INDICATORS AND METHODS FOR MEASURING TRANSITION TO CLIMATE NEUTRAL CIRCULARITY

Task 5: Case-study group PSS2

Report for: DG RTD, Directorate B – Healthy Planet, Unit B1: Circular Economy & Biobased Systems

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1. INTRODUCTION

The transition to a circular economy (CE) needs to occur on multiple levels, from households and individual consumers to national and cross-border ecosystems. Measuring and monitoring the development of this transition is an ambitious task and is ideally supported by indicators relevant to all steps in that process.

This case-study is one of 19 developed for a research project into "*Indicators and methods for measuring transition to climate neutral circularity, its benefits, challenges and trade-offs*". It provides a detailed summary of the development and testing programme conducted for Group 2 of the Product-Service Systems sub-policy area during Task 5 of the project. The main purpose of this case-study is:

1. Provide an overview of the testing and monitoring method adopted for each indicator.
2. Outline the key results and performance of each indicator.
3. Highlight any challenges or lessons learnt from the identification, planning, delivery and analysis of the relevant methodology for each indicator.

The aim of Task 5 is to take the learnings of all other Tasks thus far and develop and test the new indicators identified in Tasks 3 and 4 as having potential to enable a deeper understanding of the 3 facets of circularity for the five key approaches. This case-study is a direct output of Task 5.

This case-study focuses on the following 3 indicators outlined in Table 1.

Table 1. Overview of case-study group 2 (PSS 3, 5-6)

URN		Indicator name	Methodology	Level of implementation				
				EU	National	City / Region	Companies	Household
PSS3	**1**	The percentage of electric vehicles (EVs), in the category of passenger cars, that are operationally leased	Desk research, data analysis		x			
PSS5	**2**	No. of companies offering PSS-solutions within the electronics and ICT sector	Desk research, Interviews		x			
PSS6	**3**	The no. of public procurement contracts for electronics and ICT that incorporate PSS models	Desk Research, Interviews			x		

2. INDICATOR 1 – THE PERCENTAGE OF ELECTRIC VEHICLES (EVS), IN THE CATEGORY OF PASSENGER CARS, THAT ARE OPERATIONALLY LEASED

Indicator: The share of electric vehicles (EVs), in the category of passenger cars, that are operationally leased

This indicator refers to the number of new EV passenger cars registered for leasing by private consumers yearly as a share of the total amount of EV passenger cars registered by private consumers. It may also be measured based on new registrations in relation to the size of the entire fleet of EVs. Both measures are considered on a national level with the possibility to aggregate to an EU-wide measure.

Passenger cars are responsible for 16% of total CO2 emissions of the EU, which is largely due to the use of fossil fuels in the use-phase of the vehicles (Directorate-General for Climate Action, n.d.). In response, the EU has adopted legislation that bans the sale of new cars and vans with combustion engines from 2035 (Regulation 2023/851). EVs are currently the most prominent alternative to cars with traditional combustion engines, and increased adoption of them is an important element of the circular transition of the vehicle fleet. The provision of PSS models may allow for increased sale/use of EVs (Ensslen et al., 2020) because consumers are twice as likely to choose leasing over ownership, when shifting to EVs (McKinsey & Company, 2023), which itself is an argument for tracking the level of leasing in the EU.

EVs have lower impacts on environmental and climate parameters such as GHG emissions and air pollution compared with diesel and petrol cars. However, there is also a risk of adverse impacts on human toxicity- and ecosystem-related factors (EEA, 2018). The level of positive and adverse impacts is influenced by multiple variables across the entire life cycle and value chains of the vehicles, incl. design, manufacturing, use, and recycling. This makes it difficult to make broad-sweeping conclusions on the vehicle sector and benefits of EVs. Promoting a circular economy approach may provide opportunities to secure a beneficial development on the level of these impact variables and sustainability improvements of the critical components of EVs.

The most important element is EV batteries, which has been recognised and addressed by the EU with the updated Batteries Regulation (Regulation 2023/851). The updated regulation aims to make the entire battery lifecycle more sustainable and circular. PSS models, including leasing, consolidate the control of vehicles to fewer actors, which consequently get increase power and influence on the value chain. Because leasing operators have an incentive to increase, for example, the durability and repairability of batteries and other critical components, they will put pressure on other stakeholders to improve these metrics. This will help support a fast and successful implementation of the Batteries Regulation and contribute to even further improvements to circularity and sustainability of the EV industry.

This may be part of the motivation for the EU Circular Economy Action Plan (CEAP) to emphasise circular business models and product-service systems (PSS) for securing more sustainable vehicle fleets and mobility in the EU (European Commission, 2020). PSS models in the automotive industry can take multiple forms including operational leasing, mobility-as-a-service, and car sharing, as well as PSS solutions targeting vehicle parts (such as engines) rather than the vehicles themselves. The high growth rates of EVs have only occurred in recent years, therefore there is limited empirical research and data on the key environmental and climate-related metrics concerning the benefits of PSS-models compared to traditional ownership of EVs.

The World Economic Forum released a study in 2021, developed with Accenture Strategy and 40 companies from the automotive value chain, which proposes a five-step circularity taxonomy based on two primary measures, carbon and resource efficiency. The taxonomy aims to support actors in evaluating and improving the circularity of cars. Smart mobility and as-a-service solutions for vehicle parts lie in the upper levels of the taxonomy – assuming urban and rural implementation alike. Leasing of vehicles is considered on a lower level of circularity, but still on step towards full circularity compared with current state of affairs (World Economic Forum, 2021).

Going from traditional private ownership to operational leasing may be a stepping stone in the transition to shared mobility services, which will require innovations in how the car fleet is managed and owned. This is

already exemplified by existing business models in the EU, where private leasing of EVs is combined with a peer-to-peer car-sharing and ride-sharing platform to provide a comprehensive solution for both primary car owners/leaseholders and occasional users (GoMore, n.d.).

The benefits of monitoring and choosing this indicator include:

- Incentivising further scrutiny of the fast-growing EV leasing market and stimulating the required research to understand and document the circularity potential and environmental impacts of this PSS model.
- Providing important data and analyses for policy making on this very important sector in terms of climate impact and resource use.

The following sections will suggest a methodology for testing and monitoring this indicator, including two case studies trialled in the testing, and will finish with conclusions on the relevance and applicability of the indicator.

2.1 KEY METHODOLOGY

2.1.1 Testing method

System boundary

Leasing of vehicles is a very standard practice, but the term can be used to refer to two very distinct leasing models of which only one may be interpreted as a PSS model. The type of leasing under investigation is referred to as; “operational leasing,” which means that the company owning the vehicle (the lessor) maintains ownership during and after the leasing period. The definition excludes financial leasing, where the leaseholder (lessee) is obligated to purchase or name a purchaser, at the end of the lease period (IRFS, n.d.); this is a financing model rather than a PSS. Only “operational leasing” can be defined as a PSS model with the potential benefits for circularity and the positive environmental, social, and economic impacts that are associated with these business models.

When referring to EVs in this report and regarding data collection, we only consider Battery Electric Vehicles (BEVs) and not Plug-in Hybrid Electrical Vehicles (PHEVs), even though they are typically both considered EVs[1]. This is because the PHEV includes a combustion engine, and the data regarding CO2 emission reduction potential and the future of these vehicle types are to be re-evaluated in the coming years as per the EU regulation (Regulation (EU) 2023/851).

The indicator is measured on a national level to align with metrics collected by National Statistical Institutes (NSIs), which allows for comparison across EU countries. Leasing of vehicles is a very accessible and normal activity, and therefore, there are no prominent regional or local conditions that would make it appropriate to limit comparisons to regions or cities. Simultaneously, it is likely that there are large differences among EU countries, which makes it less appropriate to investigate the indicator solely at an EU level.

Sweden and Austria have been selected as cases for testing the indicator and constitute the system boundary for the data collection. The two MSs have (respectively) high and medium rates of annual new registrations of EV passenger cars, compared with other MS (European Environmental Agency, 2023), and have different growth rates for their leasing markets (Leaseurope, 2023). The specific variances between the two countries are not directly relevant for conclusions on the indicator's relevance, but the ability to compare progress across countries is an advantage. If both countries have relevant data readily available, this also improves the chances that the indicator could be implemented with data from across the EU member states.

The market share to be measured for each case can be defined in several ways, including by the number of new vehicle registrations per year and the total number of vehicles in the registered car stock. For this research, data based on both definitions will be relevant so both data points were collected.

Methodology

The indicator will be tested by collecting data from existing authoritative sources nationally. The data is self-reported by the industry and aggregated by other actors. Depending on the reliability and availability of the data, stakeholder engagement via interviews may be conducted to collect insights on data gaps and the possibility of securing the necessary data now or in future. The collected data will be analysed to conclude on

[1] https://alternative-fuels-observatory.ec.europa.eu/general-information/glossary

the topic and provide recommendations regarding the indicator and methodology. Below is an overview of the data sources and an assessment of their reliability and availability.

Table 2. Source, reliability and availability.

Source	Reliability*	Availability**
Trafikanalys (Sweden)	*Medium*	*Medium*
Finansbolagen (Sweden)	*Medium*	*Medium*
Statistik Austria	*Medium*	*Medium*
Verband Österreichischer Leasing-Gesellschaften (Austria)	*Medium*	*Medium*

* ***Low*** *= Some data will likely be missing and incomplete, which may lead to inaccurate conclusions*, ***Medium*** *= The data will likely be complete but may lack accuracy and quality,* ***High*** *= The data will likely be complete, accurate and of high quality.*

** ***Low*** *= The data is not already collected or readily available, and will be difficult to collect.* ***Medium*** *= The data is already collected but is not publicly available, OR the data is not already collected but is easy to collect,* ***High*** *= The data is readily available and can be accessed easily.*

2.1.2 Data collection method

The data points required for testing the indicator are:

- Total amount of EVs in traffic and/or newly registered, all ownership types
- Total amount of EVs in traffic and/or newly registered through operational leasing

National Statistical Institutes provide publicly available data points on vehicle stocks and new registrations. We first conducted a thorough search on the websites of the NSIs of Sweden and Austria to investigate whether statistics on the indicator were readily available.

It was discovered that data was available on the number of new registrations of EVs and of EVs in traffic and that ownership form, including leasing, was also collected by both NSIs. However, the right cross tabulations were not available on the websites, so it was necessary to contact the NSIs with data requests for the specific data points needed. Both NSIs replied promptly and were ultimately able to provide the required data. Once the data was received, it was consolidated in one Excel sheet with translation and unification of relevant terms and titles before data analysis.

The national leasing associations were contacted simultaneously with the data requests to NSIs to attempt this as an alternative source of data. No data was received from the two leasing associations.

2.1.3 Calculations

A simple calculation was used to calculate the share of ownership through operational leasing of the total amount of EVs in traffic and newly registered per year. The number of EVs registered for operational leasing is simply divided by the total amount of EV cars and converted to a percentage.

2.1.4 Timeline

The testing phase was conducted as outlined in the Gantt chart in Table 3.

Table 3. Gantt chart PSS3.

WC	01.jan	08.jan	15.jan	22.jan	29.jan	05.feb	12.feb	19.feb	26.feb	04.mar	11.mar	18.mar	25.mar	01.apr
Finalise Data Collection Plan														
Desk research and data collection														
Stakeholder engagement														
Data analysis														
Reporting														
Review period														

Legend

Task progress

Review period

2.1.5 Data gaps and mitigation

The sources selected for data collection are national statistical institutes mandated to collect authoritative data from financial institutions and other companies. There are EU standards on the quality, reliability, robustness, etc., of the data they collect (Eurostat, n.d.). The indicator's focus is a very established industry with strong reporting mechanisms, and the data components of this indicator are directly available. Thus, the data gaps are expected to be minimal.

However, a potential limitation of the data relates to the potential lack of separation of data between operating and finance leases. This challenge is discussed below in the section on Limitations. As described in the data collection plan, consultations with national leasing associations would give insights into the industry's practices and presumably clarify the level of uncertainty in the data received by the statistical institutions.

Table 4. Overview of identified data gaps, limitations and mitigation efforts.

