value proposition of the company targets the reduction of packaging waste related to single-use transport packaging.	FI	B2C & B2B	SME

3.2.4 Freight packaging

Freight packaging plays a vital role in securing goods during transport, providing protection from shocks, compression and climate conditions. In the Nordic region, freight transport is dominated by trucks and ships in almost equal market shares, while freight transported by planes and railroads is less frequent. PSS solutions can offer better utilisation of the packaging used during transportation[120]. Because of their high durability, some types of freight packaging are suitable for reuse, such as pallets, crates, and boxes. PSS solutions for such products are primarily relevant for the B2B market shipping their products.

Svenska Retursystem[121]	**PSS model:**
Svenska Retursystem is a medium-sized company developing and operating an efficient, reusable system that simplifies and improves customers' logistics and distribution of goods in the food and drinks industry. This user-oriented model includes four phases: 1. After placing the order via an SRS customer interface, the company delivers reusable crates and pallets to the producer. Then the reusable units are filled and delivered to the wholesaler; 2. The wholesaler delivers to the retailer; 3. The retailer empties the crates and pallets of their goods and returns them to the wholesaler; 4. Svenska Retursystem brings back reusable crates and pallets for quality control and	

[118] Yanchuk et al. (2020): Integration of Delivery Service Business Cases for improvement of Business and Environmental sustainability of E-Commerce Solutions.
[119] Repak (n.d.): Gentle on the planet. Tough on waste.
[120] Hansson et al. (2019): Sustainable Horizons in Future Transport – with a Nordic focus.
[121] Svenska Retursystem (n.d.): The reuseable system that simplifies and improves sustainability throughout the supply chain of FMCGs.

washing. After that, they are ready to be used again. The financial model includes a user fee and daily rent for pallets and a user fee and deposit for crates. The environmental performance is measured in terms of reduction of CO_2, waste reduction, replacement of disposable packaging, and increased durability of the crates.			
Potential benefits of PSS solution: The company's value proposition aims to make its customers' supply chain effective and environmentally sustainable. The pledged environmental benefits include the following: lower CO_2 emissions, transport optimisation, reduced food waste, reduced amount of chemicals, better work environment due to less waste handling and use of renewable energy for electricity	Countries: SE	Market: B2B	Size: SME

3.3 Machinery & tools

In Europe, over 17,000 equipment rental companies provide a wide range of construction and industrial equipment for customers, primarily in Europe and North America[122]. The rental of equipment is dominated by the construction industry[123]. In recent years, there has been a growing focus on the fact that equipment rental can offer both financial flexibility and circular model saving resources and CO_2. The European Rental Association (ERA) is putting much effort into communicating the potential for sustainable development with equipment rental and has, for instance, developed an Equipment CO_2 Calculator that can easily be used through their website to evaluate a single ownership period of one piece of equipment and, thus, to determine the climate impact of entire fleets of equipment or the total carbon footprint of all machines on a given job site[124].

3.3.1 Nordic conditions

Construction accounts for a considerable proportion of economic activity in the Nordic region[125], requiring machinery and tools. Repairs are often the most significant component of machinery costs, constituting around 37% of machine costs over its service life. This means that between 15% and 20% of the total equipment budget usually consists of labour for repair and repair part costs[126]. A circular economy often accentuates paths for resource-efficient growth and functions as a driver for business development in the Nordic region. Political trends among policymakers, new rules and regulations can most likely not stand alone, as there is a need for substantial economic incentives for construction companies to change existing business approaches, such as financial savings of maintenance and repair[127].

The construction industry dominates equipment rental, and in the Nordic rental sector, the share of rental revenues coming from the construction sector is approximately 70 %[128]. The equipment rental industry in the Nordic countries had been experiencing growth in recent years up until the Covid pandemic. The industry was growing more quickly than GDP and the construction industry, implying expansion of the rental penetration[129]. Operators in this area expect an increasing proportion of their business volume to derive from services rather than goods[130]. The outbreak of the Covid pandemic has had a relatively mild impact on rental activities in the Nordic countries compared to other parts of Europe since almost no construction sites have been shut down. Even though the markets in the Nordic countries are estimated to experience some long-term effects of the Covid pandemic, the rental market for equipment and

[122] ERA (2021): Discover Rental Guide.
[123] ERA (2020): ERA Market Report – ERA Equipment rental industry report.
[124] ERA (n.d.): Sustainability.
[125] Luoma et al. (2021): Low-Carbon Circular Transition in the Nordics.
[126] Yip et al. (2013): Predicting the maintenance cost of construction equipment: Comparison between general regression neural network and Box-Jenkins time series models.
[127] Høibye & Sand (2018): Circular economy in the Nordic construction sector.
[128] ERA (2020): ERA Market Report – ERA Equipment rental industry report.
[129] ERA (2020): ERA Market Report – ERA Equipment rental industry report.
[130] Sharefox (2020): Circular Economy.

machinery is expected to continue to grow[131]. Further cost or material use reductions can be found in proper maintenance since fuel efficiency with lower emissions in operations can be provided by keeping equipment in good condition[132]. The repair and maintenance cost creates good prerequisites for product-oriented and use-oriented PSS solutions, offering both convenience and repair cost reductions through ownership models. Another benefit of PSS solutions for machinery and tools is enabling access to greener, more expensive options by making the products more economically attractive and affordable compared to purchasing the products. Further, PSS solutions lower the risks often associated with new technology, supporting the implementation of best available technology[133].

Machinery and tools are utilised in most manufacturing industries in the Nordics. Heavy machinery has the most significant environmental impact during the use phase and is significantly affected by the level of maintenance and repair[134]. However, tools used for, e.g., construction have a minimal environmental impact in the use phase but are often underutilised[135]. Machinery and tools have therefore been included as a product group in assessing existing PSS solutions in the Nordics. The following section will provide insights into existing PSS solutions in the Nordics within the product types: cranes, heavy machinery, tools, processing equipment, and chemicals.

3.3.2 Cranes

Growth in the construction industry of the Nordics is overall supported by both the private and public sectors, with the development of infrastructure, sustainable framework improvements, and residential construction, which is currently the largest market[136]. While cranes are utilised in many types of construction and provide various functions, mobile cranes account for the largest share in the rental crane market due to their wide useability in various end-use industries such as construction, building, and transportation. Mobile cranes offer advantages such as mobility and reduced time needed for installation and set-up, which are expected to fuel growth in the crane rental market.

PSS solutions for cranes are primarily seen in the Nordics B2B market context, enabling the construction industry to keep costs down on acquisition, maintenance, and repair. The use-oriented models are the most common among the PSS crane solution. However, result-oriented solutions are also offered. Currently, the global key market players are outside Nordics[137], emphasising the need to strengthen the Nordic market share for crane rental services.

Certex[138]	**PSS model:** 		
Certex is a specialist in lifting equipment and related services with 135 years of experience, covering all archetypes of PSS. They provide sales and rental solutions for lifting equipment and a wide range of service options, including repair, maintenance, inspections, installations, lift operations, security, and custom-made textile lifting products. Certex is a part of the Lifting Solutions Group by Axel Johnson International, a global actor in lifting equipment and steel wire. This enables Certex to work locally and globally and provides the know-how to deliver total lifting solutions. Certex operates in four main areas where they optimise their environmental impact: transportation, energy, environmentally friendly products, and reuse. Based on projects carried out in the four areas, they have received the environmental certification ISO 14001.			
Potential benefits of PSS solution: By providing repair and maintenance, Certex facilitate a reduced need for material input in the production of cranes and other lifting equipment. Targeting other environmental impact	Countries: DK	Market: B2B	Size: LE

[131] ERA (2020): ERA Market Report – ERA Equipment rental industry report.
[132] AE Faulks (n.d.): Environmental impact of Construction Machinery.
[133] Volvo (2022): Volvo Tracks sells 50 electric trucks to truck-as-a-service start up.
[134] Ebrahimi et al. (2020): Regionalized environmental impact of construction machinery.
[135] Skjelvik et al. (2017): Environmental impact and potential of the sharing economy.
[136] Mordor Intelligence (2021b): Scandinavia construction market – growth, trends, COVID-19 impact, and forecasts (2022-2027).
[137] MarketsandMarkets (n.d.): Region – global forecast to 2024.
[138] Certex (n.d.): Udlejning af løfteudstyr.

aspects, such as transport, Certex enables internal pathway creating for improvement of their environmental impact.			

3.3.3 Heavy machinery

Even though the market share for rental services of cranes is relatively small, construction equipment rental is one of the most significant service sectors on construction sites in the Nordics, with the Nordic construction rental market worth more than 3.5 billion euros. High utilisation of construction capacity and shortage of labour has been driving the growth in the sector[139].

Among the identified PSS solutions for heavy machinery, the most common is use-oriented models, predominantly rental solutions. However, product-oriented models are also standard, e.g. pure transitional services and extended warranty and preventative maintenance services. These types of PSS models can create increased and better utilisation and prolonged lifespan of the machinery, thereby reducing material inputs by a decreased production rate. Most PSS providers target the B2B market but with some presence of PSS models for heavy machinery in the B2C and B2G markets. With incentives on reduced costs associated with acquisition, maintenance, and repair, and indications of market readiness from the Nordic construction rental market, PSS solutions on heavy machinery currently have good conditions for future development and growth.

Toyota Material Handling Sweden[140]	**PSS model:**
Toyota Material Handling Sweden is a large company that is part of a global group that is a truck manufacturer and solution provider. The company operates a traditional business model (product sale-oriented) alongside the user-oriented model consisting of renting forklift trucks for short term (1 day to several month) and long term (up to 7 years). Also, preventive maintenance and full-service options are on offer. Trucks are usually used within long-term contracts, then remanufactured and rented for shorter terms, and finally sold as used trucks. Environmental impacts related to the PSS model are estimated to be lower than normal forklift sales as forklifts in the PSS model are estimated to achieve a longer service life.	

Potential benefits of PSS solution:	Countries:	Market:	Size:
With the intent to reuse forklifts in a second-hand market, the company maintains, repairs, and refurbishes the vehicles and as such, the solution extends the life of forklifts that would otherwise be scrapped. The company is also able to salvage and reuse parts in the fleet.	SE	B2B	LE

3.3.4 Tools

Rental solutions for tools are interesting from an environmental impact perspective since most standard household tools are rarely used. A power drill is only used for around 18 minutes over its entire lifespan, resulting in the use phase of a drill contributing to only 2% of the life cycle emissions. A study of a drill rental solution showed that renting a drill six times can reduce emissions by 700 kg CO_2e in reduced material usage from avoided production[141]. Therefore, PSS models for tools are an obvious solution for economical cost reductions and greater utilisation with reduced environmental impact as a result.

Contrary to PSS solutions for cranes and heavy machinery, PSS solutions for tools are prominent in the B2C and B2B markets and somewhat in the B2G market. Providers of PSS solutions for tools in the Nordics vary from small local SMEs to large globally established enterprises. Product-oriented and use-oriented models are most commonly identified within this study, although a vast range of product types and PSS models have been mapped.

BYKO[142]	**PSS model:**

[139] Laitinen (2019): The strong growth of construction equipment rental market in the Nordic starts calming down.
[140] Toyota (n.d.): Det här är vi - Toyota Material Handling.
[141] Skjelvik et al. (2017): Environmental impact and potential of the sharing economy.
[142] BYKO (n.d.): BYKO leiga.

BYKO is one of the two most significant hardware and construction products stores in Iceland, offering a wide range of equipment and construction materials for sale. The company is a part of a multinational concern, mainly owned by Icelandic investors. Renting out tools, machinery (including heavy machinery), and multi-use building material (e.g., concrete moulds and scaffolding) is an increasing part of BYKO's operation. This part will be upscaled considerably in the coming years according to a recently revised market strategy. Until recently, the rental service has mainly focused on the consumer market, but the share of construction companies and other contractors (B2B) is increasing. Local authorities have also started using these services, such as renting lawn movers. Reducing carbon footprint is a central part of BYKO's sustainability strategy and achieving a larger share of PSS in their operations is integral to achieving this. BYKO co-operates with various partners abroad, for example, within The European Rental Association.			
Potential benefits of PSS solution: The PSS solution offered by BYKO should, according to a company representative, decrease the need for imports of tools, as well as of machinery and multi-use building material, and lead to a more intensive and efficient use of these items. This should, at the same time, reduce the amount of waste created, especially WEEE and other tool waste. Furthermore, the solution is expected to support the creation of new jobs in Iceland, by increasing the demand for workforce with technical skills for maintenance, etc. From the social perspective, the solution should be in favour of lower-income groups, as less money will need to be spent on new purchases.	Countries: IS	Market: B2C, B2B & B2G	Size: LE

3.3.5 Processing equipment

Processing equipment is used in many different sectors, from sewage treatment to food production. Depending on the function of the processing equipment, PSS can offer different solutions. Common for processing equipment is that significant investments are often needed. PSS leasing solutions provide a financing mechanism and specialised services that can be beneficial across sectors due to high acquisition costs[143]. Multiple benefits can be associated with PSS solutions for processing equipment since the manufacturers often have the best know-how on maintenance and repair, enabling reduced production of new equipment while creating continuous revenue for the PSS providers.

