INDICATORS AND METHODS FOR MEASURING TRANSITION TO CLIMATE NEUTRAL CIRCULARITY

Task 5: Case-study group PL1

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

Ref. RTD/2022/OP/0003

Customer:
European Commission, DG RTD

Customer reference:
RTD/2022/OP/0003

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Ricardo reference: ED16719

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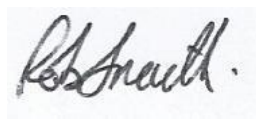T: +44 (0) 1235 753 029
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1. INTRODUCTION

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 1 of the plastics 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 PL1

URN		Indicator name	Methodology	Level of implementation				
				EU	National	City / Region	Companies	Household
PL1	1	Number of pilot/demonstration projects on circular production and treatment of plastics	Desk-based research		X			
PL2	2	Number of legislative incentives created to encourage circularity in the plastics industry	Desk-based research			X		
PL3	3	Total weight of plastic material recovered and reused through industrial symbiosis initiatives in the EU	Desk-based research/survey			X		

2. INDICATOR 1 – NUMBER OF PILOT/DEMONSTRATION PROJECTS ON THE CIRCULAR PRODUCTION AND TREATMENT OF PLASTICS

The EU has a number of legislative objectives and targets focused on reducing the environmental impact of plastics. In particular, the Chemicals Strategy for Sustainability (European Commission, 2020) states that Member States should support investments in sustainable innovations that can decontaminate waste streams, increase safe recycling and reduce the export of waste. There are no specific legislative targets for the number of sustainable innovations to be reached, however targets do exist which state that:

- By 2030, all plastic packaging placed on the EU market should either be reusable or recyclable in a cost-effective manner.
- By 2030, at least 50% of Europe's plastic waste should be recycled.
- Collection of single-use plastic waste should reach 77% by 2025 and 90% by 2029.
- From 2030, requirements will come into force for the minimum recycled content of some plastic packaging, rising in 2040.

In order to achieve the targets described above, the EU must support advancements in plastic manufacturing technology to ensure that products placed on the market are designed for reuse and recyclability and that they are made from materials that can be most effectively disposed of. It should also ensure that it adequately scales up its collection, sorting and recycling capacity to cope with the additional demand. While the number of pilot projects in a given year may not directly correlate with this scaling up of capacity, it is expected that more pilot projects will reflect a more innovative sector and so in general, the greater the number of pilot projects, the greater the chance of reaching the EU's plastic targets.

Currently, the EU tracks research and development via gross domestic expenditure, business enterprise expenditure, Research and Development (R&D) personnel and government budget allocation. The data for these indicators is also categorised by further variables including sector of performance (at a granularity of natural sciences, chemical engineering, economics and business, etc.), type of institution and source of funds.

Where this indicator builds on the existing data is the specific focus on plastics as a topic of innovation, rather than simply general subject areas. It clearly highlights plastic as a priority area for innovation, and by tracking the theme of each pilot project identified (for example, marine pollution removal or effective valorisation of waste), can also provide an indication of which aspects of the 'circular production and treatment of plastics' are either over or under-represented in research and development.

Furthermore, by tracking both the expenditure on R&D and the number of pilot projects, the EU will be able to track year-to-year whether there are a large number of small projects, potentially conducted by SMEs, or whether a smaller number of organisations are undertaking large projects. Fewer larger projects would limit the likelihood of repeating research unnecessarily, but the more organisations involved in pilot projects would indicate a dynamic, engaged sector.

In summary, the main benefits of measuring this indicator are:

- It would enable the EU to track the level of innovation in the plastics sector – more pilot projects suggests a sector that is more committed to circularity.
- More circular plastic manufacturing and disposal should also lower the sector's environmental impact as it will reduce the demand for virgin plastics.
- R&D activity supports local economies by boosting jobs and economic activity.
- It will indirectly improve the effectiveness of EU plastic targets regarding recycling and recycled content.

2.1   KEY METHODOLOGY

2.1.1   Testing method

For this indicator, pilot/demonstration projects are defined as projects of a set length that test the feasibility of an action or technology and whose primary purpose is to undertake research, collect feedback or to act as a proof-of-concept. Projects are included if their primary motivation is to test the feasibility of an idea, collect data or otherwise further technical understanding in an area. Projects which focus on understanding the costs and revenues of a new concept are also included, but excluded are projects whose primary motivations are to generate profit or commercial interest.

The system boundary will also be limited to projects that had an inception date in the reporting year. This is to avoid the double-counting of projects over multiple years if the project duration is more than one year. Finally, for projects that are conducted by organisations from multiple countries, there should be a distinction (where possible) between projects where the reporting country is represented by a contributing organisation and projects where the reporting country is represented by the lead/coordinating organisation.

The system boundary for types of project to be included in this indicator are:

- Circular production of plastic – this includes projects which aim to improve the production of plastics from recycled/renewable sources
- Circular treatment of plastic – this includes projects which aim to find high valorisation reprocessing/reuse opportunities for waste plastic

The case studies chosen for the testing of this indicator are Spain, which was selected due to it being a country with both a high level of plastic recycling and a high level of R&D expenditure, and Luxembourg, which was selected as it has a relatively high level of plastic recycling but, due to being a very small country, a low level of R&D expenditure. 2023 was selected as the year of study.

The methodology used to measure this indicator was desk-based research. In the first instance, EU sources including CORDIS (European Commission), Kohesio (European Commission), LIFE (European Commission) and Interreg Europe (Interreg Europe) were searched to identify relevant projects. These are databases which contain details of all projects funded by the European Commission. Once they were exhausted, other sources including the European Investment Bank (EIB) (European Investment Bank) and Invest in Spain (Invest in Spain) were used. Finally, once all identified databases had been fully searched, a internet search was undertaken to identify any privately funded pilot projects in the reporting countries.

2.1.2   Data collection method

The information required for this indicator is as follows:

- Participating country (including whether the country is a lead contributor to the project).
- Pilot project title.
- Project starting year.
- Link to the project.
- Summary of the project.
- Theme of the project.
- Project source.

As noted above, the primary method of data collection for this process was desk-based research. This took place in a series of stages:

- Firstly, project databases known to the project team were reviewed for relevant projects. These included the EU's CORDIS database of EU-funded projects.
- Secondly, a internet search was conducted to identify any similar databases. Additional EU sources were found at this stage, as well as data from the EIB and other private sector sources.
- Once these sources were exhausted, an internet search was undertaken to find projects not held within any databases. These google searches were conducted in English, Spanish, and Luxembourgish to capture any sources in the target countries' national languages. The methodology of this google search was as follows:

- o Varying combinations of "circular economy", "plastic", "pilot", "demonstration", "project", "programme" and "[country]" were searched for, with each key term in speech marks to exclude results which only contain some of the search terms.
- o Google's advanced search tools were used to limit results to only those from 2023.
- o In practice, it was found that the most effective combination of search terms was "plastic" "pilot" "[country]" ("piloto" "plastico" "España", or "pilot" "plastik" "Lëtzebuerg").
- o The returned results were manually screened by the team to exclude any irrelevant results. The search was deemed to have concluded when the most recent page returned no relevant results for the first time, or when page twenty was reached, whichever of the two came sooner.

A list of the database sources used can be found in the table below, along with the specific search criteria used for each.

Table 2: Overview of database sources

Source	Search criteria
CORDIS (European Commission)	Collection: Projects Start date (From): 01/01/2023 Start date (To): 31/12/2023 Organisation country: Spain/Luxembourg
Innovation Fund (European Commission)	No ability to filter results. Results were sorted by country and manually screened for start dates.
LIFE Public Database (European Commission)	Date: 2022 (returns projects with a start date of 2023) Submitting countries: Spain/Luxembourg
InvestEU (European Union)	Country: Spain/Luxembourg Eligible areas: Environment, Research, development and innovation, Seas and oceans, Sustainable bioeconomy, SMEs and small mid-caps. This returned results regarding different funding calls which were manually screened for key words.
EIB (European Investment Bank)	Country: Spain/Luxembourg From: 2023 To: 2024 Sectors: Agriculture, fisheries, forestry, Composite infrastructure, Energy, Industry, Solid waste
CDTI (Ministero de Ciencia, Innovacion y Universidades)	Date: 2023 No ability to filter results. Results were manually screened for key words.