	Description of data gap	Mitigation efforts	Level of confidence
1	Possible lack of separation of data on financial vs. operational leasing	• Interviews with key stakeholders in the leasing industry to clarify gaps.	Medium

2.1.6 Quality review of analysis

To ensure robust and high-quality results, we have conducted the following data validation and quality control procedures:

- Prior to work beginning, the Project Director (Jess Twemlow) reviewed the proposed research methodology and ensured that the data collection plan was fit for purpose. Once the research team addressed any comments from the review process, they proceeded to the data collection phase.
- Project Coordinator Bjørn Bauer oversaw the data collection phase to ensure that the collected data and analysis conducted was of a high standard and provided useful content for the final case study output.
- Andrew Dunwoody is responsible for the quality of the final case study output. Rob Snaith has assisted Andrew Dunwoody in judging the quality of the output and suggested ways to improve.

2.2 KEY RESULTS

2.2.1 Analysis

Sweden

The data shows a substantial increase in leasing from year to year during the period, while regular ownership experiences a smaller growth. The share of the total amount of new registrations between leasing and ownership in 2020 was 54% and 46%, respectively, whereas in 2022, the gap was significantly higher, with 71% leasing and 29% ownership. This development reflects the annual growth rate for leasing, 273% in 2021 compared with 2020, and 83% in 2022 compared with 2021. In comparison, regular ownership of EVs “only” grew by 102% and 59% in the same years.

Out of the total number of EVs “in traffic,” the share of leasing increased from 33% in 2020 to 55% in 2022, as shown in the graphs and tables below.

Table 5. Leasing vs. ownership of EV passenger cars in Sweden, % per year, 2020-22.

Owner Type	Private			
Country	SE			
Sum of Value		**Year**		
Category	**Ownership Type**	**2020**	**2021**	**2022**
In traffic				
	Leasing	33%	48%	55%
	Ownership	67%	52%	45%
In traffic Total		**68%**	**65%**	**68%**
New registrations				
	Leasing	54%	68%	71%
	Ownership	46%	32%	29%
New registrations Total		**32%**	**35%**	**32%**

Figure 1. Leasing vs. ownership of EV passenger cars in Sweden, % per year, 2020-22.

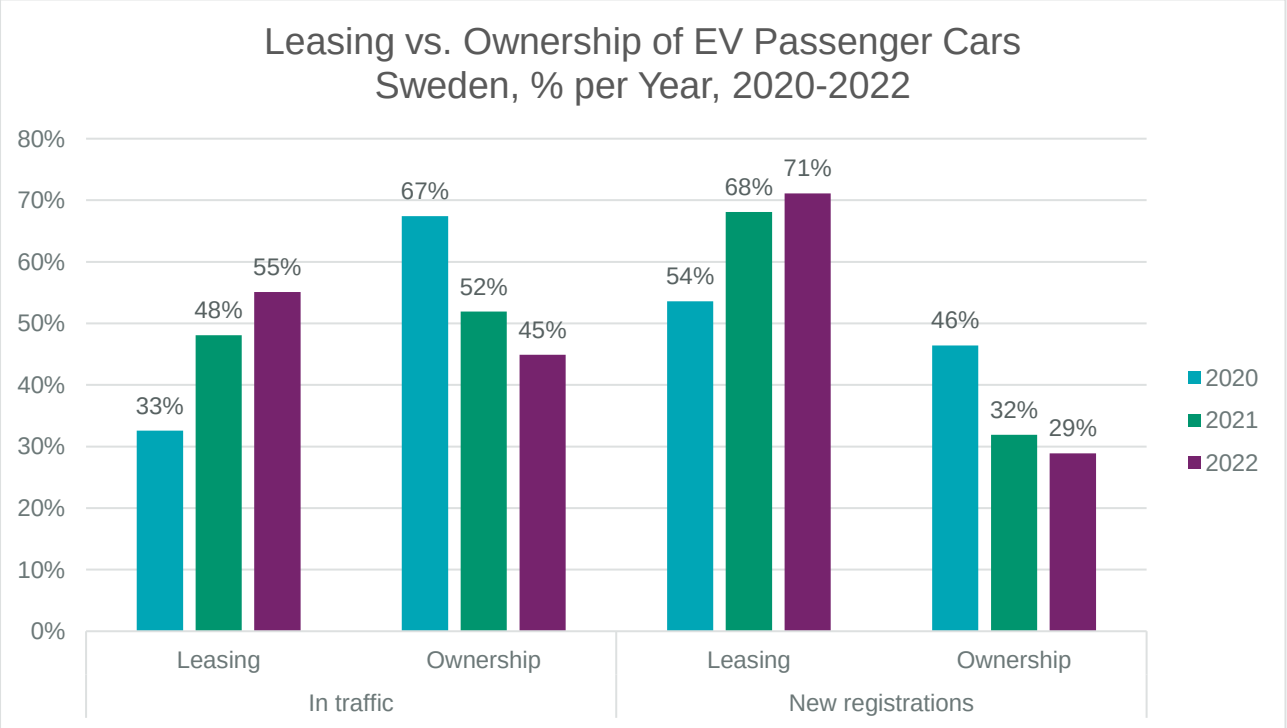


Figure 2. Leasing vs. ownership of EV passenger cars in Sweden, dif. from previous year, 2020-22.

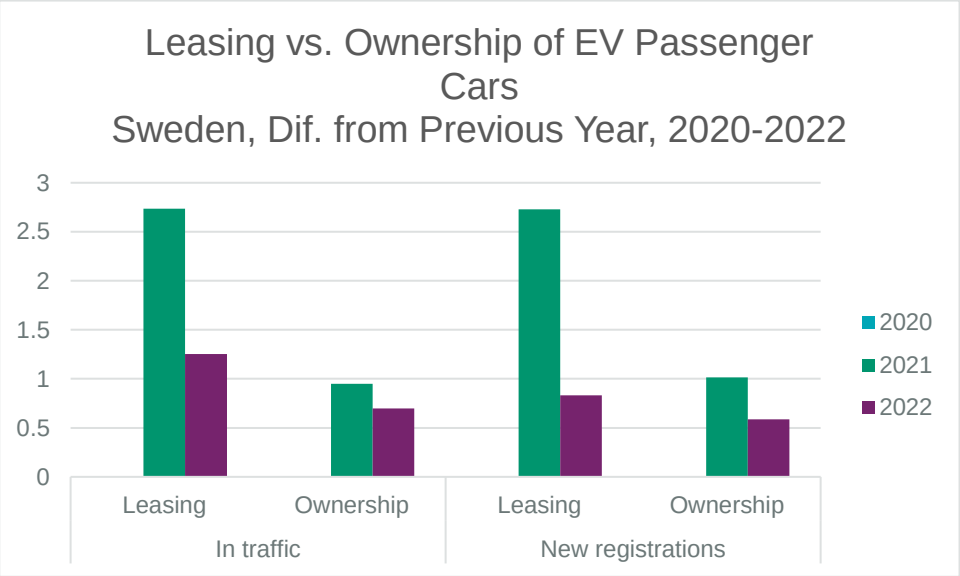


Table 6. Leasing vs. ownership of EV passenger cars in Sweden, dif. from previous year, 2020-22.

Owner Type	Private			
Country	SE			
Dif. Previous Y		**Year**		
Category	**Ownership Type**	**2020**	**2021**	**2022**
In traffic				
	Leasing		274%	125%
	Ownership		95%	70%
In traffic Total			**153%**	**96%**
New registrations				
	Leasing		273%	83%
	Ownership		102%	59%
New registrations Total			**193%**	**75%**

Austria

The trend for leasing's share of all new registrations of EVs is positive, increasing from 42% in 2020 to 50% in 2022. This reflects the growth rates of leasing from 2020 to 2021 at 97% and from 2021 to 2022 at 47%, while ownership increased by 82% and 18% in those same years, respectively.

The share of leasing compared with ownership of all EV "in traffic" increased from 29% in 2020 to 34% in 2022 as illustrated in the tables and graphs below.

Figure 3. Leasing vs. ownership of EV passenger cars in Austria, % per year, 2020-22.

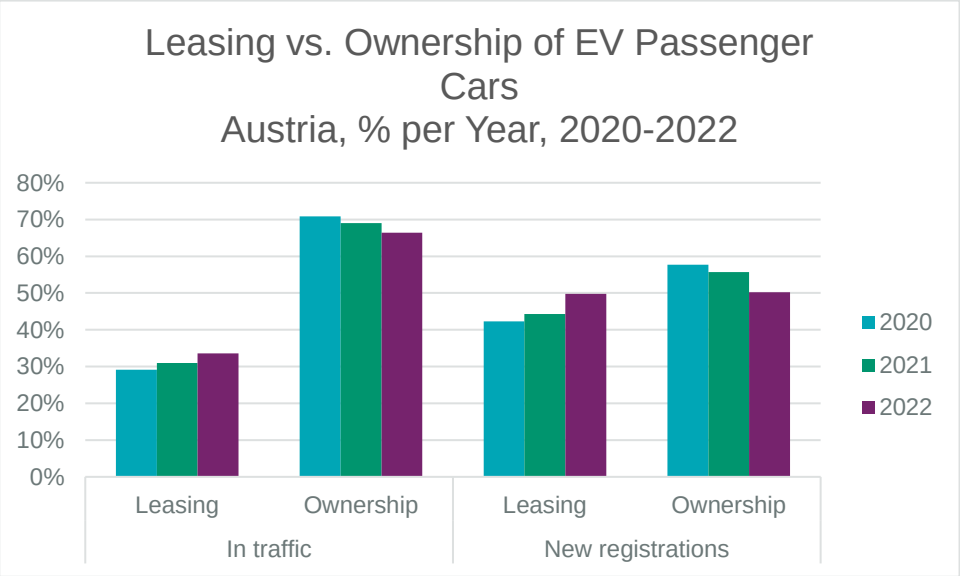


Table 7. Leasing vs. ownership of EV passenger cars in Austria, % per year, 2020-22.

Owner Type	Private			
Country	AT			
Sum of Value		**Year**		
Category	**Ownership Type**	**2020**	**2021**	**2022**
In traffic				
	Leasing	29%	31%	34%
	Ownership	71%	69%	66%
In traffic Total		**83%**	**82%**	**84%**
New registrations				
	Leasing	42%	44%	50%
	Ownership	58%	56%	50%
New registrations Total		**17%**	**18%**	**16%**

Figure 4. Leasing vs. ownership of EV passenger cars in Austria, dif. from previous year, 2020-22.

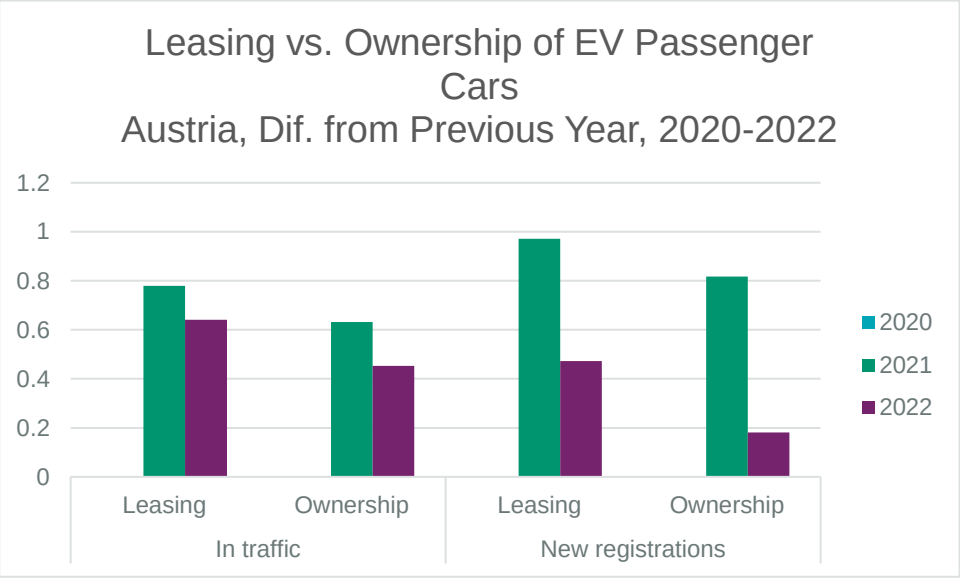


Table 8. Leasing vs. ownership of EV passenger cars in Austria, dif. from previous year, 2020-22.