Most identified PSS providers primarily offer sales of the processing equipment, with the secondary option of renting or leasing solutions to broaden their market potential by splitting up the customers' acquisition costs through leasing agreements. On this basis, the most common PSS models offered in the Nordics are product-oriented and use-oriented models. Depending on the type of processing equipment, the predominant markets are B2B and B2G. Common features among the providers of PSS solutions for processing equipment are that they are manufacturing the product themselves or are in close collaboration with the manufacturers of the product. While PSS solutions offer more intensive and efficient utilisation of processing equipment, the economic mechanisms also provide greater accessibility. This could increase the use of processing equipment. This could lead to higher emissions from the production- and use phase, depending on the type of equipment. It is important to note, that many types of processing equipment have high energy consumption during their use-phase. Some of the identified PSS solutions have done extensive work to reduce energy consumption, while others have not. This plays a major role in the assessment of the environmental impact of PSS solutions. It could be argued that some types of processing equipment can contribute to reductions of greenhouse gasses, such as in the case of sludge processing equipment, where greenhouse gasses are collected and utilised for biogas facilities. Further, some of the identified cases provide different waste treatment solutions, e.g. water purification of wastewater, targeting the B2G market. This does not, however, apply to all types of processing equipment.

Hjortkær Maskinfabrik[144]	**PSS model:** 
Hjortkær Maskinfabrik primarily focuses on the development, manufacturing, and sales of innovative machinery and processing equipment. Most of their products are intended for water purification, e.g., for sludge treatment.	

[143] Klychova et al. (2020): Development of a mechanism for making administrative decision on the use of leasing.
[144] Hjortkær Maskinfabrik (n.d.): Løsninger.

In addition to sales, they have initiated leasing and rental solutions for some of their processing equipment to ensure that one of their primary customer groups, municipalities, can afford their equipment. Furthermore, Hjortkær Maskinfabrik offers interval service and maintenance agreements. Hjortkær Maskinfabrik focuses on reducing their environmental impact by optimizing their products. They have achieved a reduction of energy consumption of 90%, and 98% of the materials going into their equipment can be recycled. Their next environmental project focuses on extending the lifespan of their products.			
Potential benefits of PSS solution: Most benefits provided by Hjortkær Maskinfabrik are oriented towards cost savings for e.g., municipalities. The water purification process provided by the machinery and the reduced energy consumption of the machinery serve as an incentive for companies and municipalities to engage in their PSS solution. This has a potential effect on aquatic biodiversity (due to improve waste water management) and reduced emissions from the use-phase of the machinery (due to reduced energy consumption compared with conventional systems).	Countries: DK	Market: B2B & B2G	Size: SME

3.3.6 Chemicals

PSS solutions for chemicals, e.g. performance-based business models, have been promoted by UNIDO since 2004. Chemical leasing models and models focusing on speciality chemicals have been established ever since[145]. But still, chemicals as a Service and other types of PSS solutions for chemical management are not well known in the Nordics. According to UNIDO, chemical PSS solutions can result in reduced consumption of chemicals and hazardous waste, better process quality, and a greater incentive for reuse and recycling of chemicals[146], which could be relevant for many manufacturing companies in the Nordics.

A few Nordic providers of PSS solutions for chemicals and chemical management have been identified, mainly product- and use-oriented. All identified chemical PSS solutions are oriented towards the B2B market, specifically the manufacturing industry.

3.4 Appliances, furniture & household products

Household appliances are a core area of consumption in the Nordics, and projections of increased population and welfare forecast that people will use and buy more and more household appliances in the future[147]. Furthermore, the frequent replacement of office appliances and furniture in European companies contributes to increased production of solid waste which end up in incineration or landfill[148].

The European furniture industry faces challenges regarding competition due to high production costs, emphasising the need for innovative business models in the industry[149]. Contrary to trends focusing on environmental impact reductions, the consumption trend moves towards shorter usage time for furniture and appliances since these are often replaced for aesthetic reasons rather than due to wear and tear. The environmental and economic challenges call for more efficient utilisation of this product group[150].

3.4.1 Nordic conditions

High income, high standards of living, and a culture of frequent replacement in the Nordic countries have led to high consumption of furniture and appliances. The Nordic consumer base spends a high percentage of their disposable income on furniture and appliances, resulting in an exceptionally high material footprint of the Nordic furniture consumption[151]. A recent study showed that furniture in a net-zero house can be

[145] Formiconi (2018): Chemicals as a Service: Can digital change the chemicals business model?
[146] UNIDO (n.d.): Chemical leasing.
[147] Hischier et al. (2020): Environmental impacts of household appliances in Europe and scenarios for their impact reduction.
[148] Besch (2005): Product-service systems for office furniture: barriers and opportunities on the European market.
[149] EC (n.d.a): Furniture industry.
[150] Besch (2005): Product-service systems for office furniture: barriers and opportunities on the European market.
[151] Storli & Heilmann (2020): Nordic lifestyle, brands and design.

responsible for around 10% of the building's total environmental impact, and appliances 25%[152] - overall indicating that there is a great need of considering new business models for furniture and appliances.

There are many emerging examples of commercial operations reselling refurbished appliances with product-oriented PSS elements such as extended warranties or commitments for take-back at end-of-life. Still, due to the quick replacement culture, there is currently a lack of incentives to design furniture produced for longevity and proper end-of-life handling for both the B2B and B2C markets. Reuse and repair markets could be strengthened by introducing certification of reused or repaired products to help alleviate consumers' concerns over quality and lifetime expectancy[153].

The Nordic circularity can be promoted through a policy framework structure and public procurement so that public entities can act as frontrunners of a sustainable appliance and furniture consumption. By shifting the focus in public procurement from the product itself to the procurer's needs, PSS solutions for furniture and appliances would be more attractive without compromising the needs of the procurer[154]. In Sweden, the National Agency for Public Procurement has worked with sustainability criteria that aim to increase the lifespan of products as a tool to increase the market for refurbished furniture 153 rapidly. However, legislation and conventions for public procurement tenders must be changed to pursue PSS solutions.

The Nordic market of furniture and appliances is known for high-value, and quality products sold internally in the Nordic market and worldwide[155], but there is no prominent focus on B2B supported market structures for circular office furniture and appliances in the Nordics[156]. Green public procurement is known for driving awareness and knowledge of good practices forward[157], so it can be assumed that the Green public procurement initiatives in the Nordics will influence or develop the B2B market for PSS.

With the great focus on reusability in the Nordic counties, PSS solutions could provide the needed logistics to ensure that office furniture and appliances are used during their entire and even extended lifespan, so office furniture and appliances have been included as a product group in the assessment of existing PSS solutions in the Nordics. The following section will provide insights into existing PSS solutions in the Nordics within the product types: Kitchen supplies, heating products, light installations, appliances, furniture and textiles.

3.4.2 White goods and large appliances

Appliances are a part of all Nordic household and most businesses. The term appliances cover a large number of product types, from washing machines to larger kitchen equipment. Most appliances consist of several materials, primarily metals and plastics, and the current recycling system to reduce the environmental impact associated with these products comes with limitations[158]. Some of the limitations are due to the chemicals of concern in some types of appliances, such as refrigerators fluids, which are challenging for current recycling systems due to the hazardous status of the fluids. PSS solutions for appliances can prolong their lifespan, thereby promoting reuse over recycling, countering the limitations of the recycling system. Most identified providers offering PSS solutions describe circular practices as the starting point of their company, focusing heavily on reuse and recycling. Identified cases are primarily oriented towards the B2C and B2B markets and promote their product services based on reduced economic costs related to maintenance and repair, reduced CO_2 emissions, and prolonged warranty. PSS

[152] Hoxha & Jusselme (2017): On the necessity of improving the environmental impact of furniture and appliances in net-zero energy buildings.
[153] Kiørboe et al. (2015): Moving towards a circular economy – successful Nordic business models.
[154] Alhola et al. (2017): Circular Public Procurement in the Nordic Countries.
[155] Hildenbrand et al. (2021): Identifying and Evaluating Recirculation Strategies for Industry in the Nordic Countries.
[156] Kiørboe et al. (2015): Moving towards a circular economy – successful Nordic business models.
[157] Testa et al. (2016): Drawbacks and opportunities of green public procurement: an effective tool for sustainable production.
[158] Bracquené et al. (2021): Quantifying the environmental impact of clustering strategies in waste management: A case study for plastic recycling from large household appliances.

solutions for appliances are often product- or use-oriented in the Nordics, depending on whether the business models are based on remanufacturing or retail.

Regarding the environmental impacts, a downside of PSS solutions for white goods and appliances is the transportation associated with the PSS. If consumers utilise maintenance and repair services, emissions from transport to and from the consumer are unavoidable, whether done through a PSS solution or traditional maintenance and repair services. Of course, better maintenance and repair prolong product life and may reduce the rate at which products are discarded. Also, if consumers dispose of broken white goods and appliances, PSS solutions with maintenance and repair services could facilitate proper waste management and recycling. On the other hand, PSS solutions might even increase consumption, as the PSS models with provider ownership enable greater accessibility and, therefore the acquisition of products that consumers might not have been able to afford without the PSS solution.

Norsk Ombruk[159]	**PSS model:**
Norsk Ombruk is a remanufacturer and reseller of refurbished consumer electronics, focusing primarily on white goods (refrigerators, washing machines, ovens, dishwashers, and dryers). Part of the sales stock is recovered from streams destined for material recycling, under the control of producer responsibility organisations for electronics. Products in these streams are recovered and ultimately rerouted back into the market. The primary business model is B2C retail – there appears to be little or no B2B. The operation is providing product-oriented PSS through the value added in identifying and refurbishing stock and the direct customer perspective through the warrantying of the (used) products sold. The company is relatively small, but a parallel operation in Denmark (Recirk) has also been established. Published estimates of added environmental and economic value are old and appear to need a complete overhaul. Nonetheless, a net saving of 3000 tonnes of CO_2 based on the 2017 level of operations was claimed.	

Potential benefits of PSS solution:	Countries:	Market:	Size:
CO_2 savings as a result of refurbishing consumer electronic goods.	NO	B2B	SME

3.4.3 Tableware & kitchen appliances

When properly maintained and repaired, most kitchen appliances have the potential for a long lifespan. However, many consumers find maintenance and repair of small kitchen appliances troublesome since the acquisition costs of new items are low and repair is inconvenient[160]. Product- and use-oriented models are the most common types of PSS solutions related to tableware and kitchen appliances, often in the form of an extended warranty, preventative maintenance and renting and leasing solutions. The market orientation depends on the type of product. Tableware is mainly provided for B2C and B2B markets, often oriented to special occasions and celebrations. With the PSS solutions for tableware, some additional result-oriented service is usually offered, e.g. aesthetic table setting and cleaning services. Kitchen appliances are mainly provided for the B2B and B2G markets.

In some cases, the B2C market is included, but private actors in the Nordics have a culture of ownership for kitchen appliances. PSS solutions for these types of products can facilitate the longer lifespan of kitchen appliances through maintenance and drive the design of these appliances towards longevity while offering cost-attractive products, in particular to the B2B and B2G markets. While PSS solutions for tableware and kitchen appliances might prolong the lifespan of the product utilised and limit single-use cutlery, the downside of PSS solutions would probably be the increased transportation to and from consumers. PSS providers would also have to build up an attractive stock to provide their services, which impacts the consumption reduction potential. Some resources are needed for cleaning, however, contrary to standard private ownership, the PSS provider would likely possess efficient cleaning services to ensure revenue of

[159] Townsend et al. (2020): Norsk Ombruk – The benefits case for remanufacturing.
[160] Terzioglu (2013): Extending the lifespan of small kitchen appliances for sustainable design: A research on product maintenance and repair with technical services in Ankara.

the model. As a result, impact reductions are very dependent on the approaches utilised by the PSS providers.