As noted above, when relevant projects were identified, the required information was input into a spreadsheet file. The projects were also categorised according to project theme at this stage. These themes, and a brief description, are outlined below.

Table 3: Summary of pilot project themes

Theme	Circular production / treatment	Description
Circular value chains	Both	Projects which are focused on policy and market mechanisms to enable the transition towards a circular economy for plastics
Innovative processing technologies	Treatment	Projects to improve the efficiency/capacity of recycling and reprocessing technologies
Innovative sustainable materials	Production	Projects which aim to test and validate plastics produced from novel sources, excluding bio-based sources
New bioplastics	Production	Projects which aim to test and validate plastics produced from novel bio-based sources
Plastic pollution removal	Treatment	Projects that concentrate of the removal of plastic pollution from the environment, including from marine environments
Valorisation of waste	Both	Projects focused on finding useful opportunities for plastic waste

These themes were developed concurrently with the desk-based research of pilot projects, with a methodology as described below:

- On review of first pilot project:
    - Summarise the main circular theme of the project as outlined in the project description in a ~2 to 3 word phrase.
- On review of subsequent pilot projects:
    - If its main theme as outlined in the project description is the same as a previously identified theme, assign this theme.
    - If its main theme does not align with any previously identified theme, assign it a new theme as with the first project.
- When reviewing the database:
    - When all pilot projects have been identified, review all of the themes assigned to projects to ensure that they are the closest possible matches.
    - If required, multiple themes can be combined where they cover the same topics.
    - Similarly, new categories can be created where distinction is useful. For example, a distinction was made between 'new bioplastics' and 'innovative sustainable materials' to cover bio-based and non bio-based plastics.

By categorising the identified projects according to these themes, trends will be captured with regards to particular focal points in the plastics sector (i.e., if the majority of pilot projects identified in a particular year are centred around new bioplastics, it may highlight that future rounds of funding or future startups should focus more heavily on processing technologies to avoid those falling behind).

2.1.3   Calculations

Once all pilot projects for the reporting countries were identified and categorised as above, the final indicator results were calculated by summing the number of pilot projects by theme and in total.

2.1.4 Timeline

The Gantt chart below shows the timeline for this indicator.

Table 4: Gantt chart of indicator PL1

	01-Jan	15-Jan	29-Jan	12-Feb	26-Feb	11-Mar	25-Mar
T1 - Develop and agree definitions of pilot projects and circular plastics	■						
T2 - conduct desk-based research of pilot projects	■	■	■				
T3 - Analyse results and categorise pilot projects				■	■		
T4 - Conduct analysis of themes/trends					■	■	
T5 - Write up case study template						■	■

2.1.5 Data gaps and mitigation

There were only minor data gaps associated with this indicator, so few mitigation strategies were required. The EU publishes detailed information about the pilot projects it funds, while other sources like the EIB's project database had similar levels of detail. Information on privately funded pilot projects was also relatively readily available via desk-based research. It is believed that pilot projects represent 'good news stories' for any organisations involved in their development, as they signal that the organisation is at the forefront of technological innovation in their sector. For this reason, it was assumed to be very unlikely for a pilot project to have been undertaken without any news coverage or funding information.

Thus, the only potential for data gaps that was identified for this indicator is the google search. As discussed above, an internet search in English, Spanish and Luxembourgish was undertaken to identify pilot projects beyond those found in the database sources. Conducting a comprehensive review of all the results returned from these searches would be very time-consuming and would likely mean the exclusion of a significant number of irrelevant results, so it was decided that the review of the findings would be concluded when either:

- The most recent page returned no relevant results for the first time.
- Page twenty was reached, whichever of the two came sooner.

These limits were designed to act as a guide for when to stop the search, and they are not expected to have had a major impact on the results of the indicator.

As noted, searches were conducted in multiple languages to avoid missing any projects that were documented in languages other than English. In-browser translation was available for the majority of webpages in Spanish while Luxembourgish webpages were translated via Google translate. However, it is acknowledged that due to the team's lack of fluency in the languages, some results may have been missed where words and phrases used differed from the key search terms used.

Table 5. Overview of identified data gaps, limitations and mitigation efforts

	Description of data gap	Mitigation efforts	Level of confidence
1	Language barriers limited the efficiency of desk-based research	• In-browser translation functions were used to translate websites from Spanish. • Luxembourgish results were translated via Google Translate.	High
2	Human judgement needed to determine when search no longer returns useful results	• Search limits were set to ensure the team did not spend significant time reviewing irrelevant results.	High

2.1.6   Quality review of analysis

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

- Prior to work beginning, the Project Director reviewed the proposed research methodology and ensured that the data collection plan was fit for purpose. Once the research team had addressed any comments from the review process, they proceeded to the data collection phase.
- The Quality Assurance Manager held responsibility for the quality of the final case study output. The Project Manager assisted the Quality Assurance Manager in judging the quality of the output and suggesting ways to improve.

2.2   KEY ANALYSIS RESULTS

2.2.1   Analysis

The table below presents the number of pilot projects per country under study, categorised according to theme and according to whether the country was a lead on the project or a contributing member.

Table 6: Number of pilot projects per country and per theme

	Spain (project lead)	Spain (project contributor)	Luxembourg (project lead)	Luxembourg (project contributor)
Circular value chains	-	1	1	-
Innovative processing technologies	-	1	-	-
Innovative sustainable materials	1	2	-	2
New bioplastics	7	8	-	-
Plastic pollution removal	4	5	-	-
Valorisation of waste	9	5	-	-
Total	**43**		**3**	

As can be seen, there were significantly more pilot projects identified for Spain than Luxembourg, an expected result considering the relative sizes of the countries. Spain's population in 2023 was 47,519,600, compared to Luxembourg's 660,800, which is approximately 1% of the population of Spain. Interestingly, when the number of pilot projects are normalised to a per 100,000 inhabitants basis, we see that Spain had 0.09 projects per 100,000 inhabitants whereas Luxembourg had 0.45 per 100,000 inhabitants.

It would be useful to compare the raw data on the number of pilot projects with the countries' expenditure on R&D. According to the Eurostat metric, "Gross domestic expenditure on R&D (GERD) at national and regional level"[1] (rd_e_gerdtot), Spain's R&D spending in 2022 (the most recent available data) was approximately €19,325,000,000 (€407.41 per person) while Luxembourg's was €757,000,000 (€1173.06 per person). When standardising the number of pilot projects to a per €100,000,000 basis, Spain had 0.22 projects, while Luxembourg's result was 0.40. A table summarising these comparisons is below.

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[1] This refers to the total expenditure of a country on R&D initiatives

Table 7: Comparison of results with country data

	Spain	Luxembourg
Number of pilot projects	**43**	**3**
Population	47,519,600	660,800
Pilot projects per 100,000 inhabitants	**0.09**	**0.45**
R&D expenditure (2022) (million €)	19,325	757
R&D expenditure per person (€)	407.41	1,173.06
Pilot projects per €100,000,000 R&D expenditure	**0.22**	**0.40**

Eurostat has an additional metric which is intended to categorise the GERD by fields of R&D (rd_e_gerdsc) which would be useful to further normalise this indicator as it would allow for the exclusion of irrelevant R&D spending, for example spending on medical and health sciences. However, the metric appears to have very sparse data and neither Spain nor Luxembourg has reported their R&D spending by research field.

In terms of themes of the identified pilot projects, two themes were most commonly represented: new bioplastics, and valorisation of waste. When considering the split between themes related to circular production, circular treatment, and those that sit across the two, 20 of the projects related to the circular production of plastics, 10 to the circular treatment of plastics, and 14 related to both. This shows a slight overemphasis on the production of greener plastics and, if the trend continues, could risk a stalling in the chosen countries' recycling/reprocessing capacity and a lack of innovation in the sector.

2.2.2 Limitations

The main uncertainty associated with this metric was the potential to miss projects if they:

    a)   Do not have a significant online presence.

    b)   If they meet the definition of a pilot project but do not use this terminology.

    c)   Are discussed in languages other than the ones searched for.

If testing of this indicator is continued, it is expected that this will be the case for relatively few projects as the undertaking of a pilot project can be a good way for organisations to market themselves, so it is expected that any organisation undertaking a pilot project would clearly advertise this. However, it should be noted that this is an assumption rather than a measured phenomenon.