Owner Type	Private			
Country	AT			
Dif. Previous Y		**Year**		
Category	**Ownership Type**	**2020**	**2021**	**2022**
In traffic				
	Leasing		78%	64%
	Ownership		63%	45%
In traffic Total			**67%**	**51%**
New registrations				
	Leasing		97%	47%
	Ownership		82%	18%
New registrations Total			**88%**	**31%**

2.2.2 Limitations

The main limitation identified revolves around the lack of a clearly defined separation of data between financial and operational leasing. This is not, as such, a limitation of the data collection method for this indicator but for the industry practices regarding reporting to national statistical institutions. Due to the lack of response to interview requests with national leasing associations, it is unclear whether the data is being collected in a way that would allow for it to be easily reported separately in future.

Even though this was not directly part of the study, it is worth considering comments that were received regarding commercial practices regarding passenger vehicle leasing. The NSIs of both countries reported much greater uncertainty regarding the commercial market in terms of the separation of financial from operational leasing. Thus, it should be noted that the same assumptions and methods for data collection cannot simply be extended to this sector.

2.2.3 Performance

During the Task 4 project phase, a RACER evaluation of the indicator was conducted. Below is the original evaluation and an updated one based on the insights of Task 5. The indicator was formulated slightly differently originally and in Task 5 following in-depth considerations on data collection. It was changed to better align with the CEAP and goals of this study, yet the original RACER evaluation is still comparable.

Below is a brief assessment of each RACER criteria.

Table 9. RACER evaluation.

Stage of project	RACER criterion					Score
	Relevance	Acceptability	Credibility	Ease	Robustness	
Task 4 (original RACER assessment)	3	3	2	1	1	10*
After Task 5 (following testing)	2	3	3	3	3	14

* Indicator formulation evaluated: “Size of the market for rental/leasing goods at the national level”

Relevance

There are two very prominent arguments for the policy relevance of this indicator. The CEAP specifically emphasises PSS as a means for securing a more sustainable fleet of vehicles and mobility in the EU (European Commission, 2020), and the EU Parliament recently adopted a regulation banning the sale of new passenger cars and other vehicle types with combustion engines as of 2035 (Regulation (EU) 2023/851).

PSS models, by design, have the potential to support higher value-added circularity opportunities that can enable systemic changes, because they can facilitate developments and coordination across the value chain. Operational leasing by private consumers is a PSS model that may enable some benefits to circularity if combined with peer-to-peer platforms, or if the leasing contracts and actions by PSS providers support increased rates of vehicle utilisation, repair, and recycling etc. However, the main contribution to circularity is the consumer preference for leasing when shifting to EVs. McKinsey has found that consumers are twice as likely to choose leasing over ownership when shifting to EVs from combustion engine vehicles (McKinsey & Company, 2023). Considering the potential circular economy benefits of EVs, this can be considered a sufficient argument for tracking the leasing of EVs in the EU.

However, there are a few reasons for not giving the indicator a full score on this parameter. Leasing is not the most promising form of PSS for the circular economy, compared with shared mobility solutions, and an increase in the metric alone does not secure increased circularity in Europe (EEA, 2018). High levels of circularity in the automotive industry are only achieved when PSS models are implemented across the value chain, including components, and life cycle of EVs (World Economic Forum, 2021). There is a lack of research and data on the effects of EV leasing on circularity and sustainability metrics regarding consumer behaviour and potential improvements in the value chain. This indicator should therefore be considered in connection with other indicators and metrics to avoid a too simplistic view on the progress of PSS models and circularity in connection with EV adoption in the EU.

Acceptability

The NSIs already have the mandate to collect the data necessary to track this indicator. Simple adjustments would solve the challenge of unclear practices regarding reporting of financial vs. operational leasing.

Credibility

The metric's definition is clear and internationally accepted since reporting on financial vs. operational leasing is part of the core accounting practices of all leasing companies. The methodology for collecting data on new registrations and “in traffic” numbers is similarly authoritative and based on NSIs' existing practices. The use of existing standards also makes it very easy to communicate to stakeholders on the indicator’s measurements. The original scoring was made for a different indicator formulation and the methodology was proven credible, which justifies the higher score.

Ease

The required data is readily available and already collected by the relevant stakeholders. Across EU member states, NSIs are collecting data on the vehicle market, including ownership form. This high quality and availability of data is unique for PSS models across product groups and industries, which is a big advantage for easy implementation of the indicator.

The only limitation is ensuring that a precise separation of data occurs in the exchange between businesses and national statistical institutions. The increase in score from 1 to 3 is justified by the data collection proving substantially more accessible than expected, incl. high availability of data from authoritative sources.

Robustness

The methodology and data are available, and the metric is one-dimensional and easy to understand. The original indicator formulation was wider in its scope and the revision focusing on a specific, well-developed market with high relevance has proven useful. Considering data availability and methodological clarity, the score is increased from 1 to 3.

Facets of CE

The original indicator formulation was assessed to be relevant to the CE facets related to the current level of circularity and economic and environmental impact.

The indicator itself is not the most direct measurement of the level of circularity. It does not cover the full life cycle of the EVs, and there is no direct information on how the amount or share of leasing corresponds to an extended life cycle of the products. As such, ownership may equally result in continued life cycles of products. The main direct potential, regarding the level of circularity, concerns the impact leasing may have on how vehicles are managed due to the changes in the relationship between customers, suppliers, manufacturers, and other intermediaries such as repairers. Businesses leasing out vehicles have a stronger power in the supply chain as aggregators of multiple vehicles and/or by having ownership of manufacturing or repair facilities. Due to their incentives for reducing the need for repairs and extending the lifetime of products, they may put pressure on the value chain to improve circularity related to both the design and manufacturing phase as well as aftermarket services. More operational leasing, thus, could lead to increased levels of circularity. However, the true level of this potential as well as the role of rebound effects etc. requires further research.

The indicator itself is not a direct measure of environmental, social or economic factors, but there are impacts on these metrics that can be further investigated and documented.

As discussed in the introduction, by supporting the increased adoption of EVs, leasing potentially has direct positive benefits on environmental factors such as reduced air pollution and GHG emissions, but also potential negative effects on human toxicity and ecosystems, especially during the manufacturing phase. It is necessary to conduct more research to assess the environmental benefits of EV leasing compared to ownership to conclude on the impacts for increased circularity. Similarly, further research and assessment models is needed to compare the environmental effects of various EV models, which may have substantially different resource and energy efficiency levels (Mathieu et al., 2024).

Aspects of relevance to the social dimension may include access to and affordability of EVs through leasing, which are important when considering the changes happening to the vehicle sector. For example, due to the EU ban on vehicles with combustion engines, governments will need to finance EV charging infrastructure and general electrification. It is easy to imagine that this may result in changes to fuel taxes and subsidies since this can have the dual effect of financing the transition and incentivising the shift to EVs. However, considering the large citizen protests across Europe, not least the yellow vests movement in France, fuelled by changes to fuel taxes (Tatham & Peters, 2023), increased affordability and access to EVs through leasing may have critical social impacts that are worth researching further.

There are also major social consequences related to jobs in manufacturing that the shift to EVs is expected to have (Celasun et al., 2023). It may be relevant to assess if EV PSS/leasing models can positively moderate the negative effect on jobs by increasing the demand for repairs and maintenance. An analysis of this question could also emphasise the more systemic aspects of transport and mobility. All these elements are linked to the indicator but cannot be assessed by the data collection or methodology concerning the indicator itself.

The indicator tracks the prevalence of leasing rather than, for example, the length of EVs lifecycle, why the changes from year to year do not directly relate to progress over time in the level of circularity, but simply describe the size of the market that may hold a promise for increased circularity.

2.3 CHALLENGES AND LESSONS LEARNED

Data collection did not face any substantial challenges.

The main challenge that may arise in future, when collecting data from additional countries with higher needs for data quality, concerns the risk of data on operational and financial leasing not being separated. Further efforts are needed to understand the various practices of NSIs and the providers of data on leasing numbers across countries to understand this uncertainty in-depth.

More indirectly is the challenge of over-emphasising the potential of this indicator due to the availability and relevance of the data. As discussed in the previous section, more research is needed to understand the full lifecycle of EVs being operationally leased and other factors of relevance to properly assess this PSS model's potential for the various aspects of the CE.

2.4 CONCLUSIONS AND RECOMMENDATIONS

It is recommended that this indicator is considered for further development, with minor work required to facilitate its progress.

Final indicator formulation:

The share of electric vehicles (EVs), in the category of passenger cars, that are operationally leased by private consumers

The indicator measures the share of EV passenger cars being operationally leased in relation to regular ownership. This relates to an area highly relevant for EU policy due to the ban on combustion engines taking effect from 2035 and the priority given in the CEAP to PSS models within the vehicle and transport sector. Research indicates that consumers are twice as likely to lease rather than purchase EVs when shifting from vehicles with combustion engines. This is a core argument for the indicator's relevance for the circular economy. By increasing the adoption of EVs, there are positive effects on the environment through reduced GHG emissions and air pollution.

Leasing is not the most promising of all PSS models for EVs in terms of increasing circularity, since shared mobility solutions and other transport forms, such as cycling and public transit, have greater environmental and social benefits. Leasing of EVs can, however, be seen as an early step in a circular transition to higher-level PSS models in the sector. It is generally not ideal to monitor a specific PSS model in isolation from other parts of the sector and value chain since the net positive effects of a PSS model will depend on many variables outside the direct influence of the model. Ideally, this indicator would be combined with other indicators for the EV industry to give a comprehensive perspective on the circularity of the sector.

An element in favour of advancing the indicator is that the quality and availability of data, necessary to monitor the indicator across the EU, is very high, compared to other PSS models. This provides an opportunity to include the indicator in the circular economy monitoring framework within a short timeline. Data on other PSS models is not currently being gathered systematically and, for example, Mobility-as-a-Service models vary significantly from case to case, whereas leasing of EVs is a fairly standardise practice.

There are many challenges related to documenting and monitoring the environmental, social, and economic effects related to the indicator. For example, there are large variations in energy and resource efficiency and carbon footprint of various EV models, which the data does not provide insights on. Other factors, such as the rebound effects of shifting consumption from ownership to leasing, are also challenging when measuring the direct impact. These elements are, however, not unique to leasing models but will be challenging when measuring the impact of all PSS models.

The testing phase showed promising results on all elements of the RACER assessment, which is why we conclude that it is relevant for further consideration and that only minor work is needed to facilitate its progress. When evaluating the indicator's potential for implementation across EU member states, as a measure of the progress to a more circular economy, there appears to be a trade-off between the generalisability and maturity of data for the model in question, with the potential for circularity and environmental benefits that may be achieved by measuring more specific cases and models. If priority is given to implementing indicators with high availability of data and low cost of development, then this indicator has clear potential. If, instead, there

is a preference for only including indicators that have a high documented potential for the circular economy, this indicator would not be directly relevant to advance without more documentation and research on its effects.

The data collected for Sweden and Austria show strong positive trends from 2020 to 2022 in the share of EV passenger cars being operationally leased as opposed to regular ownership—both for the total number of EVs "in traffic" and for new registrations. In both countries, the total share of leasing EVs was level with or above that of ownership in the year 2022. This is the metric that directly responds to the indicator. This makes it very interesting to follow whether the identified trend will continue, as it might prove to be one of the most substantial examples of consumer uptake of use-oriented PSS models within a specific (and very significant) product group. The trends identified for Sweden and Austria are interesting examples of the possibility of bridging the strong barrier to PSS adoption represented by the "culture of ownership" (Tukker, 2015). The fact that this PSS model represented 71% of the total market for EV passenger cars for private consumers in Sweden in 2022 provides an interesting case for future research on what mechanisms have incentivised consumers to overcome this otherwise well-documented barrier.

The testing phase did not result in any major challenges identified concerning the data collection method and availability, robustness, and credibility of data. The National Statistical Institutes of Sweden and Austria both collect data on the relevant metrics of EV registrations by ownership/leasing and were able to provide the necessary cross-tabulation to conclude the indicator. There are some uncertainties regarding separating financial leases from the data on operational leases, but the statistical institutions considered these minor for private consumers. It became clear that similar data collection could not happen as easily for commercial leasing since the data here is much less separated between the leasing types.

Recommendations

It is recommended that DG-RTD initiates a dialogue with representatives of National Statistical Institutes to assess the work required to facilitate the implementation of the indicator on an EU level with potential inclusion in the CE monitoring framework. The main question to clarify is whether the data availability on the indicator in Sweden and Austria is representative of all EU countries, as well as the assessment of NSIs on the identified data gap/uncertainty related to the separation of data on financial and operational leases.