Arabia Astiapalvelu[161]	**PSS model:**
Iittala, a part of Fiskars Group, is a manufacturer of diningware, drinkware, and interior items. The company has been piloting a crockery service in Finland that gives consumers access to crockery, cooking utensils and cutlery at a fixed monthly price. The products can be selected and ordered online and delivered free of charge to the address provided within approximately 5-7 days. A fixed monthly price will be charged to the given payment card on a monthly basis and the first charge will be made at the time of ordering. The contract period is at least 12 months, after which the customer can redeem the dishes or return them to our store. The same products can be kept on monthly invoicing for up to 24 months.	

Potential benefits of PSS solution:	Countries:	Market:	Size:
The solution allows consumers to get access to crockery, cooking utensils and cutlery. The service gives consumers more flexibility and an opportunity to test different products. The service also includes a breakage guarantee. In case, the rented item breaks during use, it can be replaced with a new similar one.	FI	B2C	Large

3.4.4 Heating and electricity

In the Nordics, most PSS solutions for heating are part of a total solution offering. Studies on such models show that the greatest impact on energy efficiency is related to user behaviour and not investment-heavy measures such as highly efficient heating systems and thermal insulation. This indicates that without regard for user practices, the effects of efficiency measures could be minimal. Therefore, PSS solutions addressing a change in the users' social practices and assistance in heating energy consumption could have environmental results supporting energy-efficient technologies[162]. However, such models have not been possible to identify within this study. All identified cases providing PSS solutions for heating are utilising both product- and use-oriented models, dominated by renting and leasing solutions. All identified PSS providers are oriented toward the B2B market.

PSS solutions for heating and electricity would, in most cases, create a provider incentive to select durable and energy-efficient products, supporting the market of these products. While these types of PSS solutions probably would not have an impact on energy consumption patterns, they offer greater convenience for the customer. They could prolong the lifespan of the products, still taking into consideration the potential emission increase from transportation.

Many of the PSS providers identified in the Nordics are creating market pressure for increased utilisation of mobile electricity production devices by replacing generators running on fossil fuel with portable solar cells enabling more sustainable consumer behaviour. To ensure the best use of the products, PSS providers commonly provide consumers with instructions on best practices to reduce energy consumption and prolong the lifespan. Most of the heating and electricity PSS providers identified target construction companies, and their solutions are mainly categorised as the activity management model.

Solar[163]	**PSS model:**
Solar is a sourcing and service business working within the area of industry, power, plumbing, heating, and ventilation, offering rental solutions of professional tools and equipment to businesses. The equipment is booked through an application, and Solar provides easy and fast access to needed equipment and savings on storage space. Solar are working on becoming a responsible and sustainable business, by working towards reductions of the CO_2e emissions of their products and providing greener climate and energy solutions. Internally they are working on becoming net-zero in scope 1 and 2 by 2030, as defined by the GHG protocol.	

[161] Fiskars Finland (n.d.): Uusi kätevä astiaplavelu.
[162] Liedtke et al. (2015): User-integrated innovation in Sustainable LivingLabs: an experimental infrastructure for researching and developing sustainable product service systems.
[163] Solar (n.d.): Sammen reducerer vi spild.

Potential benefits of PSS solution:	Countries:	Market:	Size:
The solutions provided by Solar has, by their experience, a positive impact on the utilisation of tools and equipment. Thereby their PSS solution has the potential to facilitate a reduction of material input needed for production of new tools. They further argue, that by providing heating, ventilation and power, utilising electricity over fossil fuels, they provide the construction sector with greener alternatives.	DK	B2B & B2G	SME

Very few PSS solutions for light installations are currently available in the Nordics, and most are offering temporary light installations e.g. events or parties. The Swedish Brighteco is one of the few PSS cases providing indoor lighting as a functional result, e.g. school buildings through public procurement. A study on their services showed a trade-off between environmental consequences and economic benefits, which can be challenging in public procurement[164]. Available literature primarily asses long-life products such as fluorescent tubes. Here, PSS solutions create an incentive to provide products with longer life span and easy maintenance, decreasing costs for the customers and increasing the revenue of the primary producer.

Environmental potentials related to PSS solutions for lighting would primarily be related to minimising rare metals in the production[165], although these rare metals are less common in modern lighting such as LED. Due to the minimal number of cases identified, it is not possible to conclude on relevant markets or models within this category. Further, it can be questioned whether PSS solutions for lighting offer any environmental impact reduction since it is unclear if such solutions would cause reduced consumption, better utilisation, or waste reduction. PSS solutions could, however, provide greater convenience for consumers and economic benefits due to proper installation and selection of products in, e.g. product-oriented models.

Valtavalo vaivaton[166]	PSS model:
Valtavalo Ltd is a Finnish SME company, specialized in energy-efficient lighting solutions. The company was established in 2008. Besides selling lighting equipment, the company also offers lighting as a Service through Valtavalo Vaivaton service. Instead of purchasing lighting equipment the service enables a customer to get access to lighting with a monthly fee. The service covers thus both installation and maintenance of lighting. Furthermore, Valtavalo takes care of the recycling of the products.	

Potential benefits of PSS solution:	Countries:	Market:	Size:
The service can lower customers' threshold for taking up modern, energy efficient lighting systems. The modernisation of lighting systems allows customers to save energy, reduce electricity costs and lower company's carbon footprint.	FI	B2B	SME

3.4.5 Furniture

Furniture is, depending on the materials used, considered high-impact products. Due to consumption patterns and trends, the utilisation of furniture is often for a shorter period than the furniture's lifespan[167,168]. High-quality, or even low-quality, furniture is a standard product for P2P resales, providing pathways for reuse and greater consumption. Nordic consumers spend around 5% of their income on furniture[169]. A study of bulky waste at two Swedish recycling centres showed that 23-30% of the furniture found among the bulky waste could have commercial reuse value, 7% had a functional value and could be reused, while 4-17% could be repaired and then reused. Although the results were from Sweden only, they are reasonable indications of Nordic furniture consumption patterns[170]. PSS solutions offer better

[164] Lindahl & Dalhammar (2022): The circular economy: towards a new business paradigm with support from public policy.
[165] Thompson et al. (2010): Benefits of a Product Service System Approach for Long-life Products: The case of Light Tubes.
[166] Valtavalo (n.d.): Hanki laadukas LED-valaistus Palveluna.
[167] Hoxha & Jusselme (2017): On the necessity of improving the environmental impacts of furniture and appliances in net-zero energy buildings.
[168] Niinimäki et al. (2020): The environmental price of fast fashion.
[169] NCM (2021): Towards sustainable consumption in the Nordic Region.
[170] NCM (2021): Towards sustainable consumption in the Nordic Region.

utilisation of the furniture if multiple users are incorporated in the PSS model and facilitate a higher rate of maintenance and repair of furniture. This could significantly affect product longevity and reduce the potential for waste production. The use-oriented models are the most common among identified PSS solutions for furniture in the Nordics, and some product-oriented models are also available. Office furniture is the most common type offered, with many PSS providers oriented towards the B2B market. PSS models targeting the B2C market are often high-quality furniture. Some PSS providers also focus on furniture for events and typically offer rental solutions for shorter periods.

The net effect on furniture consumption of these use-oriented models is unclear. On the one hand, reduced furniture consumption could be facilitated by PSS solutions. As with many other product group categories, further study is needed to assess whether, e.g. the total product consumption will increase or decrease or whether greater utilisation and prolonged lifespan of the products would make up for the increased transportation. Many identified PSS providers refurbish second-hand furniture or base their production on recycled materials, which could significantly impact waste production and management.

GoGood[171]	**PSS model:**
GoGood is a Norwegian start-up engaged in the design and delivery of sustainable and flexible office furniture solutions, based on repair and reuse of furniture that might otherwise disposed. Core operations are in the arena of use-oriented PSS and on a B2B basis. The prospective customer base include public / commercial organizations. However, the essence of the concept is complete value chain management through the tracking, monitoring and assessment of products and product flows (for example, accurately identifying furniture that is viable for repair / refurbishment / reuse). The intention is to breach common issues arising in PSS solutions – of stock being of poor quality, in poor condition and/or being unavailable / invisible to the potential customer. The concept transcends product sectors – office furniture being the initial implementation of concepts intended for broader use. The underlying concept mostly concerns high technology and industry 4.0 concepts: big data, advanced analytics, and AI, underpinned by research into the economic and environmental viability of operations.	

Potential benefits of PSS solution:	Countries:	Market:	Size:
Extending the lifetime of office furniture through reuse and repair/refurbishment.	NO	B2B	SME

3.4.6 Textiles

Consumption of textiles has been growing in Nordic countries. The increased consumption has environmental consequences across the production-, use-, and end-of-life phases. There are multiple gaps in the knowledge of the magnitude of the second-hand market, total consumption, and gaps between used and discarded textile products in waste statistics. Since half of the textiles used by consumers, new as well as second-hand, are discarded as waste[172], there are good opportunities for the Nordic PSS textile market to grow.

Most PSS providers of this category offer total textile solutions, often including washing and delivering textiles, oriented towards B2B and B2G markets. The customers of commercial laundry companies include both public and private sector enterprises, often from sectors with high requirements for hygiene. The rental, washing, and maintenance of workwear for private companies and hospitals are essential business areas in line with the rental and washing of linen and tablecloths for hotel and restaurant companies, nursing homes and hospitals[173]. Many of the existing PSS providers are therefore working on limiting textile consumption by using chips in the clothing to optimise the extradition and consumption of the textiles[174]. For the most part, the PSS providers of textile solutions are established large companies with more than 50 years of experience, and all include some washing and renting services for restaurants, hotels, and public institutions. All identified PSS solutions for textiles include a use-oriented model, and

[171] GoGood (n.d.): Kontorinnredning med ombruk inkludert.
[172] Tojo et al. (2012): Prevention of textile Waste – Material flows of textiles in three Nordic countries and suggestions on policy instruments.
[173] Dansk Industri (2019): Erhvervsvaskeribanchens årsrapport 2019.
[174] Dansk Industri (2019): Erhvervsvaskeribanchens årsrapport 2019.

some cover the full Tukker scale. Due to the PSS providers' size and market share, they all have a strategy for prolonging the lifespan of the textile provided and specific targets for recycling.

Danske Forenede Dampvaskerier[175]	**PSS model:**
Danske forenede Dampvaskerier (DFD) has been offering industry-specific laundry and rental solutions in Denmark since 1958. Today, DFD offers their solutions to five market-specialized divisions: industrial work, catering and restaurants in Copenhagen, cleaning, food and pharmaceutical industries, welfare and health procurement, and catering and restaurants in the rest of Denmark outside Copenhagen. DFD offers a range of digitally integrated solutions, providing easy access and overview of stock for their customers. DFD has been working intensively on the environmental impact, ensuring that all textiles that are able to be upcycled at the end-of-life phase are upcycled to, e.g., small reusable towels. The textiles that cannot be upcycled are downcycled to industrial articles, used for, e.g., filling in car seats and insulation.	

Potential benefits of PSS solution:	Countries:	Market:	Size:
DFD have been working on their environmental impact for many years, which have enabled them to incorporate reuse and recycling in the material flow. By upcycling all qualified textiles to new products for PSS solutions, and downcycling those which are not qualified, they have enabled reductions of their waste output. The PSS solution have served an incentive for DFD for improved recycling. They are still working on ways to reduce their environmental impact further.	DK	B2B & B2G	LE

3.5 Products for children

Playing is essential for children to learn, live, understand and express themselves. Toys constitute a crucial part of children's material culture, designed as artefacts embodying cultural and historical significance[176]. However, children in western society are locked into unsustainable consumer behaviour due to constant offerings of novel must-haves[177], and even parents aiming to become sustainable societal actors often have their intentions overrun by habits and convenience.

Strategies of consumer-product attachment that can influence parents and children towards sustainable behaviour without having to change attitudes and norms might effectively reduce the replacement rate of toys[178]. While part of the challenge with products for children has been attachment-related, another part of the challenge is short active life-time of toys due to increased and changing needs along with children growing older. Reuse or shared use of the product is one of the most sustainable solutions to this challenge, and PSS solutions, such as toys for rent, might provide access to suitable products for all ages while reducing the number of toys, furniture and garments produced and discarded as waste.