Another potential limitation regards the quality of data. While the secondary sources consulted were useful sources which contained detailed information on the identified projects, there may be issues with delays in updating information, or projects for which data is missing. This was not the case during the testing of the indicator but could be a limitation in the future.

Finally, while the number of projects is a useful way to gain a quick snapshot of the level of innovation in the plastics sector, the current iteration of this indicator does not include any analysis on the relative value of the projects. Future iterations could include a means to monitor each project's installed capacity and, when operational, their output quantities.

2.2.3 Performance

Table 8 below describes how this indicator performs against the RACER evaluation before and after testing. The original assessment for this indicator gave a score of 13; after testing, this was revised to 11 out of 15. The justification behind the adjustments to the criteria is outlined below:

- **Relevance:** the score was revised from 3 to 2 as the metric is useful for measuring the level of innovation in the plastics sector, however its relevance could be improved by normalising the results to population/level of R&D spending, as above. In addition, future iterations of this indicator could improve the relevance score by collecting data regarding the value of the pilot projects in order to compare these results more directly to the total R&D spending.

- **Acceptability:** the original score for this indicator was 2, which has been maintained. Pilot projects are an accepted part of research and development, but the indicator could be further improved by, as above, relating the results more closely to the value of the projects.
- **Credibility:** the original assessment resulted in a score of 3. This has been revised down to 2 due to the limitations noted above: it is challenging to determine when to consider the search 'completed' and further standardisation would improve confidence in the results.
- **Ease:** this score was revised up to 3, as the process of collecting and collating the required information was relatively straightforward and required little specific technical knowledge.
- **Robustness:** this score was revised down by one point, as the relative performance of the countries under study could be altered fairly significantly by normalising the results to different bases.

Table 8: RACER evaluation

Stage of project	RACER criterion					Score
	Relevance	Acceptability	Credibility	Ease	Robustness	
Task 4 (original RACER assessment)	3	2	3	2	3	13
After Task 5 (following testing)	2	2	2	3	2	11

2.3 CHALLENGES AND LESSONS LEARNED

2.3.1 Challenges

The main challenge faced during the testing of this indicator regarded how to treat projects where consortiums were made up of organisations from multiple countries. For example, two projects had teams comprised of organisations from countries including Spain and Luxembourg, meaning that currently, the indicator cannot be used to find the total number of pilot projects across a number of countries.

It was decided that a distinction would be made between projects where the country's representing organisation is a contributor, and those where the organisation is a lead/coordinator. Though this does not fully address the issue of double-counting as multiple countries may still be contributors, it means that as long as all projects are led by countries within the EU, summing the number of projects each country leads should be accurate with no double-counting.

During the testing of this indicator, no projects were identified that had a lead country outside of the EU, however this may not always be the case. It is recommended that in these cases, in order to capture the work done within the EU even if led by an external country, any relevant projects are tracked as led by a 'non-EU' category, and contributing countries recorded as normal.

In the future, the scaling of data collection could prove challenging. The data collection process, while relatively simple, is also relatively resource-intensive, and as the number of pilot projects could increase in coming years, and the indicator is extended to cover all Member States, scaling up data collection processes without losing accuracy might become challenging. A single database of pilot projects into which all project organisers are responsible for inputting the relevant information would allow for the efficient management of the data as well as potentially more automated data gathering and processing techniques in future.

2.3.2 Lessons learned

When comparing the results of the indicator against metrics like population and GERD, it was noted that it would be useful to include information on the value of the projects. This would help to assess whether, for example, Spain's 43 projects were all short-term and low-value while Luxembourg had far fewer projects but they were all multi-year, highly technical programmes. It would also provide more context as to the level of spending on plastics compared to the overall R&D budgets. Improvements to data collection for the Eurostat metric "rd_e_gerdsc", as noted above, would also improve the conclusions that are able to be drawn from the data. For projects that are EU-funded, the project value is publicly available information, though projects funded

by private organisations are not under any obligation to publish any costs and so this information is significantly less likely to be readily accessible.

In terms of data collection for this indicator, it is recommended that for each project, a list of all the contributing countries is included. This would help to trace any projects that are counted towards multiple countries' data. Additionally, further project themes may need to be added in future years depending on the trajectory of the plastics sector.

2.4 CONCLUSIONS AND RECOMMENDATIONS

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

Following testing of this indicator, it has been found to be suitable for further development across the EU. The required data was readily available, credible and useful for drawing conclusions on the level of innovation in the plastics sector of the countries under study. The results of the indicator can be normalised against factors like population count and GERD which further strengthens the conclusions that are able to be drawn. No changes to the indicator name are recommended.

For this case study, it was found that Spain had contributed to 43 pilot projects on the circular treatment and production of plastics, while Luxembourg contributed to 3. However, when this was standardised to a per 100,000 population basis, Spain had 0.09 projects compared to Luxembourg's 0.45. Furthermore, when standardising to a per €100,000,000 R&D expenditure basis, Spain had 0.22 projects, while Luxembourg's result was 0.40. While this clearly demonstrates that Spain is involved in significantly more projects than Luxembourg, Luxembourg's output is very high relative to its size.

In terms of themes of the pilot projects, there was a relatively even split between projects that focused on circular production (20), treatment (10) and those that covered both (14). In particular, a significant number of the projects identified focused on the development of novel bioplastics; further development of this indicator will allow the EU to track the trends in innovation and ensure that neither end of the plastic life cycle is overlooked.

In terms of changes to the data collection for this indicator, it is recommended that future iterations include information on each project's value in order to more accurately track the proportion of GERD that is spent on the plastics sector. Consideration should also be given to how to account for projects with contributing organisations from EU countries but a project lead from outside the EU. It is recommended that these projects are included in the indicator to reflect the innovation that EU countries are involved in, but categorised separately as projects from non-EU countries.

There is currently no single database of pilot projects to draw from. The EU's CORDIS database holds a number of (but not all) EU-funded projects, but information on projects funded by other organisations like the EIB, or privately funded projects, is spread across different websites that are not centrally connected and so were identified via desk-based research. The EU may wish to consider whether there is scope to implement a self-reporting platform for any organisations involved in a relevant pilot project to enter their details into a register. This could be mandatory or voluntary and would reduce the amount of time needed for desk-based research. This register could also be used by the EU to facilitate engagement between projects focused on similar topics, including through workshops, conferences and by encouraging knowledge sharing and partnerships.

A final improvement that could be made relates to the Eurostat dataset "rd_e_gerdsc" which is intended to split the GERD by field of study. This would be useful to compare against this indicator as it would give a better indication of the proportion of funds sent to plastic related projects compared to other fields. However, at present very few countries report their GERD by research field (neither of the countries under study here report to this granularity) so the EU should explore whether improvements could be made to the data collection process for this indicator to improve the quality of the data collected.

The EU does not currently have any targets on plastic pilot projects or R&D spending specific to plastics. However, there are some general R&D targets:

- Achieve an R&D intensity rate of more than 3% of GDP by 2030.

- Increase private, public and venture capital investment (European Commission, 2023).

It is not recommended that any targets be introduced regarding the raw number of pilot projects. This is because the number of projects alone does not account for the value of these projects or how the number relates to population, GERD or any other variables that might impact a country's capacity. However, the EU could consider either a target to increase the number of pilot projects on a percentage basis from a baseline year, or a target based on the total spending on pilot projects per year.

Table 9: Summary of recommendations for Indicator PL1

Type of recommendation	Recommendation	RACER criteria addressed	Timeline	Key stakeholders or partners
Development of data collection	Inclusion of project value and projects led by non-EU countries will improve the quality of data collection.	Credibility	Short (0.5 – 1.5 years)	EC, Member states
Development of reporting system for pilot project monitoring	An online platform for pilot projects to self-report their operations and facilitate engagement.	Ease	Medium (1.5 – 5 years)	EC, Member states, regional/municipal governments, relevant industry bodies, businesses involved in pilot projects
Improvement of Eurostat indicators	Increase the granularity of dataset on GERD by field of study in order to better compare results of this indicator.	Relevance	Medium (1.5 – 5 years)	EC, Member states, regional/municipal governments, industry bodies
Development of guidelines for information provision	Clear definitions and guidelines for what information must be reported about each pilot project, including detailed descriptions of project objectives, technologies used, and outcomes	Acceptability	Medium (1.5 – 5 years)	EC, Member states, regional/municipal governments, relevant industry bodies, businesses involved in pilot projects

3. INDICATOR 2 – NUMBER OF LEGISLATIVE INCENTIVES CREATED TO ENCOURAGE CIRCULARITY IN THE PLASTICS INDUSTRY

The EU has a number of challenging targets related to the production and disposal of plastics. For example, the Waste Framework Directive states that municipal waste recycling rates should be a minimum of 55%, 60% and 65% by 2025, 2030 and 2035 respectively (European Parliament, 2008 (amended 2023)). The Plastics Strategy, which was adopted in 2020, states that in order to achieve circularity, the issue of plastic needs to be tackled across its life cycle, from design and production through to end-of-life (European Commission, 2018).