It is also recommended that the DG-RTD considers calling for research projects to evaluate metrics related to leasing EV passenger cars with specific reference to all facets of the circular economy. Further research and innovative solutions are needed across multiple aspects related to this indicator for securing improved data. Without improved data and comparison models, it is very difficult to compare the benefits across vehicle types as well as across PSS models and other ownership types. This makes it difficult to give good recommendations for policies in this area that effectively increase circularity. The European Federation for Transport and Environment has suggested an "eco-score" framework for EV model comparison (Mathieu et al., 2023), and the World Economic Forum has facilitated a study with the automotive industry to suggest a circularity taxonomy (WEF, 2021). These are examples of models that may guide further research on the relationship between PSS models for EVs and related environmental effects.

Following these recommendations would create the necessary insights for conclusions on whether this indicator can be a good indirect measure for improved circularity within the transport sector, and under what conditions this is the case. With this, it can be determined if more work is required to facilitate the development of the indicator and whether it is possible to include it in the CE monitoring framework. The indicator could be included in the CE monitoring framework by developing a new general indicator on the market share of circular business models with sub-indicators on various product groups.

Table 10. Summary of recommendations for indicator PSS3.

Type of recommendation	Recommendation	RACER Criteria addressed	Timeline	Key stakeholders or partners
Consultation process	Clarify the data availability and gaps across all EU countries through a consultation process	Acceptability, Credibility and Robustness	Short (0.5-1.5 years)	DG-RTD to initiate and manage the consultation. NSIs and Lease Europe to provide perspectives and input in the consultation. DG-ENV to be informed on the process.
R&D	Call/funding for research project regarding the potential for increased circularity related to operational leasing of EV passenger cars	Relevance and Credibility	Medium (1.5 - 5 years)	DG-RTD / DG-ENV to initiate the funding of the research project. Leasing operators, car manufacturers, auto repair business associations, employee associations and other value chain actors to provide relevant insights. Universities or research institutions to develop research proposals.

3. INDICATOR 2 – NO. OF COMPANIES OFFERING PSS-SOLUTIONS WITHIN THE ELECTRONICS AND ICT SECTOR

Indicator: Number of companies offering PSS solutions within electronics and ICT

This indicator refers to the number of companies that advertise PSS solutions within the electronics and ICT sector with a primary focus on B2B solutions. Electronic products have a high adverse impact on the environment due to high resource use and energy requirements during manufacturing and a use phase that is often shorter than the potential lifespan of the products. These challenges are especially concerning considering the sector's growth.

PSS and other circular business models within this industry may result in environmental benefits, reduced climate impacts, and reduced business costs. Research indicates that circular business models, especially PSS, within electronics and ICT are "more cost-effective and significantly reduce CO2e compared to using a linear model (business as usual) approach over the next 12 years". Yet, there is a reluctance among the electronics industry to invest in circular business models because of a lack of specific demand from B2B and B2G customers (Lopez et al., 2023).

A natural prerequisite for realising the potential benefits of PSS models in contributing to building a more sustainable and circular economy is the PSS solutions' actual availability. This indicator measures the availability of PSS models for electronic and ICT products. Data will be collected on products offered by companies within two EU member states.

There are no comprehensive databases or overviews of the presence of PSS solutions offered by the private sector. The methodology for testing this indicator is therefore not based on an ideal situation and cannot measure the real uptake across EU member states. The testing of the indicator does not provide a final methodology for the indicator, but document the availability, or lack, of PSS solutions provided in two specific cases as a starting point for further development of the indicator and methodology.

The benefits of monitoring and choosing this indicator include:

- Developing a deeper understanding of the availability of PSS models in a sector for which they have potential to make significant positive impact.
- Providing important data and analyses for policy making on this very important sector in terms of climate impact and resource use.

3.1 KEY METHODOLOGY

3.1.1 Testing method

System Boundary

The indicator is measured at the national level with a focus on gathering general data on the availability of PSS models within the electronics and ICT sector. This may potentially allow for comparison across industries and EU countries.

Data collection was conducted in Denmark and Sweden, which were selected as "best case" countries to identify companies offering PSS solutions. The two countries have high digitalisation rates (World Bank, n.d.), also in the public sector, and a large business sector for electronics and ICT. Investigating these two cases enables comparison with the indicator PSS6, which looks at the use of PSS-solutions for electronics and ICT within public procurement.

Since little data exists on this topic, the use of presumed two "best cases" will give an indication of what can be expected in terms of data availability on this indicator. If only a few companies offering PSS solutions are identified, the prevalence of PSS solutions in other MS is presumed to be very low, reducing the immediate potential for monitoring progress on the indicator. On the other hand, if many cases are identified in the two countries, it appears relevant to collect data in other MS.

Methodology

The indicator will be tested using a desk-study approach. No database or business overview providing a comprehensive list of companies, products, and business models has been identified. Therefore, an important element of the testing phase was to identify the relevant companies that might offer PSS solutions.

Initially, in the data collection plan developed before the investigation, it was proposed to collect a gross list of companies by contacting industry associations, such as the National Chambers of Commerce and Confederation of Industries, for their lists of members within the sector. Besides the potential generalisability of this approach across countries, speaking in favour of this approach was the ability to sort out companies of a small size who likely wouldn't be members of industry associations, as it is expected that PSS models within this sector won't be offered by smaller companies.

Due to challenges in receiving data from the mentioned sources, the approach was redeveloped during the testing phase by utilising the standard industrial classification system that is used across EU Member States, which is referred to as "the statistical classification of economic activities in the European Community" and abbreviated "NACE" (European Commission, 2022-b). By using the NACE system to define the search parameters, i.e. the companies included in the assessment, we ensure that the method can be generalised across EU countries and the data has an authoritative delimitation, which increases credibility and robustness of the approach.

During testing, we selected the most relevant industry codes to define the gross lists of electronics and ICT companies to be assessed. We collected the lists for Denmark and Sweden and assessed up to 25 companies registered within each of the selected NACE codes.

The assessment of companies consisted of reviewing their websites for information on PSS models. The evaluation of websites and data was conducted by staff with sufficient expertise and understanding of the characteristics of PSS models within a broad mix of product groups. Keywords and typologies of PSS models were used to guide the assessment as described further in section 3.1.2.

An overview of the data sources is presented in the table below.

Table 11. Key data sources assessed on reliability and availability of data.

Source	Reliability*	Availability**
List of companies registered with relevant industry codes for the electronic and ICT sector: • Denmark: Central Business Register[2] • Sweden: Swedish Companies Registration Office[3] and Allebolag.se[4]	*Medium*	*Medium*
The companies' website	*Medium*	*Medium*
Stakeholder interviews	*Medium*	*Medium*

***Low** = Some data will likely be missing and incomplete, which may lead to inaccurate conclusions*, ***Medium** = The data will likely be complete but may lack accuracy and quality, **High** = The data will likely be complete, accurate and of high quality.*

****Low** = The data is not already collected or readily available, and will be difficult to collect. **Medium** = The data is already collected but is not publicly available, OR the data is not already collected but is easy to collect, **High** = The data is readily available and can be accessed easily.*

3.1.2 Data collection method

Data requirements and background

The indicator focuses on the electronics and ICT sector, which covers a very large variety of product groups. This testing study has narrowed the focus to products used in office and administrative functions, such as printers, computers, televisions, smartphones, tablets, and information systems infrastructure (e.g. servers, networking equipment, and communication devices). To align the focus with the EU CEAP, large electronics categories such as white goods (e.g. fridges and dishwashers), kitchen and home appliances, and specialised electronic equipment used in industrial processes, manufacturing, and for medical purposes were excluded.

[2] www.datacvr.virk.dk

[3] https://www.bolagsverket.se/

[4] https://www.allabolag.se/

The research emphasises B2B PSS solutions but includes some PSS models offered to households/private consumers. The type of service and business models for PSS, as well as the incentives of the customer, differs across the target groups, but our priority is identifying all relevant cases of PSS offers due to a low expected number of cases.

The relevant PSS models can be categorised as either use-oriented or result-oriented, depending on whether the customer pays for the use of a product or pays for a specific outcome generated by a product. In practice, for products within electronics and ICT, this would be implemented as models of either subscription-based access, leasing, or pay-per-use / -result, refer to the model below.

Table 12. Use-oriented and result-oriented PSS models.

Use-oriented

- **Leasing:**
  - Customers pay for the full rights to access and use a product for an extended, but defined period of time (typically min. 1 year).
  - The customer may often be able to extend the term, but can only cancel the leasing agreement early by paying a fee.
  - There is no obligation to purchase the product at the end of the leasing period as the provider maintains the ownership.
  - Often the leasing includes a service agreement to ensure that the product is properly maintained, since the provider has an incentive to increase the lifetime of the product.
  - PSS leasing models can be referred to as 'operational leasing' whereas 'financial leasing' is not PSS, since this is a form of financing agreement with a purchase commitment at the end of the term.
  - Long-term renting can be considered PSS models, though the conditions may vary from leasing.
  - *Example: A start-up company leases its internet / network equipment, such as routers, for a new office, to have the flexbility of upgrading or cancelling as their needs change in their growth phase.*
- **Subscription-based:**
  - Customers pay a recurring fee to access/use a product and are able to cancel at any time.
  - The subscription will usually entail limits to the volumne of usage, but may include access to a wider variety of products than leasing and won't be limited to a single physical unit.
  - *Example: A shop with many pop-up locations has a subscription for Point of Sale (POS) solutions, e.g. card machines, rather than purchasing or leasing the units.*

Result-oriented

- **Everything as a Service / X as a Service (XaaS):**
  - The main characteristic of these models is that the customer pays for a specified outcome rather than for a product or use of a product directly.
  - These models may apply to the outcomes created by almost any type of product as well as non-physical products and services (the latter are outside the scope of this project).
  - An agreement can meet a customer's needs despite very irregular and unpredictable usage situations and this high flexibility of the model is one of the advantages and characteristics.
  - *Example: "Data as a service" is offered to customers in an agreement where only the amount of data storage used by a customer is paid for. In this model, the physical data centre and its servers is the product being utilised, but the customer only pays for the outcome that this product provides them.*

Selection of industry codes and companies for assessment

The first step in the data collection was to identify the gross list of companies to assess the availability of PSS offers matching the models above. The most relevant NACE codes were used to establish the lists, representing the specific areas of the electronics and ICT sector and the type of business models in question.

The following three NACE codes were selected based on these criteria:

- G46.5.1 - Wholesale of computers, computer peripheral equipment and software
- G46.6.6 - Wholesale of other office machinery and equipment
- N77.3.3 - Renting and leasing of office machinery and equipment (including computers)

The NACE code N77.3.3 is specifically interesting because it is assumed that there's a higher chance of PSS models being offered among companies registered for renting and leasing than among those registered for wholesale goods. The wholesale categories were also included because PSS models are frequently offered in addition to regular product sales activities.

In Denmark, the list of companies could be downloaded directly from the national Central Business Register. In Sweden, a similar database was not available from the Swedish Companies Registration Office's website, since only search option for individual companies was available, but there was no option to access or download general lists, e.g., based on NACE code. Instead, a private database, Allebolag.se, provided the necessary data and search functions.

A data file of the companies within the respective NACE codes was created for both countries. The assessment included all leasing and renting businesses with a website. In addition, for the other NACE codes, a filter was applied to sort out companies with less than 20 employees, as these are not expected to offer PSS solutions at all or of a significant volume. By random, 25 companies were selected for assessment.

See Appendix 5.2 for a full list of the companies assessed.

Assessment of company websites

During the evaluation phase, the selected companies' websites were evaluated with a special focus on their 'About' section and any section with information on the products/services offered. Research on website content requires a certain level of qualitative/professional judgement due to the unsystematic nature of website structures and information available.

A comprehensive, case-based evaluation of available information is necessary for concluding whether the business offers a PSS solution or not. After evaluating each website, the data was noted in an Excel sheet with information on their offer of either a "use-oriented" or "result-oriented" PSS, or if no information on PSS offers was advertised.

3.1.3 Calculations

The number of companies registered with NACE code G46.5.1 exceeded 25 in both Denmark and Sweden and so, a sample of 25 was assessed. The results for the sample were extrapolated to estimate the total number of companies offering PSS for the entire list.