In the EU, the safety of toys is regulated under the Toys Safety Directive of 2009, focusing both on general and particular risks of toys[179].

3.5.1 Nordic conditions

In the Nordic countries, children have great access to material goods, such as toys and clothing, creating a potentially expedient market for more circular PSS models focusing on children's products - if cultural challenges can be overcome.

The Nordic countries are well known for their family policies and childcare arrangements, and the Nordic countries are in the global top countries for raising kids with maternity leave, child sickness days,

[175] DFD (n.d.): Vaske- og lejeløsninger der gør din hverdag nemmere.
[176] Fousteri & Liamadis (2021): Toy stories for the common good.
[177] Gulden (2014): Toys and Product Longevity.
[178] Gulden (2014): Toys and Product Longevity.
[179] EC (n.d.b): Toy Safety in the EU.

affordable day care, and proper school systems[180]. The Nordic children have relatively safe and healthy living environments and are – taken as a whole - provided with the care and playing areas needed to have a proper place in society[181]. The distinctive features of the Nordic family policies are affected by the strong role of the state, NGOs, markets and overall family structure in the Nordics[182]. Most policies directed at the Nordic children and their parents focus on rights to maternity and paternity leave and rights to day-care and education[183]. The safety of toys is regulated under the EU Toys Safety Directive of 2009, focusing both on general and particular risks of toys[184]. The Nordic countries have standards for hazardous chemicals in toys and clothing, focusing on CE marking[185] and support programmes for low-income families[186].

The children's product market includes a very long range of consumer goods, from feeding accessories to toys. The global market value for baby care products and toys is approximately 154,5 billion Euro and continues to have a strong growth forecast[187,188]. In terms of formalised PSS initiatives, children's clothing appears more prominent than non-clothing. In this product group, strong secondary markets prevail as well as an informal sharing economy with common passing-on of products between friends and families.

Many children's products have a use phase of a few years or even less, resulting in a low utilisation rate, which does not resonate well with the fact that many of the products are produced from high-impact materials and in high quality, necessitating and also enabling long product lifetimes. The following section will provide insights into existing PSS solutions in the Nordics within the product types: children's clothes, toys, nursing equipment, and furniture and equipment.

3.5.2 Children's clothes

Babies and small children often outgrow their clothes before they are even close to being worn out. Unless the children's clothes are bought second-hand or are passed on to younger siblings, relatives, or acquaintances, this results in premature disposal and underutilised potential for reuse[189]. PSS solutions for children's clothes can offer significant environmental benefits by prolonging the life span of the clothing. More and more PSS solutions for children's clothes appear in the Nordic market and most target environmentally aware new parents. The focus among the PSS providers is solely on the B2C market since the B2B and B2G markets have little to no relevance for this product type.

The use-oriented models are the most common for PSS solutions for children's clothes; however, some offers workshops and extra services that are more reminiscent of result-oriented models. Despite an interest in PSS solutions, many PSS providers offering children's clothes are struggling to keep the momentum of their business. From the identified cases, several reports that this is due to competition from hand-me-down practices, second-hand stores and cultural lock-ins regarding the ownership culture. The lock-ins related to the ownership culture are further strengthened by the availability of cheap new clothing items and the convenience of buying new ones. This challenge all types of sharing systems, PSS or not, due to the time needed to find the wanted second-hand clothing or the expense of building up effective sharing systems.

Whether the PSS models for children's clothing have an actual effect on the environmental impact depends on the life cycle approach of the solution, e.g. when and how the products reach the end of life. With PSS

[180] Broom (2019): Why Nordic nations are the best places to have children.
[181] Hiilamo (2008): Promoting Children's Welfare in the Nordic countries.
[182] Hiilamo (2008): Promoting Children's Welfare in the Nordic countries.
[183] Hauguli & Nylund (2019): Chapter 20 Children's Constitutional Rights in the Nordic Countries.
[184] EC (n.d.b): Toy Safety in the EU.
[185] Veulemans et al. (2019): Nordic enforcement project on give-away products.
[186] Herning (n.d.): Social policy and welfare.
[187] Bedford (2021): Baby products market worldwide – statistics & facts.
[188] Tighe (2022): Toys industry – statistics & facts. Statista.
[189] Kjær et al. (2019): Product/Service-Systems for a Circular Economy: The Route to Decoupling Economic Growth from Resource Consumption?

solutions for clothing, the quality of the textile is key for achieving the needed rounds of use for an economically sound business model. Furthermore, the PSS provider ensures proper maintenance and repair of the clothing to prolong the lifespan and thereby ensure longer rental periods. Some PSS providers build their stock on second-hand clothing, resulting in lower stock acquisition prices, requiring a more flaw-forgiving behaviour from customers.

STAS[190]	**PSS model:**
STAS for barn is a small-scale SME that rents children's products and clothes, focusing on babies. Under a subscription system, customers can select pre-defined or "a la carte" packages of items for exchange and replacement with larger sizes as the child grows. Non-clothing items with a limited useful lifespan (such as carrying solutions and pregnancy-related items) are also offered on a rental and, in some cases, retail basis. The operation is primarily use-oriented PSS and appears to be entirely on a B2C basis. There do not appear to be any particular technological underpinnings to the operation.	

Potential benefits of PSS solution:	Countries:	Market:	Size:
The environmental benefits of the solution are only described in the vaguest terms by the producer. It is known that the enterprise has considered engaging in research projects to investigate these matters more deeply, but any progress in this area is unclear. Potential environmental benefits compared to conventional solutions could be a reduction in the total consumption of children's clothing and products by enabling several families to use it. Furthermore, the solution allows users to exchange and replace items as needed, which may have socioeconomic benefits.	NO	B2C	SME

3.5.3 Toys

As with PSS solutions for children's clothes, PSS solutions for toys have risen in the last few years, enabling a market maturation. The business models are received among users but are in keen competition with resellers and linear business models for toys[191]. The amount of plastic and unrecyclable WEEE in toys today calls for reuse, and innovative PSS solutions could have a significant environmental impact. Of the identified PSS solutions for toys, the most common is the product- and use-oriented models, hereunder the advice and consultancy model and the renting model.

For most identified PSS providers, renting solutions is their primary revenue source. Additional advice and consultancy are often available as workshops, guides, or general advice from experts in selecting toys suited for children's development. All PSS toy providers identified are oriented to the B2C market; however, many have considered looking into the B2G market, although firm and rigid procurement requirements hinder participation in public procurement tenders.

Many PSS providers of toys still struggle with the systemic culture of ownership. Consultations with PSS providers indicate that many parents hesitate to buy subscription services because they do not want to take away toys that the children have grown attached to. Therefore, most PSS providers offer the parents a sales option on some of the products. According to the PSS providers, the main issue for the users is the fear of being held liable in case of broken or missing products. Thus, many PSS providers have included a liability clause, e.g. rental agreements, addressing that the toys can be slightly damaged and children should be able to play freely.

Although PSS solutions for toys could enable reduced consumption, it can be discussed whether PSS solutions provide a more significant environmental reduction impact than, e.g. P2P sharing schemes or second-hand incentives. Differentiating from P2P schemes, some PSS providers facilitate recycling or refurbishment in collaboration with toy producers, enabling a more straightforward implementation of

[190] Stas (n.d.): Vi leier ut tøy og utstyr av høy kvalitet.
[191] Cloos et al. (2021): Development of Startup Guidelines for Creating a Sustainable Product/Service-Systems Enabling a Circular Economy within the Field of Consumer Goods.

EPR schemes. Moreover, PSS solutions can incentivise collaboration between manufacturing actors and distributors, embedding a feedback mechanism for product durability in the value chain. This can enable the production of toys made for high utilisation rates, prolonging the product lifespan and reducing waste production. Due to the increased number of users, more transport and packaging will likely result from PSS solutions for toys compared to P2P schemes. However, many of the identified PSS providers are aware of this challenge, addressing it by utilising reusable packaging and/or bicycles for deliveries and pick-ups when possible.

An aspect often overseen for PSS solutions for toys is that the fast replacement of toys could spread the buy-use-trash culture to the users, children, reminiscent of what is seen with fast fashion. On the other hand, PSS solutions for toys could facilitate the understanding that used products can provide the same functions as new products to the children – and their parents.

Barnalán[192]	**PSS model:**
Barnalán offers various children's products for rent, including, e.g. furniture, toys, and strollers, as well as a limited number of pregnancy assistance products. The customers are mainly families in the Reykjavík area but also visitors to the city, grandparents, etc. The company was established only a couple of years ago and the demand for its service has been far above expectations. The business is still operated by the two owners only. Access to funding to build up the inventory, develop software, etc., is, according to the owners, a limiting factor in this respect.	

Potential benefits of PSS solution:	Countries:	Market:	Size:
In addition to the expected drop in resource use and emissions as a consequence of the operation, the option to rent children's products has been welcomed by lower income groups.	IS	B2C	SME

3.5.4 Furniture & equipment

Similar to children's products in general, furniture and equipment have shorter use phases for children than equivalent products for adults due to the rapid growth of young children. Some manufacturers have tried to accommodate these tendencies by producing modular furniture[193]. While furniture for children is a part of the 5% of Nordic consumer's income spent on furniture[194], equipment for childcare, such as breast pumps, is not a part of this spending. While some nursing equipment has a shorter use phase for the consumer than, e.g. baby clothes, it often has the potential for very long utilisation periods and lifespans since the products are usually of high-quality or very durable materials.

PSS solutions for furniture and equipment for children vary a lot, but common among all is the use-oriented models, primarily as renting or leasing solutions. Some PSS providers also offer product- or result-oriented services, but the renting and leasing solutions are the primary revenue model. Most of the PSS providers of this product type target the B2C market, but a few also work with the B2B market and occasionally the B2G market. Common among providers of PSS solutions for furniture and equipment for children is that the product services are often oriented towards parents with children under the age of five, creating a potential for environmental impact reductions due to the fast mental and physical growth of children in that age range.

The use-oriented models provide higher reuse potential and thereby reduce the production of waste, as well as a possibility for reduction of product consumption. The PSS solutions for the more expensive equipment provide more significant socio-economic equality potential, as the products are made available to more income groups. Repair and maintenance services could improve product lives and provide market pressure for more durable products.

[192] Barnalan (n.d.): Leigðu barnavörurnar hjá okkur.
[193] González-García et al. (2012): Eco-innovation of a wooden childhood furniture set: An example of environmental solutions in the wood sector.
[194] NCM (2021): Towards sustainable consumption in the Nordic Region.

Móðurást[195]	PSS model:
Being mainly a pure retailer, Móðurást has slowly been moving into PSS-solutions, mainly focusing on hospital grade breast pumps and scales for new-borns. These products can rarely be borrowed from maternity wards, and as the products are relatively expensive, the rental option has been welcomed by many parents. Even public maternity wards themselves are starting to use the services of Móðurást to some extent.	

Potential benefits of PSS solution:	Countries:	Market:	Size:
In addition to potential reduction of resource use as a consequence of the operation, the PSS solution has, according to the owner, proved to be quite beneficial for groups like immigrants and refugees.	IS	B2C B2G	SME

3.6 Clothing & accessories

The textiles sector constitute a significant part of the global economy, but the large production and consumption of textiles create significant negative environmental impacts from fibre production, use of fossil resources, high energy usage, toxic chemicals and colouring, microplastics emissions, and the generation of waste from the production and disposal stages[196].

Product rental models for textiles have been accessible in the United States for a while, showing that new ownership models can be economically viable across a range of categories from mid-market to luxury goods, especially among millennial consumers[197].

Approximately 80% of the total climate change impact of textiles occurs in the production phase[198], and PSS solutions for clothing, including re-commerce, rental, and repair, provide an option to reduce the material and production impact. These practices can open opportunities for customers to access high-quality fashion without commitment and cost of ownership, all while encouraging design for longevity, multifunctional usage, and end-of-use recycling.

Approximately 14% of the total climate change impact of textiles are associated with the use phase, originating from washing, drying, and ironing[199]. Use phase impact reductions can be facilitated through PSS solutions for textile maintenance, already commonly offered for workwear. PSS solutions for the use phase of textiles can be streamlined, based on specialised practices for large scale washing and drying. This approach incentivizes reductions of the environmental impact of the use phase, as economic savings for the provider can be achieved through efficient use of machinery, water, detergent, and energy. Reductions of eco-toxicity can further be facilitated through PSS solutions, as centralised washing and drying practices can enable reductions of wastewater discharge containing microplastics and fibres, through implementation of improved filtering.