However, progress on collection targets in particular has been difficult. The Eurostat indicator "Recycling rate of packaging waste by type of packaging"[2] (cei_wm020) shows that the overall rate of plastic packaging recycling in 2021 was 39.1%, a shortfall of 15.9% against the 2025 recycling rate target. In order to increase the quantity of plastic that is recycled, a variety of legislative requirements and incentives have been developed and continue to be proposed by various countries, such as Extended Producer Responsibility (EPR) in which the manufacturer of certain goods maintains responsibility for those goods once they reach end of life, and Deposit Return Schemes (DRS) in which organisations who place certain products on the market (usually beverage containers) must charge a deposit for the container which is returned to the consumer upon the container's return.

This indicator tracks the number of legislative incentives created by a given Member State in a given year. "Legislative incentive" is taken to mean any legal instrument which is intended to increase the circularity of the plastics sector. These will then be categorised according to type of incentive and theme of the incentive (e.g., increased recycling, eco-design, EPR, etc.). This indicator will have the following benefits:

- It will enable the EU to understand which aspects of the plastics life cycle are either over or under-represented in legislative incentives
    - Incentives may target the manufacturing phase of the plastics life cycle, like eco-design initiatives.
    - Incentives which target the use phase of the life cycle could include bans on single-use plastic takeaway containers, or incentives to refurbish and repair products.
    - End-of-life incentives will target recycling and reuse initiatives.
- The EU will also gain an indication of which countries are at risk of falling behind with regards to progress against the identified targets, and which types of legislative incentive are most commonly used to promote circularity in the sector.
- Though the indicator does not currently include any assessment of the legislation's effectiveness, it can be assumed that a greater number of legislative incentives will lead to a less environmentally damaging plastics sector.
    - By comparing the number of legislative incentives created against the recycling rate of plastics year on year, the EU will also be able to identify whether an increased number of incentives results in an increased recycling rate.

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[2] Eurostat does not publish data on municipal waste by material stream so packaging waste was selected as a proxy for comparison

3.1 KEY METHODOLOGY

3.1.1 Testing method

For this indicator, a legislative incentive is taken as any law passed by a national government to regulate, authorise, outlaw, fund, sanction, grant, declare or restrict actions related to the production or treatment of plastic.

Two countries were selected as case studies for this indicator: Germany, which has a high rate of plastic recycling (which is also relatively consistent year to year) and fairly advanced plastics sector, and Poland, whose recycling rate is lower with significantly more year-to-year variation. The year under study was selected as 2023, as there is no time delay between legislation being implemented and being made available online.

Desk-based research was selected as the primary methodology for this indicator. This is because the legislative systems of EU systems are transparent, well-documented and publicly available online. If there were any uncertainty with results, the team proposed to consult experts on environmental laws in the case study countries, however the documentation available online was deemed sufficient for the purposes of this testing exercise.

3.1.2 Data collection method

The data required for this indicator is as follows:

- Name of legislative incentive.
- Type of legislative incentive.
- Publish date.
- Implementation date.
- Summary of legislative incentive.
- Theme of legislative incentive.
- Source of legislative incentive.

The process of collecting this data involved first identifying the relevant sources of legal instruments in the relevant countries. An overview of these sources is found in the table below.

Table 10: Overview of sources

	Germany	**Poland**
Source name	Federal Law Gazette (Bundesgesetzblatt)	ISAP - Internet System of Legal Acts (Internetowy System Aktów Prawnych)
Filtering	Able to filter by year Able to filter by document type Able to filter by subject	Able to filter by year
Searchability	Able to search by keyword	No search functionality
Translation	In-browser translation	No in-browser translation, Google Translate utilised

Initially, the results from Germany's Federal Law Gazette were filtered using 'plastic' as a keyword, however a manual review of all results was decided to be more reliable as it would not risk excluding any relevant incentives without plastic in the title. This also aligns with the methodology used for reviewing the Polish entries, for which no search functionality was available.

Once all results were reviewed and information from the relevant documents transposed into the data collection spreadsheet, further desk-based research was undertaken to ensure that no legislation was missed. This was in the form of a internet search, in which varying combinations of "plastic", "waste", "environmental", "sustainability", law", "regulation", "legislation" and "[country]" were searched for, with each key term in speech marks to exclude results which only contain some of the search terms. Google's advanced search tools were

also used to limit results to only those from 2023. Also reviewed was a series of guides on plastics and packaging laws from CMS, a law firm that produces legal research documents covering a range of topics (CMS, 2024). These sources were used to validate the results found in the two legal registers and confirmed that no legislative incentives had been missed.

As noted above, the projects were also categorised according to project theme at this stage. These themes, and a brief description, are outlined below.

Table 11: Summary of legislative incentive themes

Theme	Circular production / treatment	Description
Correction	N/A	Corrections are issued when an error was made in a published law
Introduction of fees	Both	An incentive which imposes fees related to the production/use of single-use plastics
Plastic packaging recycling	Treatment	Requirements for recycling levels for plastic packaging
Single-use plastics	Both	Requirements for placing single-use plastics on the market and obligations to pay for their disposal

The methodology for this process was as follows:

- On review of first incentive:
    - Summarise the main theme of the legislation in a ~2 to 3 word phrase.
- On review of subsequent incentives:
    - If its main theme is the same as a previously identified theme, assign this theme.
    - If its main theme does not align with any previously identified theme, assign it a new theme as with the first incentive.
- When reviewing the database:
    - When all incentives have been identified, review all of the themes assigned to projects to ensure that they are the closest possible matches.
    - If required, multiple themes can be combined where they cover the same topics.
    - Similarly, new categories can be created where distinction is useful.

3.1.3   Calculations

Once all legislative incentives for the reporting countries were identified and categorised as above, the final indicator results were calculated by summing the number of legislative incentives by theme, incentive type and in total.

3.1.4 Timeline

The Gantt chart below shows the timeline for this indicator.

Table 12: Gantt chart of indicator PL2

	01-Jan	15-Jan	29-Jan	12-Feb	26-Feb	11-Mar	25-Mar
T1 - Develop and agree definitions of legislative incentives to encourage circularity	■						
T2 - Conduct desk-based research of legislative incentives	■	■	■	■			
T3 - Analyse results and categorise legislative incentives				■	■		
T4 - Conduct analysis of themes/trends					■	■	
T5 - Write up case study template						■	■

3.1.5 Data gaps and mitigation

The only potential for data gaps for this indicator are believed to be:

- On review of the legal registers, some relevant measures may have been missed. There is the potential that regulations related to plastics could have been included in incentives focused on recycling or packaging more broadly. However, the risk of this is deemed to be very minor, as each entry in the registers was thoroughly reviewed to assess its relevance prior to its inclusion or exclusion and desk-based research was conducted following the review to validate the results.
- For Germany's Law Gazette, in-browser translation was used to translate the site from German to English. For the Polish ISAP, Google Translate was used. It is acknowledged that the translation software may not be perfect, meaning there is a small potential that measures may have been missed. However, plastic is a very commonly used word with German and Polish translations that are close to the English ('Plastik' and 'Plastyk' respectively) and so the risk of mistranslation is considered to be very minor.

There are not believed to be any additional data gaps, because as stated above, the legal registers of the countries under study are comprehensive, transparent and readily available online.