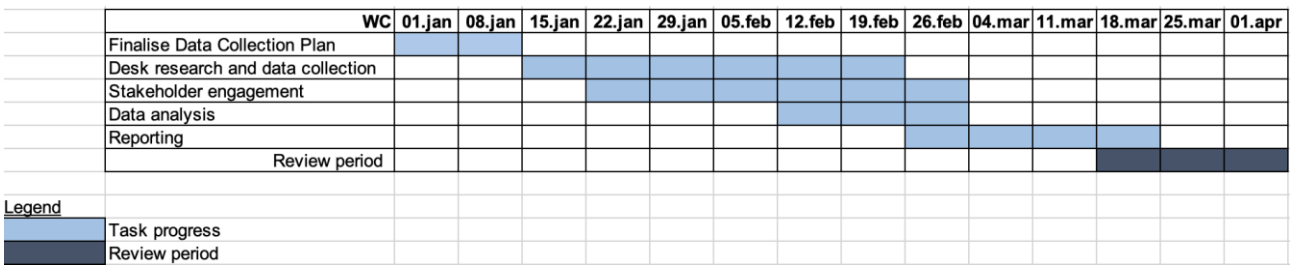
The simple calculation for extrapolation takes the share of the result for each assessment category (use-oriented PSS, result-oriented PSS, and no PSS identified) for the specific NACE code in relation to the total number of companies with this code assessed and divides each of these shares by the total number of businesses on the list. Based on the extrapolation, the total number of companies offering PSS is estimated.

Appendix 5.2 shows the results in Excel, including the formulas used, and the specific results are presented in Section 0.

3.1.4 Timeline

The testing phase was conducted as outlined in the Gantt chart in Table 13.

Table 13. Gantt chart - PSS5.



	WC	01.jan	08.jan	15.jan	22.jan	29.jan	05.feb	12.feb	19.feb	26.feb	04.mar	11.mar	18.mar	25.mar	01.apr
	Finalise Data Collection Plan														
	Desk research and data collection														
	Stakeholder engagement														
	Data analysis														
	Reporting														
	Review period														
Legend															
	Task progress														
	Review period														

3.1.5 Data gaps and mitigation

The public databases of national companies provide an authoritative overview of registered companies within specific sectors and are directly applicable to data collection. The NACE codes selected cover a very wide range of product groups within the electronics and ICT sector, and the search leads to the most authoritative list of companies available, although it may not be exhaustive. The gap is acceptable, considering that a fully comprehensive list is unavailable, the usefulness of the indicator can be tested even with an incomplete list.

The qualitative analysis of the presence of PSS models advertised on company websites entails a risk that the information available is misunderstood or simply insufficient, leading to the risk of "false negatives" in cases where a PSS model is offered but not identified. This may be especially relevant for companies mainly working with business-to-business offers, as they have specialised offers that are not advertised, since they have established business relationships. We have mitigated this risk by having experts with a strong understanding of PSS models conducting the evaluation. Further research could mitigate this uncertainty by utilising double evaluations of websites or triangulation of data, e.g., through surveys of businesses or automated web-scraping. It highlights a fundamental challenge facing research on PSS, namely the lack of frameworks that simplify data collection by defining clear system boundaries, business models, and metrics.

Based on their website information, a sample of companies registered with the two NACE codes for wholesale, G46.5.1 and G46.6.6, and with a filter of >=20 employees, was evaluated. The assumed likelihood that the sample is representative, i.e., that the rest of the companies offer PSS models to the same extent, constitutes an uncertainty that can be mitigated by expanding the number of companies investigated. Companies are very heterogeneous, so creating a representative sample would require substantial efforts to stratify the list of companies, which was unfeasible for this research.

Table 14. Overview of identified data gaps, limitations and mitigation efforts.

	Description of data gap	Mitigation efforts	Level of confidence
1	Incomplete gross list of companies potentially offering PSS solutions	Using the most relevant NACE codes and evaluating a substantial sample on each. The level of confidence is 'Medium', because there may be companies offering PSS solutions in the sector, which are registered with other NACE codes.	Medium
2	Identifying "false negatives" based on website reviews	Evaluation conducted by employees with sufficient understanding of PSS models. The level of confidence is 'Medium', since no triangulation of the assessment is conducted due to resource constraints.	Medium
3	Only a sample of the companies registered with NACE codes G46.5.1 and G46.6.6 were evaluated	The data from the sample was extrapolated to give an estimation for the entire list of companies. This has a high degree of uncertainty, due to the heterogeneity of companies on the lists, which reduces the applicability of extrapolation. The sample number excluding the extrapolation is reported to ensure transparency, but the level of confidence in the total number of PSS models identified, as an estimation of the "real" number, remains low.	Low

3.1.6 Quality review of analysis

To ensure robust and high-quality results, we have conducted the following data validation and quality control procedures:

- Prior to work beginning, the Project Director (Jess Twemlow) reviewed the proposed research methodology and ensured that the data collection plan was fit for purpose. Once the research team addressed any comments from the review process, they proceeded to the data collection phase.
- Project Coordinator Bjørn Bauer oversaw the data collection phase to ensure that the collected data and analysis conducted was of a high standard and provided useful content for the final case study output.
- Andrew Dunwoody is responsible for the quality of the final case study output. Rob Snaith has assisted Andrew Dunwoody in judging the quality of the output and suggested ways to improve.

3.2 KEY RESULTS

3.2.1 Analysis

The table below shows the distribution of the data collected on the availability of PSS models within the electronics and ICT sector.

The investigation identified eight use-oriented PSS offers in Denmark and 22 in Sweden, as well as four cases of result-oriented PSS offers in Denmark and one in Sweden. One company in both countries offers both PSS types, resulting in an overall conclusion that 11 out of 51 companies assessed in Denmark and 22 out of 85 in Sweden offer PSS solutions. This equates to 22% of the assessed companies in Denmark and 26% of those assessed in Sweden.

NACE code N77.3.3, covering the rental and leasing industry, presents – as expected – a higher proportion of PSS models than the two other NACE codes, 42% in Denmark and 32% in Sweden, against 24% and 16% for G46.5.1, and 0% and 23% for G46.6.6 in Denmark and Sweden, respectively.

Table 15. PSS models within the electronics and ICT sector – 2 x 25 companies assessed

	Total no. of companies assessed	No PSS data found	Use oriented PSS	Result oriented PSS	Total PSS Models	Companies offering PSS models	% of total
Denmark							
G46.5.1 - Wholesale of computers, computer peripheral equipment and software	25	19	4	3	7	6	24 %
G46.6.6 - Wholesale of other office machinery and equipment	14	14	0	0	0	0	0
N77.3.3 - Renting and leasing of office machinery and equipment (including computers)	12	7	4	1	5	5	42 %
Denmark Total	**51**	**40**	**8**	**4**	**12**	**11**	**22 %**
Sweden							
G46.5.1 - Wholesale of computers, computer peripheral equipment and software	25	21	4	0	4	4	16 %
G46.6.6 - Wholesale of other office machinery and equipment	13	10	3	0	3	3	23 %
N77.3.3 - Renting and leasing of office machinery and equipment (including computers)	47	32	15	1	16	15	32 %
Sweden Total	**85**	**63**	**22**	**1**	**23**	**22**	**26 %**

Table 16, below, shows the total results following extrapolation of the results for G46.5.1.

Table 16. Total number and share of companies offering PSS models within the electronics and ICT sector

	Total no. of companies	Companies offering PSS models	% of Total
Denmark			
G46.5.1 - Wholesale of computers, computer peripheral equipment and software	72	17	**24%**
G46.6.6 - Wholesale of other office machinery and equipment	14	0	**0%**
N77.3.3 - Renting and leasing of office machinery and equipment (including computers)	12	5	**42%**
Denmark Total	**98**	**22**	**23%**
Sweden			
G46.5.1 - Wholesale of computers, computer peripheral equipment and software	93	15	**16%**
G46.6.6 - Wholesale of other office machinery and equipment	13	3	**23%**
N77.3.3 - Renting and leasing of office machinery and equipment (including computers)	47	15	**32%**
Sweden Total	**153**	**33**	**21%**

As shown in Table 16, 23% (Denmark) and 21% (Sweden) of the total number of companies within the electronics and ICT sectors of the two countries offer PSS solutions. The results show that use-oriented models are the most common, which may be a reasonable expectation due to their simplicity over the more complex result-oriented models. However, there is a risk that we have failed to identify results-based PSS models due to the greater complexity of how these are constructed and, potentially not advertised as clearly on websites.

3.2.2 Limitations

As has been touched on previously, there are several limitations of the methodology related to the data gaps in the gross list of companies, lack of standard assessment methodology on websites, and uncertainty of the estimated total result related to one NACE code based on extrapolation.

The lack of an authoritative list of all relevant companies within the broad sector of Electronics and ICT creates uncertainty. The analysis has covered the most relevant NACE codes, but not all relevant companies are likely included in the analysis. There may be limitations related to 'production unit' registrations of companies, which are sub-registrations of business units that differ substantially in their business area from the main company. Companies offering PSS solutions may have their main registration under another NACE code than those used for the present investigation. In that case, we have not assessed these businesses and identified their PSS solution because this testing only assessed companies with their main registration within the selected NACE codes.

The exclusion criteria (for two NACE codes) of a minimum of 20 employees implies a risk that some PSS companies are left out; however, given the complexity of the PSS models, it is not considered likely that the business model is broadly implemented in smaller businesses, so this uncertainty is found to be minimal.

Refer also to the previous description of the challenges related to the potential 'false negatives' of not identifying companies due to lack of information or accurate website descriptions, which is also a limitation.

3.2.3 Performance

A RACER assessment is carried out to evaluate the indicator and the methodology used to test it on various parameters.

Table 17. RACER evaluation.

Stage of project	RACER criterion					Score
	Relevance	Acceptability	Credibility	Ease	Robustness	
Task 4 (original RACER assessment)	3	2	2	1	1	9*
After Task 5 (following testing)	3	3	1	1	1	9

*Original indicator formulation: "No. of companies implementing product-as-a-service business models at national level"

Relevance

The CEAP emphasises electronics and ICT as "a priority sector for implementing the 'right to repair'" and suggests initiatives concerning take-back schemes for reselling (or returning) electronic equipment such as mobile phones and tablets. At the same time, products-as-a-service models (PSS) are mentioned in relation to the need for creating and facilitating more circular and sustainable product lifecycles, which the CEAP describes as a priority in the revised Ecodesign Directive. The EC continues the exploration of options to incentivise take-back and return of small electronics to extend product lifetimes, improve the collection of products, and thus boost circular business models (European Commission, 2022).

Tracking the availability of solutions that offer PSS models for electronics and ICT is, therefore, very relevant.

Acceptability

Measuring this indicator is presumed to be accepted by stakeholders as the presence of PSS solutions for electronics and ICT products makes it clear whether the provision of PSS-models is growing and if the industry is providing the circular business models that are emphasised on a policy level. This information is necessary for informed decisions to be taken on how to promote further developments in this area, both by governments and at an EU level. There is also a public interest in this indicator since it can be expected that the demand and supply of PSS solutions are closely connected. An indirect benefit may be that consumers gain a greater ability to identify PSS solutions, while companies may become aware of business opportunities when gaps in the presence of models are identified. By focusing on one specific, though still very large, sector, the indicator becomes more applicable, which is an additional reason for the increased score from 2 to 3.

Credibility

There is no standardised methodology to collect data on the indicator, and there are several challenges related to data collection. The indicator's metric of 'Number of companies' is simple and understandable for stakeholders but may not be sufficiently granular to track the developments of greatest importance, e.g. amount of PSS models, market shares or no. of users of these, or no. of product groups covered by PSS solutions. The credibility of the indicator, therefore, depends on how the methodology is adapted when potentially deploying it across the EU member states. Since no standard solution to this challenge has been identified yet, the score is reduced to 1.

Ease

Considering aspects of data availability and cost of data collection, this indicator scores low. The indicator's focus was narrowed to a specific industry, which reduces the total amount of companies and product groups that need to be assessed to conclude on the indicator and, thus, increases the ease of data collection. Still, there are substantial challenges in relation to the ease of data collection.