3.6.1 Nordic conditions

Nordic textile design is an internationally renowned trademark based on aesthetics and functional lifestyles. Outsourcing of the manufacturing process has traditionally been significant, but Nordic Fashion Association describes how turning towards local production is motivated by increased demand for flexible, socially, and environmentally sustainable production and a growing desire for uniqueness and national identity in a global market[200].

The Nordic region is a heavy user of textile products, with an average consumption of 13-16 kg of new textiles per capita per year – a number that continues to rise. While some initiatives for the reduction of

[195] Móðurást (n.d.): Brjóstapumpuleiga.
[196] Moazzem et al. (2021): Environmental impact of apparel supply chain and textile products.
[197] Lacy et al. (2020): Fast-Moving Consumer Goods.
[198] EEA (2022): Textile and the environment: the role of design in Europe's circular economy.
[199] EEA (2022): Textile and the environment: the role of design in Europe's circular economy.
[200] Lindemann (2018): Make Works – Norway, Sweden and Denmark.

textile waste are in place in the Nordic region, still over half of all clothes are neither reused nor recycled, resulting in vast amounts of barely used clothes ending up as waste[201]. 350,000 tonnes of new textiles are put onto the Nordic markets each year, but only 120,000 tonnes of used textiles are collected with charities as the main collectors of used textiles with the aim of reuse and recycling[202]. Second-hand ownership of clothing items is well-engrained through retail by charitable organisations, peer-to-peer sales, and informal sharing, but many of the collected reusable textiles are exported and not reused within the Nordics.

In 2017, there was no common standard to increase the levels of reuse and high-grade recycling in the Nordics and no specific regulation governing textile waste management in the Nordic region. In 2017, the Nordic Council of Ministers introduced The Nordic textile re-use and recycling commitment, a voluntary certification system with two types of certificates: one for collection of textiles aimed for reuse, and one for collection of textiles aimed for both reuse and recycling[203]. In 2020, the first collection initiatives were implemented in Nordic countries[204].

In line with other western economies, overall clothing consumption has risen sharply in the past two decades. Consequently, many items are very seldomly worn over their life cycle and a massive untapped usage potential for clothing exists. More recently, many operations dedicated to PSS of clothing items have emerged. The Nordic market conditions for textiles and the environmental impacts related to the production phase call for action, and PSS solutions have the potential to accommodate a greater utilisation of reusable clothing and textiles. The following section will provide insights into existing PSS solutions in the Nordics within the product types: Casual clothing, clothes for special occasions, workwear, and accessories and jewellery.

3.6.2 Casual clothing

The garment industry is one of the largest, most globalised industries. In recent years, technological advances, societal changes, growth and market changes at the retail level have increased the ecological footprint of the industry[205] and fast fashion trends. However, rental services of casual clothing are becoming increasingly common in many countries[206] and have been typical for festive clothing for a while. This is also the case for Nordic countries. The PSS solutions for casual clothing have great environmental impact potential: if a dress is rented out 25 times, there is an expected reduction of 684 kg CO_2e[207]. This number is, however, not representative of every dress, and the emissions can significantly differ depending on the dress design and materials. The current Nordic PSS solutions for casual clothing primarily target women and children in the B2C market. Very few PSS providers of casual clothes are targeting the B2B and B2G markets.

Many of the identified PSS providers are SMEs but a few larger casual clothing retailers are also looking into PSS solutions, especially the use-oriented models, as an additional service to their sales model. The use-oriented models are the most prominent among PSS providers of casual clothing. However, some include product-oriented models to supplement the revenue flow. The prevailing culture of ownership is considered a great barrier among PSS providers of casual clothes. Many build their business models on

[201] NCM (2015): Well dressed in a clean environment: Nordic Action plan for sustainable fashion and textiles.
[202] Fråne et al. (2017): The Nordic textile reuse and recycling commitment – a certification system for used textile and textile waste.
[203] Fråne et al. (2017): The Nordic textile reuse and recycling commitment – a certification system for used textile and textile waste.
[204] LSJH (2020): National Collection of End-of-life Textiles in Finland; Carlsson et al. (2020): Planning a Swedish Collection and Sorting Plant for Used Textiles; Watson et al. (2020): Towards 2025: Separate collection and treatment of textiles in six EU countries.
[205] Anguelov (2016): The Dirty Side of the Garment Industry.
[206] Piontek et al. (2020): Environmental implication of casual wear rental services: Case of Japan and Germany.
[207] Skjelvik et al. (2017): Environmental impacts and potential of the sharing economy.

either high quality, socially and environmentally sourced or recycled and reused clothing to stand out from the standard business models.

PSS solutions for casual clothing could facilitate a reduction of consumption and production, increased reuse, and reduced waste, but they could also do the opposite. This is very dependent on the PSS provider's approach and the consumption pattern of the users of the PSS solution. None of the identified PSS providers has developed a scheme for recycling clothing, but a few collaborate with other market actors on recycling possibilities. However, many actors have a well-established scheme for mending the products ensuring a longer lifespan. Most identified PSS providers utilise postal services, but since the product rental model is the most common, this could result in much transport to and from the consumer and more significant production of packaging waste. Further studies are needed to evaluate the environmental perspectives of the these solutions.

Vaatepuu[208]	**PSS model:**
Vaatepuu is a small Finnish company, founded in 2014, that offers clothing rental for consumers. Stores are located in five cities in Finland (Helsinki, Järvenpää, Turku, Tampere, and Jyväskylä). The clothing selection is based on sustainable high-end designer fashion brands with focus on casual clothing and a selection of formal and festive attire. Clothing rental is offered a membership-based model. The customers are committed to the clothing rental membership for a certain amount of time and fixed fees are applied.	

Potential benefits of PSS solution:	Countries:	Market:	Size:
The potential benefits of the Vaatepuu model include enabling affordable access of expensive, high-end designer fashion brands to the consumers. The owners of Vaatepuu also emphasize the focus on communality and social benefits of sharing the clothes among the consumers. Both environmental and social sustainability benefits are also highlighted by the company, in terms of the product selection and the model itself.	FI	B2C	SME

3.6.3 Clothing for special occasions

As with casual clothes, the same or even more significant environmental impacts can be associated with clothes for special occasions[209]. Clothes for special occasions have even lower utilisation than casual clothing, as seen with, e.g., bridal dresses and gala clothing. Therefore, there is a unique environmental incentive to promote PSS solutions for clothes for special occasions. Most identified PSS solutions for clothes for special occasions are SMEs, and all are targeting the B2C market.

There are multiple similarities with the tendencies seen with PSS solutions for casual clothing, e.g. the utilisation of high-quality, environmentally and socially sourced, or recycled and reused clothing. All identified PSS providers have use-oriented models and, in some cases, product-oriented models as a supplement to renting or leasing solutions. Most of the solutions are membership-based. There seems to be less of a barrier regarding the culture of ownership regarding clothes for special occasions compared to other textile products, which could be due to the high prices and low utilisation of clothes for special occasions. However, the PSS solutions face the same challenges regarding the environmental impact of transport and waste production from packaging. As with PSS solutions for casual clothing, there is an almost unified focus on women as potential customers. This is despite the fairly common practice of renting tail suits and similar for balls and other formal events among young men in student cities.

Spjara[210]	**PSS model:**
Three entrepreneurs established Spjara after their business idea received an award at a "Fashion Hackaton" arranged by the Icelandic EPA in August 2020. Spjara offers festive clothing for weekly rentals. The customer orders the garment online, picks it up and takes care of cleaning and maintenance, while the customer is invoiced in the	

[208] Vatepuu (n.d.): Kestäviä pukeutumisratkaisuja.
[209] Anguelov (2016): The Dirty Side of the Garment Industry.
[210] Spjara (n.d.): Nýjar áskoranir kalla á nýja hugsun. Taktu þátt í hringrásinni.

case of damages/losses. The typical customers are 25-35 years old women who wish to wear new clothes without spending too much money or causing too many negative environmental impacts.			
Potential benefits of PSS solution: According to the owners of Spjara, their PSS solution has the potential to reduce textile waste by reducing unnecessary purchases. However, the owners point out that the real impact is somewhat hard to measure. The PSS model might even be an addition to the current consumption instead of being a substitute for a part of it. Further research is needed to compare the fashion footprint of Spjara-customers to other consumers. In addition to the possible environmental benefits, the solution might lower the borders between higher and lower income groups.	Countries: IS	Market: B2C	Size: SME

3.6.4 Workwear

PSS solutions for workwear have been available in the Nordic market for years. Today there is an increasing focus on environmentally friendly behaviour in the industries the PSS providers target, as demand from the B2B and especially the B2G market is rising continuously. All identified providers offering PSS solutions for workwear are large and well-established companies, often with a global outreach. There is almost no connection to the B2C market, but both short- and long-term contracts with the B2B and B2G market. Therefore, there are often little to no barriers regarding product-service demand.

There is, however, a demand for sustainable workwear, and in more and more B2G cases, workwear with documentation for the environmental impact has become a requirement. The use-oriented models are common among PSS solutions for workwear. The result-oriented models are also on their way to normalisation in the B2B and B2G market as more total solutions and industry 4.0 technology, such as automated operating technology, are implemented. There are a few strong market actors in the sector and lock-ins among customers are present. The identified PSS solutions for workwear first and foremost offer convenience, as the B2B and B2G customers often are offered a total solution for the workwear (i.e. including personalisation, maintenance, repairs etc.).

Due to the large size of identified companies, the market for this service is already well developed. This implies that strategies for reuse and recycling of waste reductions are already implemented, and transport of the workwear can be coordinated to reduce overall transport. The large size of the companies enables the Nordic market actors to put significant pressure on affected value chains for sustainably produced materials. Thereby the Nordic market actors have the opportunity to increase demand and requirements for sustainable sourced and processed textiles.

Lindström[211]	**PSS model:**		
Lindström is a family owned, large Finnish textile service company, that operates mainly at B2B interfaces in Europe and in Asia. The company's turnover is 388 Meur and it has over 4000 employees. Finland is Lindström's largest country of operation accounting for more than half of the turnover. In Finland Lindström has service centres in 17 locations through which the company aims to respond cost-efficiently and fast to the customer's needs, and avoid unnecessary transportation, which in turn enhances the environmental impact of the service. The rental service for workwear operates in a business-to-business model, and it includes acquiring the workwear, as well as washing, maintaining, repairing, renewing, and storing the products.			
Potential benefits of PSS solution: According to Lindström their textiles are designed to be easy to maintain, repair and recycle, which improves material efficiency and reduces waste. The production of textiles, logistics and washing stages are optimized to reduce emissions. The company says that the service model also lowers the water, detergent and energy consumption of washing.	Countries: FI	Market: B2B	Size: LE

[211] Lindström (n.d.): Workwear services is flexible to your needs.

3.6.5 Accessories & jewellery

Jewellery and accessories are a highly competitive sector, and environmental issues have emerged as a factor of selection for customers and retailers, especially the impact of jewellery products on climate change. Jewellery and some accessories are considered high-impact products due to water pollution, soil erosion, and greenhouse gas emissions from extraction and mining practices. Further, many social aspects of the industry can be problematic[212]. Therefore, better utilisation of existing jewellery products facilitated through PSS solutions, could impact the emissions associated with the production phase. Throughout the project only very few cases of PSS solutions for accessories and jewellery have been identified in the Nordic market. The few available solely focus on expensive and high-end products, thus probably not replacing the production of new accessories and jewellery.

The PSS providers in the Nordics are only targeting the B2C market. All identified PSS providers offer product sale as their primary revenue model, with use-oriented models as an add-on to extend their market reach to other customer types and income groups. There is an equal distribution between renting and leasing models, which appears to depend on the product type and price. From available material it is not fully clear if PSS solutions for this product type are supporting reduction of waste production or improved work conditions in extraction and production, e.g. jewellery.

Geizha[213]	**PSS model:**
Geizha is a Danish SME offering sales and leasing solutions of expensive quality jewellery. The leasing idea grew from the knowledge that quality jewellery can be reused repeatedly since quality products of gold, silver, and gemstones do not perish over time. Therefore, the company created their leasing concept Flex-for-life, where the customer pays a monthly subscription and has the right to switch between the available jewellery while paying the subscription. After a subscription time of 24 months, the ownership of the jewellery is transferred to the customer. Timeless designs are chosen for the products and if the jewellery begins to look worn out, it is polished and prepared for the next customer. In cases where the style of a piece of jewellery becomes untrendy the jewellery is moulded into a new piece.	