Table 13. Overview of identified data gaps, limitations and mitigation efforts

	Description of data gap	Mitigation efforts	Level of confidence
1	Some relevant entries in the legal register may have been missed	• Each legal measure was thoroughly reviewed prior to inclusion or exclusion • Additional desk-based research was undertaken to validate the results of the assessment	High
2	Some entries may have been mistranslated	• Highly regarded translation software was used to translate web pages • Additional desk-based research was undertaken to validate the results of the assessment	High

3.1.6   Quality review of analysis

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

- Prior to work beginning, the Project Director reviewed the proposed research methodology and ensured that the data collection plan was fit for purpose. Once the research team had addressed any comments from the review process, they proceeded to the data collection phase.

- The Quality Assurance Manager held responsibility for the quality of the final case study output. The Project Manager assisted the Quality Assurance Manager in judging the quality of the output and suggesting ways to improve.

3.2 KEY ANALYSIS RESULTS

3.2.1   Analysis

The table below presents the headline results from this indicator.

Table 14: Headline results for indicator PL2

Legislation theme	Germany	Poland
Correction[3]	1	-
Introduction of fees	2	2
Plastic packaging recycling	-	1
Single-use plastics	1	1
Total	**4**	**4**

Further detail on the legislative incentives identified for this indicator are found in the table below.

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[3] An error was made in one of the laws and a correction issued; this has been included for comprehensiveness

Table 15: Details of legislative incentives

Legislation title	Date	Type	Theme
Germany			
Act implementing Article 8(1) to (7) of Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment (EWKFondsG) (German Government, 2023)	11/05/2023	EU Transposition	Transposition of EU Directive (2019) on the reduction of the impact of certain plastic products on the environment. Allows for annual increases in mandatory recovery and recycling levels for packaging producers. Sets out obligations for producers who place single-use products on the market to pay an annual fee to cover the costs of their disposal. A levy will also be applied to the end user who purchases packaging for their own use. Sets out obligation for producers of certain types of packaging to pay a fee if levels of recycled material content, collection and recycling are not met. Sets out the banning of certain single-use products from sale. The specific fee rates are to be set out in a separate regulation after the adoption of the act.
Corrigendum to the Act transposing Article 8(1) to (7) of Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment (German Government, 2023)	07/07/2023	Corrigendum	Correction to the above transposition of EU law.
First Ordinance amending the Special Fee Ordinance of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety for individually attributable public services within its area of responsibility (German Government, 2023)	05/09/2023	Amendment	Amendment of previous regulation to include requirements from the above EU law.
Ordinance on the levy rates and the points system of the single-use plastics fund (Single-use plastics fund regulation — EWKFondsV) (German Government, 2023)	17/10/2023	Ordinance	Sets out the levy rates and administrative fees associated with the EWKFondsV

Legislation title	Date	Type	Theme
Poland			
Act of April 14, 2023 amending the Act on the obligations of entrepreneurs regarding the management of certain waste and on the product fee and certain other acts (Polish Government, 2023)	14/04/2023	EU Transposition	Transposition of EU Directive (2019) on the reduction of the impact of certain plastic products on the environment. Allows for annual increases in mandatory recovery and recycling levels for packaging producers. Sets out obligations for producers who place single-use products on the market to pay an annual fee to cover the costs of their disposal. A levy will also be applied to the end user who purchases packaging for their own use. Sets out obligation for producers of certain types of packaging to pay a fee if levels of recycled material content, collection and recycling are not met. Sets out the banning of certain single-use products from sale. The specific fee rates are to be set out in a separate regulation after the adoption of the act.
Regulation on minimum annual recycling levels for multi-material packaging and for packaging for hazardous substances (Polish Government, 2023)	22/11/2023	Regulation	Sets out minimum annual recycling levels for different packaging types including plastic from 2024 to 2030. 2024: 40%, 2025: 42%, 2026: 44%, 2027: 46%, 2028: 48%, 2029: 49%, 2030 (and onwards): 50%
Regulation of the Minister of Climate and Environment of December 7, 2023 on fee rates for single-use plastic products that are packaging (Polish Government, 2023)	07/12/2023	Regulation	Sets out fees for producers who place on the market certain single-use plastic products per item sold.
Regulation of the Minister of Climate and Environment of December 9, 2023 on product fee rates for individual types of packaging (Polish Government, 2023)	09/12/2023	Regulation	Sets out fees for producers who place on the market packaged products per kg of packaging type.

As can be seen, the results for Germany and Poland were fairly even: Germany and Poland introduced equal numbers of legislative incentives to promote circularity in the plastics sector in 2023, with a relatively similar split in theme. Both countries also transposed the same EU Directive into national law and published supplementary legislation setting out the specific fees outlined in the EU Directive.

All the legislative incentives identified covered either:

- The banning of certain single-use plastics.
- Increased plastic recycling targets.
- Fees for producers of certain plastic products.

Due to the relatively small number of legislative incentives, no trends in the countries' strategic vision were able to be identified at this stage, though if this indicator is selected for future development and tested over a multi-year period, a more complete picture of the legislative landscape could be developed.

3.2.2   Limitations

Some minor limitations were found during the testing of this indicator:

- It was decided that this indicator would track the number of new incentives related to plastics in a given year. This is because if the indicator simply counted the total number of incentives, it would risk disadvantaging countries which have not historically had a large amount of legislation related to plastics, but which may now be introducing legislation at similar or faster speeds than other more developed countries. However, it is recommended that some work is undertaken to understand each country's baseline of legislation to better understand how each year's data affects the legislative landscape. An alternative approach could be to take a multi-year view of the indicator, so it would track the number of incentives over a five year (or similar) rolling period. A larger temporal scale would allow for the continuous tracking of the metric at a more statistically significant level.

- For the testing of this indicator, amendments to existing legislation were included within the scope, as were any supplementary regulations that outlined the specific fees referred to in the countries' transpositions of the EU Directive. However, further thought should be given as to how to record different types of legislative document. For example, for a regulation that has been amended over the years, each amendment would currently count as one additional legislative incentive, risking potentially significant double-counting. However, some of the amendments that are made, such as the Polish Act amending the Act on the obligations of entrepreneurs regarding the management of certain waste and on the product fee and certain other acts, represent significant steps forward for plastic circularity and so excluding amendments entirely is not considered to be an ideal solution to this limitation.
    - Future iterations of this indicator may wish to split the results into the number of new legislative incentives introduced, number of legislative incentives amended, and number of supplementary regulations.

- This indicator considered in scope any legislative incentive that makes specific reference to plastic as a problem material. However, regulations may exist that impact the way plastic is handled, but without making specific reference to individual materials. This could include any regulation on furniture, textiles, electronics, among other examples. It will be challenging to set a fixed system boundary for this indicator as a range of legislation could have an indirect impact on the circular production and treatment of plastics but may not directly reference the sector.

- It should also be noted that this indicator does not include any provisions to judge the success of any of the identified legislative incentives. This is in part due to the fact that many new regulations take a number of years to be fully implemented, and there is also a time lag between the introduction of a piece of legislation and its tangible impacts on the plastics industry, meaning that there would need to be a significant time delay in the reporting of this indicator. Additionally, any piece of legislation is generally intended to work in tandem with other regulations, and so isolating the impacts of any one legislative incentive could prove problematic, particularly if countries have multiple incentives all designed to target one issue, such as increasing the recycling rate of plastics. However, a mechanism to track the implementation and enforcement stages of the legislation identified could help to provide a more accurate picture of its effectiveness over a number of years.

3.2.3   Performance

The original RACER assessment for this indicator resulted in a score of 15 out of 15. Following testing, this has been revised to 14 out of 15. The reasons for this change have been outlined below:

- **Robustness:** due to the limitations discussed above, at this stage it is felt that some more development may be needed to ensure that results are transparent, not able to be misinterpreted, and useful for the relevant stakeholders.

Table 16. RACER evaluation

Stage of project	RACER criterion					Score
	Relevance	Acceptability	Credibility	Ease	Robustness	
Task 4 (original RACER assessment)	3	3	3	3	3	15
After Task 5 (following testing)	3	3	3	3	2	14

3.3   CHALLENGES AND LESSONS LEARNED

3.3.1   Challenges

The only challenges faced during the monitoring process were the large number of legal documents to review for each country, and the fact that the documents were in languages other than English. These challenges were mitigated by utilising both in-browser translation services and Google Translate, and by using the websites' filtering functions where possible. Desk-based research was also undertaken once the review of legal registers was complete to validate the results found and ensure that no legislation was missed.