When considering the method of this testing study, the data is not readily available as it is not collected by any entity or gathered by the companies themselves in a way that can easily be reported. Counting PSS solutions in units, which is the basis for estimating the number of companies that provide these, is simply more complex than counting a clearly defined single product unit. With a sufficient understanding of the definition of PSS solutions, data can be collected by assessing company websites. This involves a substantial amount of manual research and, thus, cost. Data could also be collected via other methods, e.g. surveys to companies, but this would also entail challenges that may not reduce the cost or workload required to collect the data.

Robustness

A gross list of companies within the relevant industries is not readily available, nor is data on PSS models offered by the companies. There are no sources that continuously gather this data, and there are no commonly used clear definitions of all the business models (concerning the specific products) to be identified, which would have eased the development of a methodology. This creates great challenges for a coherent and scalable data collection process in future, which means that it will be difficult at this point to create a highly robust methodology.

Facets of CE

The original indicator formulation was assessed to be relevant to the CE facets related to Transition/progress over time and Economic and Environmental impact.

The challenges concerning the data and methods for collecting it mean that no simple tracking of progress can be done. A similar conclusion must be drawn for the Economic facet of CE since there are too many challenges with defining the scope of the indicator to measure economic factors related to it accurately. There is good potential regarding this facet; however, the challenges should be resolved since there are many indirect economic metrics directly related to the PSS models.

Factors concerning the Environmental facet of CE are not considered for this indicator as this would require either a substantial additional data collection effort for documentation on the environmental benefits of the PSS models offered by the companies in question or an application of general assumptions on environmental benefits of PSS solutions, which involves several potential pitfalls. Research indicates the potential for CO2e emission reductions of PSS solutions within electronics and ICT (Lopez et al., 2023).

3.3 CHALLENGES AND LESSONS LEARNED

3.3.1 Challenges

The lack of comprehensive national lists of businesses within the broad sector of electronics and ICT was mitigated through the identification of companies within relevant NACE codes. This provides a good authoritative list of companies within the NACE code definition, but it does not necessarily provide an exhaustive list of all companies that potentially provide PSS solutions related to the product groups in question.

Even when NACE codes specifically target PSS-related models for a specific sector, all companies registered with that NACE code may not necessarily be relevant to this indicator. For example, during data collection, it became apparent that not all businesses on the list for NACE code N77.3.3 covering ‘Renting and leasing of office machinery and equipment (including computers)’ advertise or provide PSS solutions on their websites. In fact, only 32% of the Swedish N77.3.3 companies and 42% of the Danish ones do so. This eliminates the possibility of a simple data collection method based on the assumption that all companies with relevant NACE codes offer PSS solutions.

The manual assessment of company websites is time-consuming and only partly reliable due to the big variation in how PSS solutions are described and what information is available on business offers. The assessment requires a good understanding of the PSS models, which excludes the option of using automated assessments, e.g. based on web-scraping methods. There is no universal definition of what constitutes a PSS model, and the form these may take differs greatly depending on several factors such as product type, sector, consumer attitudes etc. This is also a great challenge, especially when considering implementation of the indicator across EU Member States.

3.3.2 Lessons learned

The use of NACE codes to create an authoritative list of companies within certain sectors for assessment creates a more reliable foundation for data collection compared to requesting national chambers of commerce to provide lists of member companies. In the two test MSs, it was possible to achieve the relevant data on NACE codes through publicly available websites, but this may not be true for all MSs. Similarly, it may not be able to format the lists based on, e.g., the number of employees and/or other parameters. Contacting national business authorities who manage the registration of companies may ease data collection when conducting this for countries where access to public databases on all companies is less available. It should also be considered to include production units registered within the relevant NACE codes, even if the owner/main company is registered with a different code.

The assessment of company websites was time-consuming, and there are potential gaps in the data due to non-identified cases and lack of information. Surveys of all companies registered with relevant NACE codes, using email or mail addresses registered with the authorities, may be an alternative or supplementary approach to triangulate the data. There is a risk that companies may falsely claim that they do or do not offer PSS solutions due to misunderstandings on the concept (e.g. confusing it with financial leasing). Such a survey might also suffer from a lack of respondents, leading to incomplete data, and would add a burden on companies and the researchers to send letters and/or follow-ups.

3.4 CONCLUSIONS AND RECOMMENDATIONS

It is recommended that this indicator is considered for further development, with significant work required to facilitate its progress.

Final indicator formulation:

Number of companies offering PSS solutions within electronics and ICT

This report describes testing conducted to assess the relevance of the indicator to determine the number of companies offering PSS solutions within the electronics and ICT sector. Denmark and Sweden were used as cases, and the emphasis has been on office-related IT equipment such as computers, screens, TVs, tablets, network equipment, etc. Data has been gathered on both use-oriented and result-oriented PSS models by assessing the websites of companies registered with three relevant industry classification codes (NACE). Gross lists of companies were drawn from national registries. The focus has been on PSS models for B2B, but relevant examples of B2C models have been included as well since the products for both customer groups are similar or the same and value chains therefore overlap.

It is clear from the policy priorities and many measures on an EU level, which aim at improving the circularity of the electronics and ICT sector, that the focus of the indicator is highly relevant and acceptable by EU stakeholders. This is further strengthened by the emphasis given to circular business models, including PSS, for securing the circular transition of the sector. Research has documented the substantial potential for cost savings and CO2e emission reductions that can be achieved for the sector through circular business models, especially PSS (Lopez et al., 2023).

Observed challenges regarding for example the availability of data and the ease of data collection have led to a low score on robustness and credibility and a fair score on ease in the RACER assessment. The conclusion is that *significant* work is required to facilitate progress on the indicator. There is a path to secure reliability and robustness of the data and the credibility and ease of data collection, but it requires work to potentially adapt the indicator formulation and define the system boundary and measured variables. If these challenges are overcome, there is a potential for the indicator to provide an important contribution to the CE Monitoring Framework as a measure of progress on the availability of circular business models within a priority sector.

The framing and title of this indicator should be re-considered following further development and the recommendations described below.

Recommendations

<u>Define the most promising product groups for PSS solutions and develop annual tracking methodology</u>

Initiatives to provide information on the availability of PSS solutions are often general research, case studies, or collections of cases without a data collection orientation (Sitra, 2022). These are helpful, but they do not provide the necessary foundation for monitoring progress across the EU or even on a national level.

To progress on this matter, it is necessary to define the data and metrics to be collected clearly. This could be the number of companies providing PSS solutions within a widely defined sector, as proposed with this indicator. However, it may be equally or more relevant to measure the amount of turnover for PSS solutions, the number of PSS solutions in the market for specific products or product groups, the number of users/customers for the specific PSS solutions, or other metrics related to the uptake of the PSS solutions.

The Joint Research Centre (JRC) recently developed a methodology for determining priority product categories for use in the development of a reparability score in the EU responding to the implementation needs resulting from the Ecodesign regulations (Spiliotopoulos et al., 2024). The paper highlights the need for prioritising

product groups and the complexity of the process to do so, which we would argue applies not only to repairability but to various elements of the circular economy transition incl. choosing the focus of CE indicators.

To make data collection feasible, it is necessary to limit the scope of this indicator so the research and data collection can focus on specific products or product groups. Naturally, the more products, and thus companies and sectors, are included in continuous monitoring efforts, the higher the cost of the data collection. And without focusing on specific models, data may not provide meaningful insights for the strategy and policy priorities. Since PSS models are at varying levels of maturity and availability across product groups, it would be advisable to focus monitoring efforts on the most promising or important products/product groups for PSS solutions.

The CE Monitoring Framework does not currently include any indicators regarding the supply, demand, and design of circular business models or value chains, including PSS solutions. By applying the above recommendations and focusing on a few specific product groups, it would be feasible to define a methodology for collecting data on these and monitor the progress over time. As the sector for circular business models expands, additional products and product groups could be added.

It is therefore recommended that DG-RTD implements a research initiative to develop a relevant methodology for selecting product groups to monitor for PSS models provided, as well as a methodology for collecting data on these PSS models on a general level or specific to the product groups.

Initiate or support efforts on national level to establish practical networks on circular business models and PSS

The data collection on this indicator would have been easier had there been networks or national associations of businesses to represent and facilitate knowledge sharing related to PSS and circular business models. A network or association representing the interest of circular businesses that offer PSS models may contribute to data collection and be a hub for knowledge generation and activities to promote circular business models.

A network could have members across industries and types of stakeholders to also include perspectives of national authorities, consumer groups and researchers, who all play important roles in the value chain of circular business models. Concerning this specific indicator, the advantage would be a network could help define the relevant metrics and potentially collect the necessary data from members to track progress.

Most likely, such a network would sit best within existing associations, such as national chambers of commerce or associations of national industries. An added benefit of this would be to utilise existing feedback mechanisms to authorities and other actors, which would improve data collection efforts. For example, the availability of a NACE code for renting and leasing of products within the electronics and ICT sector was an advantage, since a more substantial proportion of the companies registered with this NACE code provided PSS solutions, compared to companies within the other codes identified. NACE codes for renting and leasing exist for other sectors as well, where some are much more general, e.g. “N77.2.9 - Renting and leasing of other personal and household goods” while others are much more specific, e.g. “N77.3.4 - Renting and leasing of water transport equipment”. As circular business models based on renting and leasing, such as PSS, are incentivised even further and the market for these grows, it may be relevant to consider a revision of these NACE codes. Such revisions are much more likely to be enabled if suggested by networks or industry associations rather than individual companies. Therefore, enabling networks for PSS would strongly improve the foundations for improved data collection opportunities in future.

Table 18. Summary of recommendations for indicator PSS5.

Type of recommendation	Recommendation	RACER Criteria addressed	Timeline	Key stakeholders or partners
Development of methodology and guidance	Conduct research to define metrics and select promising products/ product groups to enable continuous monitoring efforts on the availability of PSS solutions and potential inclusion of indicators in CE monitoring framework	Relevance and Robustness	Medium (1.5 – 5 years)	DG RTD to coordinate stakeholder engagement and finance research. DG ENV, EEA and other key stakeholders to agree on and help define the focus of the research to ensure alignment.
Stakeholder initiative	Promoting and potentially funding the creation of national networks on PSS and circular business models within specific sectors within existing associations to help foster developments and facilitate easier data collection on the topic in future	Acceptability, Credibility and Ease	Medium (1.5 – 5 years)	DG RTD or other entity to promote the creation of the initiative and provide resources, incl. knowledge sharing. National industry associations and key companies to champion and own the initiative. National authorities and other actors, incl. universities, to support.

4. INDICATOR 3 – THE NO. OF PUBLIC PROCUREMENT CONTRACTS FOR ELECTRONICS AND ICT THAT INCORPORATE PSS MODELS

Indicator: No. of public procurement contracts for electronics and ICT that incorporate PSS models

This indicator refers to the public sector's procurement of PSS solutions for electronics and ICT.

Public authorities in EU member states spend around 14% of total GDP on the purchase of goods, services, works and supplies (Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, n.d.-a). The magnitude of public procurement implies an enormous opportunity for influencing suppliers and manufacturers to provide more sustainable products and services. This is the aim of the Green Public Procurement (GPP) framework of the EU, which was first established in 2008 (European Commission, 2008) and since then developed to provide detailed sector-specific (voluntary) criteria as well as legal requirements to integrate the GPP with wider public procurements legislation and initiatives (Directorate-General for Environment, n.d.-a). There are GPP Criteria for a wide range of product groups, including several related to the sector of electronics and ICT; '*Computers, monitors, tablets and smartphones'; 'Data centres, server rooms and cloud services';* and *'Imaging equipment, consumables and print services'*. The criteria include a long list of selection and award criteria, technical specifications, contract clauses, etc., but do not mention product-as-a-service models or specific references to PSS solutions.

PSS models provide substantial potential for increased circularity and reduced material use, CO2e emission reductions, and cost-saving potential for companies (Lopez et al., 2023). The EU CEAP strongly emphasises incentivising PSS models in future regulatory initiatives, which is reflected in the Ecodesign Directive (European Commission, 2022). Previous research has found that little data is available on the use of PSS in public procurement (Egebæk et al., 2023). The indicator can serve to promote increased use of PSS models in public procurement, hereby supporting more circular solutions to the environmentally challenging area of electronics.

The benefits of monitoring and choosing this indicator include:

- Developing a deeper understanding of the demand for PSS models in a sector for which they have potential to make significant positive impact.
- Providing important data and analyses for policy making on this very important sector in terms of climate impact and resource use.