Potential benefits of PSS solution:	Countries:	Market:	Size:
The Flex-for-life concept isa new concept in Geizha. The environmental effect depends on the consumption pattern of the consumer, as the PSS solution does not guarantee reduced consumption. This is however highly dependent on the stewardship, regulation and follow-up action of the material sourcing, which has not been fully documented by the provider.	DK	B2C	SME

3.7 Seasonal & special occasions

The number of cultural festivals, major events, public shows, and other seasonal celebrations has grown in the Nordic countries over the years. Various studies have been conducted on the large-scale events' effect on potential economic, social, cultural, and political impacts, parallel to a growing focus on these types of events from funders, policymakers, and planners. Large events and seasonal products play a role in enhancing a country's image, attracting tourists, and stimulating urban actives, but the net activities related to seasonal and special occasions, products, and events can also be negative[214]. Research on events and festivals has predominantly focused on the evaluation of their economic impacts and to a lesser extent, their social and cultural implications. Assessments of the environmental effects are almost non-existing[215]. The potential impacts classified under the environmental, sociocultural, and political headings have been played down or completely ignored[216]. PSS solutions for products utilised on seasonal and

[212] Usapein & Tongcumpou (2015): Greenhouse Gas Emissions in Jewelry Industry: A Case Study of Silver Flat Ring.
[213] Geizha (n.d.): Køb eller flex?
[214] Langen & Garcia (2009): Measuring the Impacts of Large Scale Cultural Events: A Literature Review.
[215] Collins & Cooper (2016): Measuring and managing the environmental impact of festivals: the contribution of the Ecological Footprint.
[216] Langen & Garcia (2009): Measuring the Impacts of Large Scale Cultural Events: A Literature Review.

special occasions might offer a greater focus on environmental, sociocultural, and political subjects while delivering more sustainable products due to an improved utilisation through, e.g. product rental models.

3.7.1 Nordic conditions

The tourism industry has been booming in the Nordic countries, presenting new challenges and possibilities. The Nordic tourism industry has the potential to contribute to economic growth, social inclusion, and environmental awareness and consumption[217], but since the tourism sector affects multiple parts of the economy, identifying common goals can be challenging.

Sustainable tourism development in the Nordics depends on integrated technological innovation and active collaboration and knowledge-sharing between public and private actors in the region[218]. The Nordics have an extensive rental market for many seasonal and special occasion products, including temporary structures such as tents or marquees, furniture, and sound and lighting equipment. Sporting activities also include many well-known PSS schemes. Nordic skiing is the essential form of nature-based winter tourism activities, opening windows for short-term rental of skiing equipment. In summer, backpacking, hiking, canoeing, boating, fishing, and hunting are significant activities with relevant opportunities for PSS solutions[219].

With the Nordic tourism industry booming, new windows are opening for PSS solutions for products and equipment for the sector. The following section will provide insights into different aspects of PSS solutions in the Nordics within the product types: Party equipment, event sound and lights, and sports, camping and hiking gear.

3.7.2 Party equipment

Party equipment is a broad product type, ranging from single-use items to sizeable expensive equipment. Event tents, furniture and electronics are common product types within this category. Throughout the year, there is a demand for party equipment for all markets, and the rental solutions for larger equipment are far from new[220]. However, many PSS case examples provide the same product services, such as party tents or table rental services. Mainly the product renting model is commonly used, offering short-term rental agreements without any other additional services. However, customers are becoming increasingly aware of the environmental impacts of the products used[221].

PSS solutions for party equipment offer reductions in single-use items by replacing them with reusable alternatives, e.g. product rental models. As with other product groups, PSS providers would have an economic incentive to choose more durable products. PSS solutions could therefore increase market drivers for durable party equipment.

Barnas Dag[222]	**PSS model:** 		
Barnas Dag offer rental of a wide range of products and services relating principally to parties for children and young adults. Rentals include catering equipment, sound and lights, games and activities, furniture, and power supplies. Associated services include entertainers for hire. The business model appears to be essentially a rental model, with little accompanying service beyond the possibility for transport and perhaps installation.			
Potential benefits of PSS solution: Possible socioeconomic benefits in making children's entertainment more accessible.	Countries: NO	Market: B2C	Size: SME

[217] Reynisson & Törmänen (n.d.): Tourism in the Nordics. -
[218] Malmborg & Reynisson (n.d.): Sustainable Tourism in Nordic Harbor Towns.
[219] Hall et al. (2009): Nordic Tourism: Issues and Cases.
[220] Kataria (n.d.): Comprehensive Guide on Party Supplies & Event Equipment Rental Industry.
[221] Kataria (n.d.): Comprehensive Guide on Party Supplies & Event Equipment Rental Industry.
[222] Barnas Dag (n.d.): Vi gjør store dager enda større!

3.7.3 Event lights & sound

Sound and lights are often considered one of the most critical aspects of an event when it comes to creating a sound and festive atmosphere[223]. There is, however, low awareness of environmental sustainability within the audio-visual production sector and its impact on CO_2 emissions[224]. This proposes an opportunity to improve the environmental impact through the use phase of the equipment, which PSS providers could facilitate through, e.g., rental – and total solutions on lights and sound. Most PSS providers offering event lights & sound solutions are oriented toward the B2B market, and products are often costly and big. However, some providers also offer their services to the B2C market, but often for larger private events like weddings, where especially product renting and leasing models are the most common. However, many PSS solutions providers for event lights & sound offer result-oriented services for, e.g. light shows or live bands.

The core offerings for these PSS models are typically convenience and accessibility to expensive products. The PSS provider can facilitate environmental impact reduction by, e.g. choosing energy-efficient and durable equipment. With the demand for sustainable PSS solutions for event light and sound, market pressure for energy-efficient products could have a positive effect.

Festkungen[225]	**PSS model:**		
This small company is a complete supplier of sound, light, and technology, renting out professional sound and light equipment for all events and contracting professional sound and light technicians. In addition, the company rents stages and tents and can even source DJs, troubadours, and live bands. The company also tailors and packages these individual services to provide a complete experience. Combining expertise with hardware rental, their service aims to maximise the experience generated with key hardware.			
Potential benefits of PSS solution: With the company's interest in deploying and renting out equipment, the use intensity of their equipment on hand can be higher than if individual professionals or private persons were to own such equipment and only use it on rare occasions. Such a solution can help reduce the production and stock of such equipment in the economy.	Countries: SE	Market: B2C & B2B	Size: SME

3.7.4 Sports, camping & hiking gear

When looking at the Nordic tourism sector and local outdoor life, the gear needed for sports, camping and hiking adds to significant amounts. The downside of this flourishing tourism sector is the environmental impact caused by the production and life cycle of the garments and equipment perhaps used only for a short period. For most people, renting would likely be more accessible, convenient, and sustainable than buying[226], giving reasonable grounds for PSS solutions with environmentally awareness on the rise.

The relevance of rental and other types of PSS solutions differs depending on the sport, making PSS solutions for sports and activities with specialised and often expensive gear most applicable. This applies to some of the seasonal sports practices in the Nordics, such as skiing and surfing. PSS solutions further enable people to try out different types of sports without committing fully to expensive equipment purchases, which could facilitate lower amounts of mistaken purchases. PSS solutions for sports, camping and hiking gear can potentially improve the utilisation of the products, as most of them are used for brief periods. PSS solutions could provide market pressure for durable design and the development of structures for reuse, repair, and maintenance.

The use-oriented model is most common among the identified PSS providers in the Nordics. Still, many providers offer either product- or result-oriented PSS solutions as an addition to rental or leasing options. Most identified PSS providers offer their product services to the B2C and, to a lesser extent, the B2B

[223] Jelfs (2020): The importance of sound & lightning at your event.
[224] Interreg Europe (n.d.): Greening the Audio Visual Industry.
[225] Festkungen (n.d.): Låt oss hjälpa dig.
[226] Lettig (2021): Rental: A new frontier for the great outdoors.

market. Solutions offered to the B2B market are often result-oriented, such as workshops and teambuilding, including equipment rentals.

Iceland Camping[227]	**PSS model:**
Iceland Camping is a steadily growing rental service, initially established in 2011 by a French couple but now owned and operated by Icelandic entrepreneurs. The selection of equipment for rent covers everything needed for hiking and camping, including tents, sleeping bags, hiking boots, outdoor jackets, cooking equipment, etc. The customers are mainly tourists from abroad, but tour operators are increasingly using the service to escape the need to buy and maintain an equipment inventory for their customers. This B2B part of the business is growing, partly due to strategic partnerships with car rentals, bus companies, etc. When the equipment no longer fulfils the quality standards of Iceland Camping, it is sold at low prices at a 2nd hand market.	

Potential benefits of PSS solution:	Countries:	Market:	Size:
As with many other PSS models, the solution of Iceland Camping has the potential to reduce the demand for virgin raw materials, prevent the accumulation of rarely used garments in garages and attics, and prevent waste from being created. Additionally, it might open up for new possibilities for lower income groups.	IS	B2C & B2B	SME

3.8 Electronic equipment & solutions

We live in an era where IT and digital information has exploded. Electronic waste is a rapidly growing stream, and most electronic appliances are prematurely discarded – not due to lack of function but to being outdated. The large amount of electronic waste created poses a threat to both the environment and human health, and the amount of recyclable material that could have been utilised is striking. In 2016, about 45 million tonnes of electronic waste were produced worldwide, and in 2019, the world generated 53.6 million tonnes of electronic waste, corresponding to 7.3 kg per capita[228]. While the negative impacts of production and end-of-life handling of electronic appliances are vast and growing, most people are unaware of the challenges this approach to IT can create. Lack of proper recycling leads to the release of toxic compounds and the continuation of mining impacts for the production of new IT products[229].

PSS solutions for electronics could create more sustainable usage and open up new markets for refurbished, maintained, or repaired IT. An LCA study shows that use-oriented or product-oriented refurbishment PSS solutions offer significant potential for reducing the impacts associated with terrestrial ecotoxicity, human toxicity, and depletion of mineral resources, exposing the environmental and social impact potentials[230].

In addition to the increasing amount of e-products used (and wasted), the amount of data needed worldwide is also increasing due to virtual worlds, wikis, blogs, e-mails, online games, traffic systems, and much more. Today most businesses are unable to thrive without entering the digital market. Cloud-based computing provides new capabilities to store, search, mine, and distribute massive amounts of data in organisations. IT integration in businesses has provided many opportunities. However, these come with a polluting downside, from the extraction of raw materials, production, use-phase, and disposal[231]. This is an example of another aspect of the PSS spectrum, and the following section will further provide insights into cloud-based PSS solutions, including streaming services and other online platforms for entertainment and knowledge.

[227] Iceland Camping (n.d.): Want to be closer to nature?
[228] Nunes et al. (2021): Life cycle analysis of electronic products for a product-service system.
[229] Bansal et al. (2016): Socio-economic and environmental impact of electronic waste.
[230] Nunes et al. (2021): Life cycle analysis of electronic products for a product-service system.
[231] Bagheri & Shaltooki (2015): Big Data: Challenges, Opportunities and Cloud Based Solutions.

3.8.1 Nordic conditions

The Nordic region is one of the global leaders in the digital economy and an outstanding digital economy market, with more than 90% of the population being regular internet users[232]. The emergence of new streaming-based solutions has been conspicuous in the Nordics, from small local services to national solutions and even some services entering and dominating the global market. Streaming services have allowed for cultural exchange, allowing small, independent producers bypassing traditional gatekeepers and voicing their opinions, but overall, major media corporations and their streaming services dominate the markets of streaming media[233]. During the pandemic, a massive uptake was seen in the Nordics, and if following international trends, this could be the new normal[234].

The Nordic region has been the starting point of many globally known digital solutions such as Spotify, Skype, and Trustpilot, so the Nordics are a breeding ground for innovative digital solutions. The high GDP per capita in the Nordics enables the average person to spend more on technology than in most other regions, and statistics show that Nordic citizens are very curious about the latest technology. The technological market growth is supported by the Nordic governments with implementation of numerous innovation policies to support tech development, from R&D tax credits to grants[235].

In terms of marketing of electronic products, B2B operations typically involve offers for rental or leasing alongside outright purchase opportunities. In some cases, leasing options appear to offer financing assistance but little else by way of service. Other examples feature more solution-oriented offers, perhaps facilitated by bundling across product groups, such as IT hardware being bundled with office furniture, software, or other services. In contrast, there is a weak market for leasing or renting IT equipment to private customers, with conventional retail being the typical business model, sometimes embracing reused or refurbished products.