Otherwise, for the testing of this indicator, there were no challenges with data gaps. All the required information was publicly available online and easy to source. It is expected that if the indicator is extended across the EU, all EU Member States will have transparent legal systems from which to gather information, though it is acknowledged that there may be some challenges with accessing up-to-date and comprehensive legal documents across all countries.

In the future, the scaling of data collection could prove challenging. The process of reviewing large numbers of legal documents is resource-intensive, and as the indicator is extended to cover all Member States, scaling up the data collection processes without losing accuracy might become challenging. A framework could be developed in which Member States report their legislative incentives directly to the European Commission. This would mean that Member States could also provide insights that are not evident through just the document analysis on the implementation and impact of the legislative incentives.

3.3.2   Lessons learned

The main lesson from the testing of this indicator regards the recording of different types of legal acts (particularly amendments and any supplementary acts which must be understood in combination with a larger regulation). The data collection matrix includes a column on the type of legal document, so when summing the number of legislative incentives by type, it is possible to identify how many of the total incentives were amendments. However, thought should be given as to whether to include these amendments or supplementary acts in the total number of legislative incentives developed in the year, as they individually may not contribute much to the promotion of circularity in the plastics sector. In future, a rubric could be developed so that for any given legislative document identified, the indicator tester can go through a list of questions to determine the legislation's relevance and whether it is in scope.

3.4   CONCLUSIONS AND RECOMMENDATIONS

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

Following testing of this indicator, it has been found to be suitable for further development across the EU. The required information on implemented legislation appears to be readily available and transparent based on this testing process, and when tracked over a number of years, can provide useful conclusions on the proactivity of countries to react to the growing challenge of plastic waste. Some minor changes will improve the quality of data collected and further increase the indicator's utility, though no changes to the indicator name are recommended.

For this case study, it was found that Germany and Poland had both published four legislative documents related to increasing the circularity of plastics (though one of Germany's legislation acts as a correction to a previous document). Of these, both countries transposed an EU Directive into national law, Poland introduced a legislation mandating minimum plastic recycling levels, while the remaining incentives related to fees for producers of certain products. From this, we can see that legislative incentives are being developed for both ends of the plastic life cycle, though further development of this indicator will allow the EU to track the trends over multiple years and ensure that neither end of the plastic life cycle is overlooked.

In terms of changes to the data collection for this indicator, it is recommended that future iterations consider:

- How amendments should be accounted for. In the testing period, amendments were treated as legislative incentives, however this could risk double-counting if older regulations are amended multiple times.

- How to treat supplementary legislation that must be understood in combination with a more detailed regulation, such as specific information on fees that are introduced at a high level in a regulation. For this testing process, these supplementary documents were tracked, however the EU may wish to exclude these from the final totals.

- Whether to include in scope legislative incentives that may have an impact on the plastics sector but that is not directly targeted at the sector, such as regulation targeting furniture or electronics that may contain plastic components.

- Involving stakeholders for the testing of this indicator. It was felt that due to all the required information being publicly available online, requesting additional information from stakeholders would not yield any additional results. However, it could act as further validation of the research done and ensure a full understanding of the legislative landscape.

The EU does not currently have any targets on the introduction of legislative incentives to promote circularity in the plastics sector, beyond the requirement to transpose EU Directives into law within a certain time frame. It is not recommended that any targets be introduced regarding the raw number of legislative incentives, because this would not provide any information regarding the topics of the incentives or their effectiveness, and also does not take into account how well developed a given country's plastic-related legislation was prior to the tracking of this indicator. However, the indicator can still provide a useful snapshot on how much countries are taking the initiative to tackle plastic pollution over time, and given that this data is anticipated to be freely available across the EU, should not have a significant administrative burden associated. As more work is done to harmonise plastic laws across the EU, a target based on innovation in the legislative system could be considered.

Table 17: Summary of recommendations for indicator PL2

Type of recommendation	Recommendation	RACER Criteria addressed	Timeline	Key stakeholders or partners
Development of guidance	Develop a rubric to confirm whether a given legislation is within scope of the indicator, including whether it is an amendment, supplementary document or regarding a topic other than plastic	Robustness	Short (0.5 – 1.5 years)	European Commission, Member states, IS networks, trade groups
Scale of indicator	Consider tracking indicator over multi-year period to increase the statistical significance of the results	Robustness	Short (0.5 – 1.5 years)	European Commission
Develop a baseline understanding of Member States' plastic legislation	Undertake an exercise to understand current numbers of plastic legislation for more effective interpretation of results	Robustness	Short (0.5 – 1.5 years)	European Commission
Develop a portal for reporting of information	Develop a digital portal where Member States can directly report information on legislative incentives to European Commission	Ease	Medium (1.5 – 5 years)	European Commission

4. INDICATOR 3 – TOTAL WEIGHT OF PLASTIC MATERIAL RECOVERED AND REUSED THROUGH INDUSTRIAL SYMBIOSIS INITIATIVES IN THE EU

Plastics represent a significant challenge for the circular economy, given their production using fossil fuels and the relative difficulty in recycling the material when compared to other material streams like metal and glass. The EU has a range of targets related to plastics, including increasing the recycling rate of municipal waste to 55%, 60% and 65% by 2025, 2030 and 2035 respectively (European Parliament, 2008 (amended 2023)). A directive on the reduction of the environmental impact of plastics also states that there should be an effort to promote the transition to a circular economy with innovative and sustainable business models, products and materials (European Parliament, 2019).

Industrial symbioses (IS) are networks of organisations that work together to share resources and knowledge in order to foster environmental innovation and promote the keeping of resources in circulation for longer. In the EU's Circular Economy Action Plan, it was stated that an industry-led reporting and certification system should be adopted in order to facilitate the increase of IS networks across the continent (European Commission, 2020). In practice however, the progression towards a fully circular economy has proved challenging, particularly with regards to plastics.

This indicator would have a range of benefits if implemented, such as:

- It would allow the EU to gain insights into policy effectiveness, particularly regarding the efficacy of efforts to promote IS.
- The EU would also gain a better understanding of the activities of IS networks and how resources are shared.
- It would enable the EU to track the resource efficiency and environmental impact of IS networks.
- IS principles support collaborative working between businesses, strengthening the social and economic resilience of local economies.

4.1 KEY METHODOLOGY

4.1.1 Testing method

For this metric, an industrial symbiosis is defined as "the use by one company or sector of underutilised resources broadly defined (including waste, by-products, residues, energy, water, logistics, capacity, expertise, equipment and materials) from another, with the result of keeping resources in productive use for longer" (European Committee for Standardization, 2018). The system boundary for plastics to be included in the indicator is as follows:

- Post-consumer waste[4] - waste plastic (e.g., used packaging) – in scope of indicator.
- Pre-consumer waste[5] - manufacturing offcuts (e.g., scraps from cutting of plastic sheets) – in scope of indicator.
- Excess stock (e.g., unsold plastic bottles) – in scope of indicator.

Excess stock is included in this indicator because it though it contradicts a key principle of IS that resources should be used more efficiently, tracking the over-manufacturing of plastic products can indicate how efficient or inefficient an IS network/business is in their manufacturing and sales. The over-manufacturing of plastic products, regardless of whether they can eventually be recovered or (re)used, does not represent a resource-efficient activity and therefore should not be included.

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[4] Post-consumer waste is taken as "material generated by households or by commercial, industrial and institutional facilities in their role as end-users of the product, which can no longer be used for its intended purpose. This includes returns of material from the distribution chain." (ISO 14021 (2016))

[5] Pre-consumer material waste is taken as "material diverted from the waste stream during a manufacturing process. Excluded is reutilization of materials such as rework, regrind or scrap generated in a process and capable of being reclaimed within the same process that generated it." (ISO 14021 (2016))

The following case studies were selected to test this indicator:

- The city of Kalundborg - recognised best practice; the oldest of Europe's IS sites.
- The region of Catalonia - promoting industrial symbiosis across municipalities.
- The Scheldt Delta region - an IS system that spans Zeeland/West-Brabant/East Flanders.
- The Île de France region – the French organisation Orée monitors IS initiatives in the region.

The team conducted comprehensive desk-based research on IS systems in each case study city/region. Given the interdependencies present in regional circular economy support networks, a snowball sampling method was employed to identify other potential primary data sources to survey and/or a 30-minute semi-structured interview to sense check findings. This is a sampling method in which primary source contacts provide information on other potential primary data sources, and is useful when potential sources are difficult to identify through other methods.