4.1 KEY METHODOLOGY

4.1.1 Testing method

System Boundary

The indicator is measured at the city level with data collected directly from municipalities to assess the number of PSS contracts for electronics and ICT in municipal procurement. Data was collected from Denmark and Sweden, two countries known for high ambitions related to sustainability in their public procurement (Alhola et al., 2017), presumably representing "best case" scenarios for gathering data.

Data has been gathered from procurement entities in two cities in each country, Göteborg and Malmö in Sweden, and Roskilde and Aarhus in Denmark.

Methodology

The indicator focuses on the 'number of contracts' rather than spending amounts or similar metrics due to the confidential nature of procurement information and the low likelihood of disaggregated data on PSS models being available. Due to the complex nature and variations among PSS models across sectors, as well as inconsistent use of terminology, it is difficult to collect data through standardised surveys. Therefore, qualitative interviews were conducted with public procurement officers, supplemented with written interviews and requests

for data for further analysis. National public procurement associations were consulted to gain insights on wider trends and potential data of relevance on a general level.

Overview of key data sources

Table 19. Source, reliability and availability.

Source	Reliability*	Availability**
Public procurement offices of e.g. Göteborg, Malmö (Sweden) as well as Århus and Roskilde (Denmark)	*Medium*	*Medium*
National Public Procurement offices from Denmark (SKI) and Sweden (Adda)	*Medium*	*Medium*

** **Low** = Some data will likely be missing and incomplete, which may lead to inaccurate conclusions, **Medium** = The data will likely be complete but may lack accuracy and quality, **High** = The data will likely be complete, accurate and of high quality.*

*** **Low** = The data is not already collected or readily available, and will be difficult to collect. **Medium** = The data is already collected but is not publicly available, OR the data is not already collected but is easy to collect, **High** = The data is readily available and can be accessed easily.*

4.1.2 Data collection method

Data requirements

The interviews with representatives from public procurement offices were semi-structured and focused on the integration PSS solutions in procurement activities. The interviewer explained the terminology of PSS models that may be relevant for public procurement within the electronics and ICT sector and answered questions from the interviewees.

The national public procurement associations were interviewed to establish a broader overview of whether PSS is considered in national framework agreements for public procurers. Relevant metrics, including spending amounts, product groups, contract volume, number of contracts, etc., were noted down.

Due to a lack of response to the interview requests and limited examples of the use of PSS, additional municipalities were consulted by phone and mail.

Data collection steps

1. Assess publicly available information for the cases to identify any relevant data concerning PSS.
2. Develop interview guide for public procurers at municipalities.
3. Approach and engage local municipalities via interviews with procurement employees.
4. Approach and engage national public procurement associations.
5. Conduct interviews with national public procurement associations.
6. Send out a written survey to additional municipalities.
7. Collate and analyse results for reporting.

Interviews with employees from municipalities

Semi-structured interviews were conducted with public procurement officers in the chosen municipalities (see interview guide in Appendix 5.3). The questions addressed the municipalities' environmental, climate, circularity and PSS considerations in public procurement, and specifically how these considerations were implemented in contracts for electronic and ICT equipment. Due to the procurement officers' limited knowledge of PSS, the interviewer explained the concept and the specific relevance within electronics and ICT contracts in municipalities.

Interviews with national public procurement associations

Interviews with representatives from national public procurement associations were conducted to assess whether municipal information was reflected in the national procurement context.

The interviews were also conducted to investigate the practices of the national public procurement associations and whether they integrate PSS requirements in their framework agreements.

The national public procurement associations establish agreements for multiple municipalities and other public institutions to reduce transaction costs and increase bargaining power. They also create and implement policies, e.g., on green public procurement, and have an overview of and influence on the processes, tenders, purchasing opportunities, and practices of the municipalities.

4.1.3 Calculations

There were no calculations made during the testing of the indicator

4.1.4 Timeline

The testing phase was conducted as outlined in the Gantt chart in Table 20.

Table 20. Gantt chart - PSS6

	WC	01.jan	08.jan	15.jan	22.jan	29.jan	05.feb	12.feb	19.feb	26.feb	04.mar	11.mar	18.mar	25.mar	01.apr
	Finalise Data Collection Plan														
	Desk research and data collection														
	Stakeholder engagement														
	Data analysis														
	Reporting														
	Review period														
Legend															
	Task progress														
	Review period														

4.1.5 Data gaps and mitigation

Due to the lack of national data on public procurement contracts with PSS aspects, data was collected on a municipal level. Since information on PSS elements in contracts is not a common metric for procurement systems, consultations with procurement officers were carried out, acknowledging that the individual procurers do not necessarily have an overview of data on all relevant product groups. The potential data gap is directly related to the lack of data aggregation and the broad definition of 'Electronics and ICT'. This may be mitigated by increasing the number of consultations, but the low response rate for our data and interview requests means that the level of confidence in our mitigation efforts is rated as 'low'.

The research is, however, limited by procurement officers' ability and willingness to participate and provide relevant information. The researchers pursued cooperation by sending reminders and taking contact through various channels (email, phone), but the timeframe of the research and the voluntary nature of data collection made it impossible to mitigate this fully. Thus, there is a risk of a data gap related to a lack of responses or a lack of quality in responses from key stakeholders, which means that our level of confidence in mitigation efforts is marked as 'low'.

Table 21. Overview of identified data gaps, limitations, and mitigation efforts.

	Description of data gap	Mitigation efforts	Level of confidence
1	Lack of aggregate data related to the indicator	• Interviews with subject matter employees in the municipalities	Low
2	Lack of willingness from employees/key stakeholders to participate in interviews	• Interview requests to a broad group of employees and reminders sent	Low

4.1.6 Quality review of analysis

To ensure robust and high-quality results, we have conducted the following data validation and quality control procedures:

- Prior to work beginning, the Project Director (Jess Twemlow) reviewed the proposed research methodology and ensured that the data collection plan was fit for purpose. Once the research team addressed any comments from the review process, they proceeded to the data collection phase.
- Project Coordinator Bjørn Bauer oversaw the data collection phase to ensure that the collected data and analysis conducted was of a high standard and provided useful content for the final case study output.
- Andrew Dunwoody is responsible for the quality of the final case study output. Rob Snaith has assisted Andrew Dunwoody in judging the quality of the output and suggested ways to improve.

4.2 KEY RESULTS

4.2.1 Analysis

Of the 24 stakeholders contacted, nine responded, including eight municipalities, of which four had one PSS-related contract on digital office equipment.

Table 22. Overview of data from stakeholders

Country	Municipality	Contact Form	Response	PSS in Contracts	Details, e.g. Product Type(s)	No. of Contracts
DK	Faaborg-Midtfyn	Email	Yes	Yes	Digital whiteboards	1
DK	Vesthimmerland	Email	Yes	Yes	Multifunctional printers	1
SWE	Hylte	Email	Yes	Yes	Multifunctional printers	1
SWE	Malmö	Email	Yes	Yes	Communication equipment for events	1
DK	Aarhus	Email	Yes	No		
DK	Brøndby	Email	Yes	No		
DK	Odense	Email	Yes	No		
DK	Roskilde	Phone interview	Yes	No		
DK	SKI (National public procurement association)	Phone interview	Yes	N/A		
DK	Ballerup	Email	No			
DK	Egedal	Email	No			
DK	Lolland	Email	No			
DK	Sønderborg	Email	No			
DK	Vejle	Email	No			
SWE	Nyköping	Email	No			
SWE	Uppsala	Email	No			
SWE	Åmål	Email	No			
SWE	Linköping	Email	No			
SWE	Kristianstad	Email	No			
SWE	Mariestad	Email	No			
SWE	Pajala	Email	No			
SWE	Karlskrona	Email	No			

Country	Municipality	Contact Form	Response	PSS in Contracts	Details, e.g. Product Type(s)	No. of Contracts
SWE	Adda (National public procurement association)	Email	No			
SWE	Göteborg	Email	No			

Denmark

Danish municipalities showed only a few PSS-related contracts for electronics and ICT products, and many municipalities did not reply to the request for information.

Responses highlighted an important barrier for utilising PSS models. If a municipality has joined a framework procurement agreement negotiated by the Danish National Procurement Agency (SKI), the municipality is often obligated to use the framework agreement. If PSS models are not included in such agreements, municipalities will be directly limited from using PSS models. For example, SKI has a framework agreement for computers and IT accessories, which many Danish municipalities are required to use, and this agreement does not include PSS models (SKI, 2023).

SKI is a publicly owned not-for-profit organisation that streamlines and professionalises public procurement to ensure the best price and quality. Around 1.5 B€/year is channelled through SKI's framework agreements (Staten og Kommunernes Indkøbsservice, n.d.-a).

SKI framework agreements reduce the municipalities' administrative burden of setting sustainability requirements in tenders. There are other initiatives taken, rather than promoting PSS solutions, related to increasing circularity of procurement, such as applying Total Cost of Ownership (TCO) calculations, requirements for repairability and upgrades for devices, high environmental standards for production and packing, as well as recyclability and take-back schemes (Staten og Kommunernes Indkøbsservice, n.d.-c).

Our interview with SKI confirmed that there is a high use of PSS-models within software categories (Software as a Service), but a yet more limited use or demand of PSS-models in other framework agreements as well as those related to it-hardware. There is an awareness of the potential of PSS and continuous efforts to ensure that the most appropriate standards and best practices concerning circularity and sustainability are applied in their agreements throughout. However, in the development of specific framework agreements, there needs to be demands from the buyers, i.e. the municipalities and other public institutions, regarding PSS, for SKI to advance the use of such models. Additionally, the market needs to be able to provide models at a sufficient, large scale and maturity, besides meeting requirements for price, quality, and other requirements, in order for the PSS models to ultimately be relevant for use in the framework agreements SKI creates. Since such requests from buyers have been limited for the areas in question, SKI has not implemented PSS-models at a large scale as of today. However, SKI is working on a circular IT agreement, which will allow buyers to prolong the life of their existing hardware products as well as procure used ICT - this agreement is set to enter into force in 2026.

This has the direct implication that for most product groups within electronics and ICT, where municipalities use SKI framework agreements, there is a low chance of increased adoption of PSS models in public procurement in Denmark in the coming years.

Sweden

Only two Swedish municipalities responded to the inquiry, each with only one example of PSS models used in procuring ICT. A representative from Malmö Municipality states that:

> "When we bring the subject [circularity] to the suppliers, they reply "Yes, we have this business model called Product-as-a-service, where you can lease it". For us, we feel that there must be more options on the market. Leasing the product is connected to higher costs and as a municipality organisation, we need to always focus on being able to buy the cheapest option" (Interreg - North Sea Region, 2021).

This illustrates one potential barrier to using PSS solutions, namely that the cost of leasing is perceived to be higher than purchasing. To properly compare the cost of various models, it is important that methods of calculating Total Cost of Ownership (TCO) and/or Life-Cycle Costing (LCC) are applied, so that all relevant cost aspects of products' life cycles are included in the assessment.

In Sweden, municipalities can utilise framework agreements set by the Central Purchasing Body *Adda AB*, which is owned by the Swedish Association of Local Authorities and Regions (SKR). Like SKI in Denmark, Adda has several framework agreements for product groups within electronics and ICT, including an agreement for digital devices such as laptops, computers, tablets, phones, monitors and more. The agreement includes detailed guidance on how to utilise 'device-as-a-service' models, a type of PSS model (Adda Inköpscentral, 2022). This means that Swedish municipalities have direct access to negotiated agreements where the suppliers are obligated to provide a PSS model when requested to do so. Adda also sets standards for sustainability within the agreement, including by asking suppliers to offer refurbished products, extended warranties, TCO certifications, eco-labels and other standards, circular take-back schemes for end-of-life digital devices, and requirements to secure high-quality products, long life cycles, and promote repairs and upgrades (Adda Inköpscentral, 2023).

Despite multiple attempts, it was not possible to secure an interview with representatives of Adda during the testing period. It was, therefore, impossible to obtain data or information on the usage of the device-as-a-service option. When the framework agreement was announced in 2021, a representative of Adda said that the agreement was voluntary to use and estimated that at least 200 public authorities would use it. One company, Qlosr Group, which was selected as a supplier for the agreement, estimated that approx. 35% of its expected revenue from the agreement of SEK 160 million (approx. EUR 14 million) would be from device-as-a-service elements (Djurberg, 2021).