The global COVID-19 pandemic had a significant impact on the entertainment industry and changed the driving forces in the dynamics of media and entertainment. Habits accrued during the long periods of lockdown and restrictions remain embedded, illustrated by a growing shift towards digital products and online sales. The most prominent entertainment growth is seen in areas such as virtual reality, video games and e-sports, music, radio, podcast, and e-books[236]. The following section will provide insights into different Nordic PSS solutions within the product types: Computers and smartphones, printers, batteries, and cloud-based solutions and streaming services.

3.8.2 Computers & smartphones

Computers and smartphones are high-impact products, completely essential in most people's daily lives. Although the reduced environmental impact in reuse and recycling of appliances is evident, current take-back schemes of computers and smartphones are not very effective[237,238], making PSS solutions a potential solution for prolonging lifespan and increasing reuse and environmentally sound recycling. In the Nordics, renting- and leasing solutions for the B2B market have been present for quite some time.

Most of the identified providers offering PSS solutions for computers and smartphones can be classified as SMEs, often branding themselves as founded on circular principles. Many PSS providers offer refurbished products, arguing that the recycled materials and reused products enable significant environmental impact reductions. Currently, the use-oriented models are dominant, e.g. product leasing,

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[232] Christensen et al. (2018): Data centre opportunities in the Nordics.

[233] Andersen & Lüders (2021): Streaming media – Production, interfaces, content and users.

[234] Ceci (2022): Share of individuals using video streaming services weekly before and during the coronavirus outbreak in the Nordic Countries in 2020.

[235] Carlsson (2019): Why the Nordics are the Tech Market to Watch.

[236] Pwc (n.d.): 2021 Outlook segment findings.

[237] Suckling & Lee (2015): Redefining scope: the true environmental impact of smartphones?

[238] André et al. (2019): Resource and environmental impacts of using second-hand laptop computers: A case study of commercial reuse.

where some product- and result-oriented services are additional. All identified providers offer product services for both computers, smartphones, and a wider range of IT products such as monitors, cables etc. Some also provide take-back or sales of used electronic equipment. However, PSS solutions for computers and smartphones could increase a 'fast replacement' culture since these product types quickly become outdated by newer models. The life cycle approach of the provider is, therefore, essential for the potential environmental benefits of the solution.

Release[239]		**PSS model:**	
Release engages in the repair, refurbishment, and reselling of mobile phones as well as leasing refurbished ones, making the PSS model both use-oriented (leasing) and product-oriented (selling refurbished phones, the primary model). There are separate offerings for business and private customers. Business customers are offered leasing options which come with a functionality guarantee. Private customers are offered a conventional retail operation for (refurbished) phones.			
Potential benefits of PSS solution: Reduce consumption of consumer electronic goods through repair and refurbishment.	Countries: NO	Market: B2C & B2B	Size: SME

3.8.3 Printers

The printing industry has long been using PSS solutions due to increased effectiveness and efficiency of printing operations and financial analysis showing that there are long-term benefits to the manufacturer and users of printing machines when utilising PSS models. Studies show that PSS printing solutions extend the printing machines' lifecycle due to better device maintenance[240]. PSS solutions for printing services are relevant from a Total Cost of Ownership (TCO) perspective since one of the major costs of ownership for printers is maintenance. There are various PSS printer solutions in the Nordics, of which the use- and product-oriented models are the most common. Result-oriented models are to a larger extend available for printers than many other product types, where the pay-per-service unit, e.g. pay per print, is dominant. The B2B market is the most targeted among providers of printer solutions, but the B2C and B2G markets can also be considered in most cases.

PSS solutions for printers could reduce environmental impact through better maintenance and repair services, which might result in reduced consumption and more efficient use of the machines. PSS solutions could further enable more companies to utilise high-quality industry or business printers since the PSS providers handle acquisition prices.

Dustin[241]		**PSS model:**	
Dustin Group is a multi-national enterprise, specialised in IT solutions. Dustin was founded in Sweden in 1984, and expanded their online business model to Denmark, Norway, and Finland in the 2000's and Belgium and the Netherlands in the 2010's. Besides product-sales, Dustin offers a range of IT services, such as the total solution 'Managed Print'. The Manged Print solution provides all the tools needed to manage documents, both physical and digital. Through the solution, Dustin provides a cloud-license, installation, hardware, service, support, management and surveillance, automated toner delivery, and transcripts. The standard contract period is 36 months. The contract period can, however, be modified under certain circumstances. The services offered in the Manged Print solution are overall aligned with the concepts of the activity management model, oriented towards small and large enterprises, and governmental entities.			
Potential benefits of PSS solution: The potential environmental benefits depend on the individual agreement. Through the Managed print, the customer is offered printers as a part of the total solution. These printers are produced with recycled plastic and describes that they ensure proper reuse and recycling	Countries: SE DK, NO, FI	Market: B2B & B2G	Size: LE

[239] Release (n.d.): Tenk nytt, velg brukt.
[240] Salwin (2021): Design of Product-Service Systems in printing industry.
[241] Dustin Group (n.d.) Managed Print.

practises. Including printers in the offer provides an economic incentive, for Dustin, to prolong product lifespan. Toner deliveries are based on feedback mechanisms, enabling a potential reduction in wasted toner.			

3.8.4 Batteries

If not appropriately recycled, batteries can cause a significant impact on the environment due to mixed metal components and heavy metals. Taxation on batteries has been present in the Nordics since the 1990s, and extensive collection schemes have been implemented[242]. However, consumers still lack awareness of the issues connected to battery recycling, illustrated by the fact that 44% of the Danish population are unaware of the 30 years of collection schemes, resulting in inefficient collection rates[243]. PSS solutions for maintenance and collection of batteries could counteract the improper treatment.

Few PSS providers offering battery solutions have been identified in the Nordics offering product-service solutions on larger batteries, e.g. electric bikes, scooters, and cars. The low number of cases can be due to the challenges related to repair services for batteries. For many e-products, maintenance and repair of batteries are difficult, challenging cost-effective repair services for independent repairers[244]. Of the few identified companies are all oriented toward the B2C market and utilising product-oriented models.

The environmental impact potential of PSS solutions for batteries are highly dependent on the type of battery and electric product, type of components in the batteries, and the approach of the PSS provider. PSS providers offering repair and maintenance services on batteries can enable impact reduction, based on reduced consumption of scarce materials, reduced hazardous waste, and improved reusability, due to prolonged lifespan. These types of PSS solutions will most likely benefit from product passport regulation, suggested in the European Commission's proposal for a new Battery Regulation[245]. PSS providers offer swapping schemes by replacing batteries which could be repaired, can result in an increase of the environmental impact. Swapping schemes are often easier and faster, and in some cases cheaper, and will cause the PSS solution to contribute to higher consumption of scarce resources, and an increase the amount of hazardous waste produced. The latter could, however, still offer environmental benefits with proper waste management practices, if the alternative entail a complete replacement of a given product, e.g. a smartphone or an electric bicycle[246].

Nordjyllands Batteri Service[247]		**PSS model:**	
Nordjyllands Batteri Service is a Danish company selling new batteries but also providing repair and maintenance of batteries and battery management systems. Customers' batteries for electric bicycles, boats, e-scooters, auto campers, and solar cell packages can be sent for repair at Nordjyllands Batteri service; if they deem the battery repairable, they offer two years warranty on the repair. Nordjyllands Batteri service started offering repairs to extend the lifespan and reduce the need to produce new batteries, thereby reducing the environmental impacts.			
Potential benefits of PSS solution: As batteries significantly impact the extraction and production phases, repairing batteries for different purposes could provide an environmental benefit. The product-oriented models are, however, still very focused on sales, which provides an incentive for selling instead of preparing if sales are the cheapest option.	Countries: DK	Market: B2C	Size: SME

[242] Olofsdotter (2002): The Use of Economic Instruments in Nordic Environmental Policy 1999-2001.
[243] Elretur (2022): Halvdelen af danskerne kender ikke til batteri-ordninger.
[244] IIIEE & EEB (2021): Removable, replaceable and repairable batteries – how to improve the circularity of rechargeable batteries in consumer electronics and light electric vehicles.
[245] JRC (2022): 5 ways EU scientists are making batteries better, safer, and greener.
[246] Right to repair (2021): Non-replaceable batteries are bad news for the environment and consumers.
[247] Nordjyllands Batteri Service (n.d.): Har du problemer med dit batteri, eller mangler du et nyt?

3.8.5 Cloud-based options & streaming services

With the digitalisation of the Nordic countries, many cloud-based solutions and streaming services have become widespread and in demand. Cloud-based options come in a wide range of implementations and are built for either consumer or business usage while streaming services primarily target the private consumer market. The consumer-oriented solutions for cloud-based options and streaming services are often low-cost mass-market solutions. In contrast, business-oriented cloud-based solutions are often more robust, focusing on reliability, availability, security, privacy, and options for customisation. With streaming services for, e.g. e-books, the e-books can be considered the product. Therefore monthly subscription plans for e-book streaming services can be viewed as a use- or result-oriented model. All identified PSS solutions for streaming services are targeting the B2C market.

There are no significant indications that PSS solutions for streaming services would provide a reduction in environmental impact. To some extent, the PSS solutions facilitate a reduction of paper with e-books and a reduction in the transport of books and movies, but whether this can be counted as a significant reduction is questionable. It can further be questioned whether PSS solutions for streaming services challenge the utilisation of public libraries, which often provide additional community services such as IT aid for the elderly, entertainment for children and a place for local meetups.

PSS solutions for cloud-based option are already a part of the Nordic market exemplified with software as the product, licensed on a subscription basis. On-demand service is managed on a provider's cloud computing infrastructure, and the provider is often responsible for guaranteeing the software's back-end security, management, availability, and application upgrades[248]. The cloud-based solutions identified in the project mainly utilised result-oriented models, with only a few products involved. The B2C market is small to non-existing. However, there is a large B2B and B2G market for cloud-based solutions.

The environmental impact of cloud-based solutions is, like streaming services, challenging to assess, since the only physical product involved is the servers for the cloud-based solution. However, this does not imply that the environmental impact of cloud-based solutions is favourable compared to procurement options since data centres consisting of servers contribute 2% of the total global greenhouse gas emissions[249].

Cloud solutions make it possible for consumers to store more data, which increases the need for storage and associated electricity. There could be several rebound effects connected to Cloud-based solutions. Attempts to reduce the environmental impact of cloud-based solutions are often based on server optimisation.

Prosys[250]	**PSS model:**
ProSys is a Danish SME of self-identified IT nerds. Since 2007, they have delivered IT solutions for all types of companies. ProSys offers a wide range of pure service solutions, including IT, support, IT management and outsourcing, IT infrastructure and cloud-based solutions, and IT consultancy work. Of cloud-based solutions, ProSys offers tailored solutions for RF optimisation and VPN configuration, providing an overview of all devices to businesses. ProSys has no descriptions of their environmental impact or efforts to reduce their impact	

Potential benefits of PSS solution:	Countries:	Market:	Size:
As described above, the environmental impact potential for cloud-based PSS solutions is hard to define. The centralised management of cloud-based solutions does, however, impose an incentive to reduce the energy consumption of, e.g. servers and other products utilised, due to a reduction of the costs for the provider.	DK	B2B	SME

[248] Nordic IT (n.d.): When, where and what about cloud services.
[249] Supermicr (2018): Data Centers & The Environment – The state of Global Environmental Sustainability in Data Center Design.
[250] Prosys (n.d.): Hvad kan vi?

3.9 Other

Throughout the report, different product groups have been presented. Some major product groups have not received their own category due to only a few existing examples within the category. This section will provide insights into some of the specific product types that cannot be considered as well-established PSS solutions in the Nordics, but that have some PSS potential regarding increased product utilisation, reduction of waste, or smart technology utilisation. The following section will provide insights into existing PSS solutions in the Nordics in the categories: Agriculture, infrastructure, animals, plants, and dinner subscriptions and catering.

3.9.1 Agriculture

The Nordic agricultural sector provides products of vital importance, including food, fibres, animal fodder, materials for construction, and energy generation. However, it further significantly impacts drinking water, soil quality, and biodiversity on land and in fresh and saltwater bodies[251]. Very few PSS solutions are currently available in the agricultural sector, but there is potential for new markets for use-oriented solutions in particular. Most existing PSS solutions for agriculture are available in Denmark, which mainly cater to the B2B and B2G market, providing functional result models such as haying executed by one contractor on multiple farms. There is, however, a new trend with the P2P sharing economy platform for agricultural machinery, indicating that PSS models for leasing-, renting- and pooling models have a window of opportunity, with the high acquisition prices for agricultural machinery as a driver.