Following identification of the IS systems, data was requested which would be developed into a material flow analysis (MFA) of the network in order to map inflows and outflows of plastic. However, as is discussed in Section 4.1.5 below, there were a number of difficulties associated with the engagement of IS networks and the collection of required data, meaning that the intended testing method could not be employed.

4.1.2   Data collection method

The data required for this indicator is as follows:

- The total quantity of plastic purchased.
- The total quantity of waste plastic produced.
- The total quantity of plastic reused within the IS network.
- The total quantity of plastic recycled within the IS network.
- The total quantity of plastic incinerated for energy production within the IS network.

The above data points should be reported by each organisation in the IS network for the calendar year under study.

The data collection method involved first identifying relevant IS networks via desk-based research and the utilisation of existing IS monitoring organisations like Orée (Orée) in France, which is a professional association and network which maintains a database of all IS initiatives in France. Following the exhaustion of available data sources, the team reached out to the networks either directly via email where available or through the contact form found on the networks' websites, to request the data outlined above. An example of the emails sent can be found in **Appendix 4**. Stakeholders were contacted in Kalundborg (5), Île de France (16), Scheldt Delta (46) and Catalonia (38) between January to March 2023. Organisations who did not respond to the initial email were followed up with at least once.

A survey was developed with the aim of simplifying the data collection process for IS networks. The full survey is available in **Appendix 5**.

4.1.3   Calculations

No calculations were utilised during the desk-based research phase of the investigation. Had sufficient data been provided, some extrapolation would have been undertaken to account for any non-reporting networks.

4.1.4   Timeline

The Gantt chart below shows the timeline for this indicator.

Table 18: Gantt chart of indicator PL3

	01-Jan	15-Jan	29-Jan	12-Feb	26-Feb	11-Mar	25-Mar
T1 - Build data request form & stakeholder engagement template							
T2 - Identify and engage individual stakeholders in relevant IS system							
T3 - Identify and engage individual stakeholders							
T4 – Data collection requests							
T5 – Stakeholder interviews							
T6 - Write up case study template							

4.1.5   Data gaps and mitigation

Significant data gaps were identified during the testing of this indicator which made calculating any final results very challenging. Specifically, feedback from IS networks found that data is either:

- Not being collected at a network level.
- Not being collected in general due to a lack of specific reporting requirements in regulation.
- Too complex to collate and provide to the team.
- Too time-consuming to collate and provide to the team.

Two networks from the Île de France regions stated that at this stage they were not far enough advanced to consider collating and reporting the required data to the project team. Kalundborg Symbiosis and Smart Delta Resources, which were identified in the data collection plan as key organisations representing the largest IS clusters within their respective regions, advised contacting the individual organisations within their IS networks directly as they themselves were unable to collect, access and/or share company data. The same response was received from Símbiosy, a consultancy specialised in IS and responsible facilitating numerous IS partnerships in Catalonia. Subsequently, a second wave of desk research was conducted to identify and engage with individual partners through a short survey.

Emails containing the survey link were then sent out to collect data at the level of individual businesses. The survey was also shared with regional IS associations for dissemination within their IS networks.

Table 19 below summarises the identified data gaps, and outlines the strategy used to mitigate the gaps to obtain meaningful insights.

Table 19. Overview of identified data gaps, limitations and mitigation efforts

	Description of data gap	Mitigation efforts	Level of confidence
1	Data at the regional level was not available.	• A short MS Forms survey was created to share with municipal-level stakeholders for dissemination among organisations within their industrial symbiosis (IS) network. • Individual business within IS systems were also directly contacted to gather organisational-level data. • The team explored secondary alternative sources of data that may indirectly provide insights into municipal level IS or byproduct valorisation activities.	Medium
2	The stakeholders contacted either did not answer, or they could not provide the information needed.	• Stakeholders contacted were chased at least once via email or phone call. • Requested to be put in touch with a colleague/ alternative contact who may have access to the requested data. • Where feasible, further desk research was conducted to explore the use of alternative data sources	Medium
3	Private organisations unable to share commercially sensitive data.	• Support was sought from IS umbrella organisation industry associations to engage private organisations within their network. If unsuccessful, these organisations were listed in the study but not included in the quantitative assessment. • Regional government representatives/industry bodies were contacted to fill regional data gaps.	Low
	Language barriers limiting efficiency of stakeholder engagement and desk research.	• DeepL was used to translate Spanish email correspondence. In-browser translation functions were for web pages in French, Dutch, Danish and Spanish/Catalan where possible. However, it is acknowledged that these translations are not perfect. • Internal staff with Spanish language competencies were contacted to sense-check emails before sending.	High

4.1.6 Quality review of analysis

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

- Prior to work beginning, the Project Director reviewed the proposed research methodology and ensured that the data collection plan was fit for purpose. Once the research team had addressed any comments from the review process, they proceeded to the data collection phase.

- The research team built an excel database to record the quantifiable data associated with each industrial symbiosis system, categorised by by-product/material stream. This was reviewed by the Project Director prior to analysis being conducted.

- The research team presented semi-structured interview guides and a list of stakeholders identified for interview to the Project Director for review prior to interviews being carried out.

- The Quality Assurance Manager held responsibility for the quality of the final case study output. The Project Manager assisted the Quality Assurance Manager in judging the quality of the output and suggesting ways to improve.

4.2 KEY ANALYSIS RESULTS

4.2.1 Analysis

The table below presents the quantitative findings from the testing of this indicator.

Table 20: Quantitative findings for indicator PL3

	Kalundborg	Scheldt-Delta	Catalonia	Île de France
Tonnes plastic recovered or reused	N/A	N/A	2,000 (Ministerio de Agricultura y Pesca, Alimentacion y Medio Ambiente, 2017) 10 (survey)	N/A

4.2.1.1 City of Kalundborg

The Kalundborg Symbiosis (KS) cluster was able to report that their network recovered 62,000 tonnes of residual material in 2019, however, they were not able to share data for each of the 19 individual organisations. Desk-based research was undertaken to obtain an indication of the types of material included in the residual waste stream, which included household waste, gypsum, organic material and waste oils. However, no quantities of specific materials were found so no conclusions on the tonnes of plastic recovered or reused could be derived.

4.2.1.2 Scheldt Delta

There were limited responses to the initial engagement with organisations in this region, with those responding stating that there were time and resource constraints that left them unable to contribute to this project. Desk-based research was undertaken but did not yield any results.

4.2.1.3 Catalonia

For Catalonia, there was also limited engagement from IS networks, though one respondent was able to share data on their plastic recovery via survey, while an additional datapoint was found during desk-based research. These results are as follows:

- GRID Granollers recovered 10 tonnes of plastic film waste in a pilot test.
- An agreement between Spanish Plastics S.A. and Solplast S.A. resulted in the sharing and recovery of 2,000 tonnes of waste plastics.

4.2.1.4 Île de France

Two responses from the emails sent to relevant stakeholders were received. Of these, one indicated that they were unable to share company-level data while the other stated that they are in the beginning phases of developing their network and so did not have robust enough reporting at this stage to provide any data. Desk-based research did not yield any additional results.

4.2.1.5 Summary

As can be seen, data proved difficult to obtain for this indicator. This is believed to be for a number of reasons, including:

- Networks not collecting the information required.
- Networks being unable to share commercially sensitive information.
- Time and resource constraints.
- Lack of regulatory requirement to monitor plastic recovery/reuse.
- Lack of central reporting system or methodology.

Desk-based research was also largely unsuccessful in returning additional results with the exception of one source.

4.2.2 Limitations

This indicator has a number of limitations associated with the collection of data:

- There are no standardised systems or methodologies for reporting the recovery and reuse of plastics within IS networks, potentially resulting in inconsistencies regarding how data is collected and recorded both within and between networks.
  - Feedback from stakeholders also highlighted that the process of collating and providing this data would be very time and resource-intensive, so with no legislative incentives to prompt the reporting of data, response was limited.
- Due to the lack of available data, it was not thought to be possible to undertake any extrapolation of data because the level of uncertainty involved would not yield robust results.
- When collecting data across a range of Member States, there may be differences in waste regulations that change the way data is required to be reported, potentially affecting the results and availability of data. For example, in Catalonia, by-product producers and recipients must apply for a specific permit when sharing by-products, making the redistribution of resources costly and time-consuming.
- Knowing the quantity of plastic recovered by IS networks does not necessarily provide an understanding of the effectiveness of this activity. It would be useful to track the specific end-uses of the recovered plastics to understand what applications they are being used for and whether they will be retained in the system.