Clearly, there are trends towards increased uptake of PSS models for ICT in public procurement in Swedish municipalities.

4.2.2 Limitations

The electronics and ICT sector is very broad and encompasses many different products and product groups. The investigation has not focused on a specific subset of products because of the risk that this may exclude results of relevance for the indicator. All information identified and provided by the respondents is noted.

The lack of focus might have been a contributing factor to the low number of respondents, as they may have been overwhelmed by the number of product groups they would need to check. It might also have been harder for the respondents to identify all relevant product groups since they did not have a list of specific products against which to check their procurement systems. The lack of responses might also be explained by a lack of knowledge and experience with PSS models related to the complexity of these solutions compared to regular product sales.

The low number of respondents and the risk of unreported cases of PSS usage in the municipalities in question are limitations of the results. The research does not give a complete picture of the municipalities' use of PSS, nor a comprehensive picture on a national level. The results can, therefore, only provide indications on the procurement of PSS models for electronics and ICT.

4.2.3 Performance

A RACER assessment is carried out to evaluate the indicator and the methodology used to test it on various parameters.

Table 23. RACER evaluation.

Stage of project	RACER criterion					Score
	Relevance	Acceptability	Credibility	Ease	Robustness	
Task 4 (original RACER assessment)	2	2	1	1	1	7*
After Task 5 (following testing)	3	2	2	1	2	10

*Original indicator: "Share of Public Procurement spent on PSS"

Relevance

EU institutions broadly recognise the important role of public procurement in the circular transition, as reflected in the CEAP and the Green Public Procurement framework. PSS solutions have substantial potential for

creating more sustainable and circular procurement. By tracking the use of PSS models in public procurement, the indicator supports wider systemic changes and high R-level strategies (Rethink) in this sector's circular transition. This justifies a high score on the parameter of Relevance.

Acceptability

EU policy initiatives significantly focus on the circularity of procurement processes, and CEAP's intentions may soon lead to more binding public procurement requirements related to PSS. In Sweden, PSS models are included in the requirements of a central procurement body with substantial influence on many public authorities' procurement practices. However, procurement entities are not in favour of complicated monitoring models, so the overall acceptability is ranked medium.

Credibility

We have applied a basic methodology to collect the data since the indicator asks for a simple count of contracts in which PSS models are included for product groups within the Electronics and ICT sector. The methodology is not pre-defined in other research and may lack credibility, since it is not anchored within existing data collection frameworks, but it is easy to understand and communicate to stakeholders, which justifies a medium score of 2.

Ease

There is a lack of an authoritative, accessible dataset of municipalities' use of PSS solutions in their procurement. This could be established nationally through the national procurement institutions but limited in scope to areas for which national framework contracts are established. Presently, information is to be gathered through consultations with individual municipalities about their use of PSS models with related costs, limitations, and data gaps, and this will be the case in most or all MS. This requires strong support from the municipality in providing the necessary information in a timely manner, including access to all potentially relevant employees, even when responses to the data requests are achieved, they may not result in complete data.

Robustness

The data collected via the methodology is sufficiently robust despite the uncertainties concerning data gaps and limitations since it is primary data collected directly from the municipalities. However, since many municipalities did not respond to our data request, the dataset is not complete, and the indicator, therefore, cannot receive a full score on this criterion.

4.3 CHALLENGES AND LESSONS LEARNED

4.3.1 Challenges

The main challenge for implementing this indicator is the lack of existing research and data on PSS in public procurement. Our data collection was challenged by the lack of responses from the municipalities and, additionally, the lack of knowledge by municipalities' employees on PSS solutions across the wide range of product groups included in the research. This was mitigated by expanding the scope from the original four municipalities across the two countries to 22 municipalities and consulting with the national procurement associations, however, with limited results.

In a broader view, the main challenge for collecting data on this indicator is a lack of aggregate data available on public procurement practices with specific reference to the use of circularity metrics and circular business models such as PSS. If more data was collected and readily available, it would be possible to conduct research on this indicator with much higher accuracy and ease[5].

4.3.2 Lessons learned

Ideally, data collection would be based on assessing information shared by national or regional procurement associations, such as SKI in Denmark and Adda in Sweden, since this would give reliable, aggregated data relevant to the indicator. If the procurement associations include PSS models as an option, it should be

[5] The EU platform TED (Tenders Electronic Daily) includes all tender notices by public authorities and institutions in the EU above the regulated thresholds, but does not provide an easy method for searching for tenders that include PSS requirements.

possible to access data on which organisations have used such models or have a gross list of organisations to contact with requests for information.

Another lesson learned is to specify the system boundary under investigation further. The testing has shown that the Electronics and ICT sector is very broad, encompassing many products and product groups, which puts a heavy burden on data collection. A more specific system boundary for investigation might have reduced the methodological challenges and the complexity of the research.

4.4 CONCLUSIONS AND RECOMMENDATIONS

It is recommended that this indicator is considered for further development, with significant work required to facilitate its progress.

Final indicator formulation:

No. of public procurement contracts for electronics and ICT that incorporate PSS models

The indicator is formulated to track the number of public procurement contracts of municipalities that include PSS models within the Electronics and ICT sector. The overall conclusion is that the indicator is highly relevant, but the advancement of it in the EU is significantly challenged by the lack of available data and the feasibility of new data collection efforts. Further development is highly dependent on the interest and commitment of key stakeholders to develop reporting and data collection frameworks to allow for analysing and monitoring the indicator across the EU MS.

PSS models provide an opportunity to address circularity at a high R-level by contributing to rethinking procurement and stimulating changes across the value chain (Morales, 2023). The goals of the CEAP for circular public procurement and the continued intensification of requirements in the EU related to the sustainability and circularity of the sector provide ample reasons for the relevance of the indicator.

The testing method for this indicator was designed to gather data on public procurement contracts with PSS models in Denmark and Sweden, considering the lack of aggregated data available. Overall, only four contracts with PSS models were identified, one each in four different municipalities, while four municipalities claimed to have no contracts with PSS and 14 municipalities did not respond. The Swedish central procurement body, Adda, which provides framework agreements for hundreds of public authorities, has included provisions and guidance for including PSS models in tenders using device-as-a-service models for computers, smartphones, tablets, and similar products. This indicates that there may be municipalities that have procurement contracts that include PSS in Sweden, which were not identified in this testing phase since we only covered a sample of municipalities and suffered from a lack of responses. However, this is an assumption, which has not been tested, and since Denmark and Sweden were chosen as best-case scenarios for the indicator, likely, the uptake of PSS models for electronics in public procurement elsewhere in the EU is also very limited.

The report has also discussed the specific challenges and data gaps related to the methodology and the limitations of investigating a broad sector such as Electronics and ICT. The JRC has developed a methodology for determining priority product categories for use in the development of a reparability score in the EU (Spiliotopoulos et al., 2024). This highlights the need for prioritising product groups and the complexity of the process to do so, which we would argue applies not only to repairability but to various elements of the circular economy transition incl. choosing the focus of CE indicators. Efforts to develop this indicator would benefit from revising the method and narrowing the system boundary by reducing the scope of products included.

The framing and title of this indicator should be re-considered following further development and the recommendations described below.

Recommendations

We recommend that DG RTD implements an initiative to conduct further research on the potential of this indicator by investigating the interest on a national and city/regional level for advancing PSS solutions through public procurement. The Swedish lessons may provide a valuable starting point, while other Member States in the EU may have additional experiences not explored in this report, either on a national or municipal level.

This would contribute to and could be anchored within the Big Buyers Working Together project, launched by the EC in 2023, where ten Communities of Practice (CoPs) have been created, including one for the Digital sector (Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, n.d.-b). This Digital CoP

will bring public authorities together around several objectives to “effectively address sector-specific opportunities and challenges on innovative and sustainable practices of public procurement” (ibid.).

A research initiative could utilise the network and platform of the Digital CoP to collect best-practices and build methodologies for data collection that would facilitate implementation of the indicator across EU Member States. The Circular & Fair ICT Pact, which is part of the Sustainable Public Procurement Programme of the UN One Planet Network (Circular and Fair ICT Procurement, 2022), could be informed or consulted as well for this initiative. It could include considerations on how to adapt the EU Tenders platform “TED” (tenders electronic daily) to include further sections related to PSS models or circular business models generally[6].

[6] https://ted.europa.eu/en/index

Table 24. Summary of recommendations for indicator PSS6.

Type of recommendation	Recommendation	RACER Criteria Addressed	Timeline	Key stakeholders or partners
R&D initiative	Implement an initiative to conduct further research on the interest in the indicator across public buyers in EU Member States as well as further development on a cost-effective methodology that allows for collecting aggregated data.	Acceptability, Ease and Robustness	Medium (1.5 – 5 years)	Responsible: DG RTD Accountable: EC Consulted: Digital CoP under the Big Buyers Working Together project; Business Associations representing the suppliers and manufacturers Informed: Circular & Fair ICT Pact

5. APPENDICES

5.1 APPENDIX 1: PSS3. DATA COLLECTION RESULTS

See MS Excel document “DGRTD_PSS3_DataCollectionResults_V01.00 “ provided alongside this report.

5.2 APPENDIX 2: PSS5. DATA COLLECTION RESULTS

See MS Excel document “DGRTD_PSS5_DataCollectionResults_V01.00 “ provided alongside this report.

5.3 APPENDIX 3: PSS6. INTERVIEW GUIDE FOR MUNICIPALITIES

See MS Word document “DGRTD_PSS6_InterviewGuide_V01.00 “ provided alongside this report.

5.4 APPENDIX 4: RACER ASSESSMENT MATRIX

Criterion	Description	1 (Poor)	2 (Neutral)	3 (Good)
Relevance	Refers to whether the indicator is closely linked to the objectives to be reached.	Does not support a better understanding of true circularity.	Supports a better understanding of true circularity.	Highly supportive towards gaining a better understanding of true circularity.
		Supports no value-added circular opportunities.	Supports lower value-added opportunities (i.e. metrics related to waste generation, recycling, waste management, etc.)	Supports higher value-added opportunities (i.e. all R-strategies above remanufacturing) and wider systemic change (e.g. indicators that encourage PSS or circular design).
		Not linked to the project objectives and/or European policy objectives (existing or upcoming).	Linked to the project objectives, but not to European policy objectives (existing and/or upcoming).	Fully aligned with project objectives and European policy objectives (existing and/or upcoming).
Acceptance	Refers to whether the indicator is perceived and used by key stakeholders (such as policymakers, civil society, and industry).	Poorly accepted by key stakeholders, e.g. due to the use of confidential data.	Relatively accepted by key stakeholders as the benefits of measuring are clear.	Key stakeholders are motived to report this indicator, due to mandatory legislative requirements (current or upcoming), potential commercial benefit or being in the public interest.
Credibility	Refers to whether the indicator is transparent, trustworthy and easy to interpret.	No defined methodology associated with this indicator and/or interpretation of the indicator is ambiguous.	Methodologies have been proposed or currently existing, but not for this particular indicator (e.g. in a research article).	There is an EU defined methodology.
		Difficult to understand and communicate to stakeholders (e.g. units or measurement of something that stakeholders are not familiar with).	Moderately easy to understand and communicate to stakeholders (e.g. units or measurement of something that stakeholders are aware of but are not confident in practical use).	Easy to understand and communicate to stakeholders (e.g. units or measurement of something that stakeholders already use and are confident in applying).
Ease	Refers to the easiness of measuring and monitoring the indicator.	No defined methodology associated with this indicator and/or interpretation of the indicator is ambiguous.	Methodologies have been proposed or currently existing, but not for this particular indicator (e.g. in a research article).	There is an EU defined methodology.
		Difficult to understand and communicate to stakeholders (e.g. units or measurement of something that stakeholders are not familiar with).	Moderately easy to understand and communicate to stakeholders (e.g. units or measurement of something that stakeholders are aware of but are not confident in practical use).	Easy to understand and communicate to stakeholders (e.g. units or measurement of something that stakeholders already use and are confident in applying).
Robustness	Refers to whether data is biased and comprehensively assesses circularity.	No consistent methodology and dataset are available.	A consistent methodology and dataset available.	A consistent methodology and dataset available.
			A composite/aggregated indicator (based on multiples dimensions).	A one-dimensional indicator.
			A proxy indicator.	

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