Depending on the provider, PSS solutions for agriculture could facilitate better utilisation of machinery and thereby reduce resource consumption. PSS solutions could further facilitate access to expensive equipment for the farmers contributing to more efficient land use. Providing access to state-of-the-art innovative technologies, such as precision-based drone distribution of fertiliser and pesticides, could positively impact emissions and pollution from the agriculture sector.

Nielsen's Service [252]		**PSS model:**	
Nielsen's Service is an SME offering agricultural services such as ploughing, potato planting and harvesting, pruning of protective forest belts, and nature conservation services. The ploughing services include evaluating the best methods for ploughing, depending on the soil type. The potato planting and harvesting services are done with the newest technologies, enabling an efficient planting process and harvesting in soft areas. Pruning of protective forest belts and nature conservation services include cutting and crushing of branches, field and forest path care, and maintenance of forest areas bordering up to public roads.			
Potential benefits of PSS solution: Nielsen's Service describes how their services are rooted in sustainability and protecting nature but does not elaborate on how this is achieved. The potential benefits of this solution depend on the agricultural school of thought the assessor belongs. The PSS solution offers a trade-off, resulting in greater efficiency in planting and harvesting. Still, the effects on biodiversity because of the methods utilised could result in both positive and negative impacts.	Countries: DK	Market: B2B & B2G	Size: SME

3.9.2 Infrastructure

The Nordic infrastructure systems are changing to accommodate the electrification of vehicles, and the transition to sustainable energy sources, but also due to changes in the public-private responsibility configurations. Complete privatisation of infrastructure is a sensitive political topic in the Nordics, but co-ownership has been more and more normalised[253]. This poses options for Nordic PSS companies with an

[251] Prestvik et al. (2013): Agriculture and the environment in the Nordic Countries.
[252] Nielsen's Service (n.d.): Vores landbrugsservice.
[253] Carroll & Bentley (2021): Roundtable: Infrastructure's Nordic Opportunity.

understanding of the needs in Nordic countries. Only one Nordic provider of PSS solutions for infrastructure has been identified.

Whether or not these public-private collaborations enable reduced consumption and more efficient resource use is highly dependent on the approach and practices of the providers. However, PSS solutions for infrastructure reduce the burden of governmental tasks and provide a competitive market. As much public procurement focuses on sustainability to a greater and greater extent, PSS solutions for infrastructure in the B2G market could provide incentive structures for sustainable PSS solutions. Further, the technology-based PSS solutions for damage detection to infrastructure could reduce materials input by identifying damage in an early stage.

Pluto Technology[254]	**PSS model:**
Pluto Technology is a start-up SME offering administration of municipal infrastructure based on artificial intelligence technology. Their goal is to make the comprehensive tasks connected with overview, maintenance, and repair of the public road network easier for municipalities, using an application that scans the roads and that can be placed in municipal vehicles and thereby be active when the municipalities perform another task. The application identifies minor and acute damage of the roads, enabling optimization of maintenance and repair done on public roads. Timely repair can extend the life of the roads by up to 30%, and the overview provided by the application makes it possible to prioritize maintenance according to the damages. Pluto Technologies thereby ensures that materials used for maintenance can be reduced through prolonging of the lifetime of the roads, and reduced repair of vehicles damaged from poorly maintained roads.	

Potential benefits of PSS solution:	Countries:	Market:	Size:
As Pluto Technology offers a result-oriented PSS solution, the potential benefits are hard to define quantitatively. Their technological solution provides needed data on road damage, which could lead to better maintenance of the road and thereby reduce the amount of material needed for maintenance and reduce the damage done to cars using the roads. These effects are, however, completely dependent on the action taken by the municipalities utilising Pluto Technology's services.	DK	B2G	SME

3.9.3 Animals

Animals may not appear as the most apparent PSS product type compared to many other product types presented in this report. However, some innovative PSS solutions based on ecosystem services provided by animals have been identified in the study. This product type is included due to its potential contribution to biodiversity and animal welfare. A few providers offer PSS solutions with animals as the "product", while some offer the yield of animal husbandry, such as honey.

The environmental impact of PSS solutions with animals is undocumented and highly dependent on the animals, the intensity of production, waste management, fodder, transport, and packaging of products derived from the animals. However, positive impacts on local biodiversity could be an effect, e.g. in the case of using grazing animals for nature preservation, which could also significantly affect animal welfare for animals otherwise kept in small spaces. There is also an advantage for the ecosystems themselves, as the use of grazing animals can be better for soil conservation and compaction compared to the use of heavy machinery for mowing, for example. Still, animals also emit greenhouse gases, so whether or not PSS models for animals provide a positive net is unsure.

Rent a Cow[255]	**PSS model:**
Rent a Cow is an SME offering two services involving cows. Firstly, they provide a rental solution, where a landowner or farmer rents a herd of cows for grazing an area. This practice has been utilised in Denmark for 6000 years since the approach is a very suitable method for caring for common nature types in Denmark, such as pastures, fresh and salty meadows, heathlands, and less open deciduous forests. Most of these nature types can be disrupted by the	

[254] Pluto Technologies (n.d.): Bedre veje med kunstig intelligens.
[255] Rent a Cow (n.d.): Rent a Cow har nu på 10. år alene fokuseret på naturpleje, afgræsning og dyrevelfærd.

sudden growth of shading trees, so the cows are used to keep the vegetation growth down. Rent a Cow further offers to comply with Danish legislation on nature protection, which affects approximately 10% of the Danish land area. With this offer, Rent a Cow is responsible for ensuring that the law is complied with and obligations are fulfilled, lifting the burden from the private landowners and municipalities. The cows provide the light and space needed for the local biodiversity to flourish, all while the cows can live as natural a life as possible.			
Potential benefits of PSS solution: Cows have been offering essential ecosystem services for centuries in Denmark, such as grazing in heathlands, where trees and larger shrubs threaten the ground cover necessary for insects. The model provided by Rent a Cow simulates natural interaction in the ecosystem of some of the Nordic nature types, enabling the maintenance of areas where overgrowth is detrimental to biodiversity without machinery. Besides compliance with nature protection regulations, the PSS model provides better animal welfare than conventional husbandry and more balanced fertilisation than, e.g. artificial fertilisers.	Countries: DK	Market: B2C, B2B & B2G	Size: SME

3.9.4 Plants

Plants are an important aspect of interior design in the Nordics and have been connected to the improvement of physical health, positive characteristics of a room, and better emotional state of mind[256]. PSS solutions for plants are available for the Nordic B2B and B2G markets but has not been identified for the B2C market. The most common product-services offered are potted plants, plant walls, and maintenance services. A few PSS providers offer the functional result model for plants at offices, e.g. in the form of agreements such as an offer that green plants will always surround the customer. Use-oriented models are most common for PSS solutions for plants in the Nordics, in the form of rental agreements for plants, including maintenance.

The environmental impact of PSS solutions for plants is affected by the way plants are produced. If the plants are grown in heated greenhouses, there could be high emissions related to the production of the plants. The mere production of plants can further contribute to the increased use of fertiliser and pesticides, resulting in nutrient pollution of water bodies. If probably facilitated, PSS solutions for plants could prolong the lifespan of the plants providing positive psychological effects and CO_2 capture. Depending on the transportation, plant type and maintenance approach, PSS solutions might positively affect the environmental impact compared to traditional business models for plants.

Ambius[257]	**PSS model:**		
Ambius is a Swedish company offering sale, design, installation and maintenance of plant furnishings to businesses. Besides the traditional selling model, the company also provides a use-oriented business model renting plants to decorate the work environment. The subscription model includes design, installation and regular maintenance to ensure that plant arrangements are in the best possible condition. The ownership of the plant furnishing stays with Ambius. The value proposition includes a reimbursement when the plants have lost their ornamental value, provided that the company hire Ambius to continue the maintenance of the plant furnishings			
Potential benefits of PSS solution: The plant furnishings service is designed to ensure that the plants stay healthy and live longer. However, no documentation is provided by the company to fully assess the environmental benefits of the solution. Another potential benefit could include increased well-being for employees in their work environment.	Countries: SE	Market: B2B	Size: SME

3.9.5 Dinner subscriptions & catering

Catering can be considered an old type of PSS solution and has been included in this study due to its potential to help change cultural food habits. Associating, e.g. organic or plant-based food with a good experience through catering poses a possibility of changing dietary habits to benefit the environment and

[256] Lohr & Pearson-Mims (2000): Physical Discomfort May be Reduced in the Presence of Interior Plants.
[257] Ambius (n.d.): Kontorsväxter och inredningsdesign.

biodiversity in the Nordics. Dinner subscriptions have also been available in the Nordics for a while and can serve as an example of the successful implementation of PSS models.

Whether PSS models for dinner subscriptions and catering lead to reduced consumption, more efficient resource use, better waste management, and other circular economy aspects is highly dependent on the PSS provider's approach. Some PSS providers further focus on local food sourcing, following the seasonal availability.

Årstiderne[258]	**PSS model:** 		
Årstiderne is a Danish provider of meal boxes, where all needed ingredients and recipes are provided. Årstiderne has a significant focus on sustainability, and the boxes are designed to reduce food waste by only providing what is required. The company collaborates with farmers to reduce overproduction and ensure needed transport conditions. Årstiderne measures its CO_2e footprint every quarter and implements new, more environmentally friendly initiatives based on that data, one being reduced meat in their meal boxes. They utilise an 80/20 principle, meaning that 80% of the meal must be plant-based, while a maximum of 20% of the meal can originate from animal sources, while also offering 100% plant-based boxes.			
Potential benefits of PSS solution: Årstiderne has taken measures to reduce the amount of food waste related to its services. Furthermore, the company has some nudging elements in the business model to increase the amount of plant-based products included in the boxes. By measuring their quarterly CO_2e emissions, they enable data-based actions.	Countries: DK	Market: B2C & B2B	Size: SME

[258] Årstiderne (n.d.): Fødevarer og klima.

4 CONCLUDING REMARKS

The first two steps of the project *PSS in the Nordics* have thrown light on the state of play of PSS solutions in the Nordics. 275 PSS cases of interest have been identified within a multitude of product groups and covering eight different archetypes of PSS models.

- For some product groups, use-oriented PSS models targeting the B2C market are prevalent (e.g. Transportation, Products for children, and Clothing).
- For other product group clusters, the use-oriented models targeting the B2B market are more widespread (e.g. Machinery and tools, and Electronic equipment & solutions).
- And for other product groups again, combinations of PSS models are identified, primarily targeting B2B markets (e.g. Packaging, Appliances, Furniture, and Household products)

The research indicates that use-oriented PSS solutions are quite common in the Nordics, adding incremental innovations and some environmental benefits to the well-known renting and leasing solutions. Although there seems to be significant environmental and economic potential in result-oriented PSS models, up until now, only a few have been implemented in Nordic countries, perhaps due to the rather radical innovations embedded in the models compared to product-sales models.

The position and role of a PSS provider in the value chain have imperative implications for the potential feedback mechanisms for product design innovation coming from customers and users of a PSS solution. Overall, PSS providers are retailers or distributors, while in only 20 % of the cases, the PSS providers are producers, manufacturers, or designers. There is a relatively even distribution between PSS solutions targeting the B2C and B2B markets, whereas only a few – around 15 % - target the B2G market. Consultations with PSS providers indicate that this is due to a lack of accommodation for PSS and circular business models in the criteria for public procurement.

The PSS providers have met a bouquet of different barriers in the pursuit of a proper market share and a sound economy. The main part of the PSS providers experience challenges in competing with the product-sales models utilising cheap and unsustainable sourced materials for their products, enabling low retail prices; lack of interest from the public sector is experienced by many; especially providers targeting the B2C market experience challenges with cultural lock-ins regarding product ownership and consumption patterns, and PSS providers with use-oriented models have challenges in upkeeping an efficient stock to stay attractive to consumers.

The project's first two steps have created significant new knowledge on PSS models, adding to what can be found in literature and among researchers. The project's next step entails a complete sustainability analysis of the most promising PSS models, allowing the Consortium and Steering Group to point out priority PSS models for piloting in step 4.

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