4.2.3 Performance

Table 21 below shows the updated RACER evaluation following testing. The original assessment resulted in a score for this indicator of 13 out of 15; this has now been revised to 10 out of 15. The reasons for the changes made are detailed below:

- **Relevance:** this score was kept at 3, as although there were significant challenges in data collection, the indicator is still strongly aligned to the EU's goals of reducing plastic waste and promoting IS initiatives
- **Acceptability:** this score was unchanged as the lack of response from stakeholders highlights that the indicator may not be fully accepted at this stage
- **Credibility:** industrial symbiosis as a concept is well-understood and credible in theory, however the score was revised down to 1 due to the challenges associated with obtaining complete, reliable data and with communicating the indicator to stakeholders.
- **Ease:** this criterion was given a score of 1, as despite outreach to a significant number of stakeholders and desk-based research, no final results could be achieved for this indicator due to the complexities discussed above.
- **Robustness:** this score was revised down to 1, as there is no consistent methodology or dataset available. There may also be some difficulties in establishing a system boundary for plastic waste moving within and outside of IS networks, and specific definitions for recovery and reuse activities.

Table 21. RACER evaluation

Stage of project	RACER criterion					Score
	Relevance	Acceptability	Credibility	Ease	Robustness	
Task 4 (original RACER assessment)	3	2	3	2	3	13
After Task 5 (following testing)	3	2	1	1	1	8

4.3 CHALLENGES AND LESSONS LEARNED

4.3.1 Challenges

The main challenges associated with the testing of this indicator are as follows:

- There is no one central database of IS networks. Some organisations, such as Orée in France, maintain lists of networks at a national or regional level, however the level of information stored in these databases is fairly high-level, meaning desk-based research was required to understand the operations of each network, the individual businesses within them, and obtain contact information. An EU-led initiative to improve the interconnectivity of IS networks within and between companies would greatly aid engagement and will allow for a greater understanding of the potential barriers associated with data collection.

- Similarly, a standardised methodology for reporting material savings associated with IS networks does not currently exist. As networks are not required to report this information, the data was not readily available, and stakeholders stated that collating it would be too time and resource-intensive for the timescales of this project. Though stakeholders were contacted early into the project timeline in order to maximise the time they had to provide a response, further efficiencies could be built into future iterations of the indicator. This could include disseminating a survey in the first instance rather than as a mitigation against a low response rate from the initial emails.

- Technical concepts like industrial symbiosis and plastic recovery can be challenging to communicate through a language barrier. Including within the team individuals with proficiency in the target countries' languages could aid the stakeholder engagement activities as well as desk-based research when the sources are in non-English languages.

- There would likely be challenges with the accuracy and reliability of the data. The risk of receiving inaccurate or incomplete data from IS networks would require a robust verification processes, which would also be very resource-intensive. Some IS initiatives might also lack the technology or the expertise to actually implement data monitoring which could lead to inconsistent data collection and impact the quality of the data.

- It is also important for stakeholders to understand the respective material streams of the plastic waste that is recovered. Pre-consumer waste could theoretically be reused whereas post-consumer waste would be treated through recycling. The source of waste that is recovered could have a significant impact on the favourability of IS networks.

4.3.2 Lessons learned

The primary lesson learned from this testing exercise is that significantly more time is required to engage with IS networks, explain the indicator, and give them sufficient time to collate and report the required data, when it is available. In addition, if there were more resource, a greater level of engagement with the networks would be possible, allowing the team to work through any challenges with data collection on a more individual basis and ensuring that the data provided is clear, comprehensive and within the scope of the indicator. However, in some cases, the required data is not being recorded at all, and so some kind of incentive to collect and report this information should be considered in future.

4.4 CONCLUSIONS AND RECOMMENDATIONS

It is recommended that this indicator is not considered for further development.

Testing of this indicator was very challenging. While it could represent an opportunity to track the progress on circularity in the plastics sector as well as adoption of IS principles it is felt that the changes and work required to ensure effective data collection would be too complex at this stage.

As discussed throughout this case study, there were a number of challenges that limited the ability to fully test this metric. These primarily regarded the ability of the stakeholders to provide the required data, for reasons including a lack of time or resource, the inability of the organisation to share commercially sensitive information, and the fact that some networks stated that no monitoring of plastic waste is undertaken so the underlying data does not exist. There is also currently no legal requirement for IS networks to report the quantity of plastic waste recovered and reused and so a lack of incentives for organisations to undertake the time-intensive

exercise of collating all their plastic waste data. The EU could consider implementing some kind of requirement for IS networks to report their waste valorisation activities which would address some of the difficulties in obtaining data, though it is assumed that any new requirement would take several years to implement. In addition, indicators relating to IS were tested as part of the Bioeconomy and Cities and Regions sub-themes of this project. If the EU were to implement a requirement for ISs to report their waste data, it could cover a range of priority material streams and effectively combine multiple indicators into one overall metric.

An alternative metric could be a simplified version in the short term to cover the number of and capacity of IS networks in a given region that are involved in plastic recovery and reuse, without the requirement to report specific quantities. The suggested indicator name for this alternative is "number and capacity of industrial symbiosis initiatives involved in plastic recovery or reuse". This would be highly beneficial for the continued development of this indicator, as it would provide the EU a better understanding of the proliferation of IS principles and networks, giving an indication of the adoption of circularity over a period of time. This would also enable a transition to the more robust indicator focusing on quantities of plastic recovered, as all relevant networks would already be known to the monitoring team, making communication significantly simpler. It would also allow for the EC to provide more bespoke training and guidance for any networks that may need additional support understanding its reporting requirements.

Overall, while the indicator is clearly aligned with the EU's strategic goals (there are a range of EU targets relating to the reduction in plastic waste and increasing recycling levels, some of which have been highlighted above, while a need to develop more innovative business models was also highlighted), the fluid nature of IS networks and commercial sensitivity of the information requested means that the likelihood of obtaining any complete dataset is fairly small. The EU has previously published reports on the fostering of IS networks (European Commission, 2018), so this indicator would increase the visibility of IS and may help to promote its adoption in the future, though significantly more work is required to understand how IS networks operate and how best to track their operations.

Table 22: Summary of recommendations for indicator PL3

Type of recommendation	Recommendation	RACER Criteria addressed	Timeline	Key stakeholders or partners
Legislation	Implement a legal requirement for IS networks to report their waste valorisation activities	Acceptability	Medium (1.5 – 5 years)	European Commission, Member states, IS networks, trade groups
R&D	Consider whether to combine similar indicators into one overall indicator	Ease	Short (0.5 – 1.5 years)	European Commission, Member states, IS networks, trade groups
R&D	Consider whether to simplify indicator to "Number of IS networks involved in plastic recovery or reuse"	Ease	Short (0.5 – 1.5 years)	European Commission, Member states, IS networks, trade groups
Communication	Improve the engagement from IS networks, potentially by developing a database of networks for knowledge sharing and other support opportunities	Acceptability	Medium (1.5 – 5 years)	European Commission, Member states, IS networks, trade groups
Technical guidance	Develop a standard methodology and set of definitions for the indicator to make data more replicable	Credibility	Medium (1.5 – 5 years)	European Commission, Member states, IS networks, trade groups

5. APPENDICES

5.1 APPENDIX 2: EXAMPLE STAKEHOLDER EMAIL

Subject heading: [Data/Interview] request: DG-RTD study on circular indicators?

Dear XXXX,

I hope this email finds you well.

My name is XXX, a [Consultant within the Circular Economy team at Ricardo]. We are currently leading a consortium of partners to develop and test indicators that are fit for use to measure circularity for the EU Commission's Directorate for Research and Innovation (DG-RTD).

Due to your XXX's work in XXX, we would like to ask if your [organisation/ city/ region/industry] would be interested in participating as a case study within the following EU DG-RTD study: Indicators and methods for measuring transition to climate-neutral circularity, its benefits, challenges and trade-offs'?

To do this, we would like to collect [XXX] data on the following indicator XXX. This will require [a XXX minute interview, survey, XXX data].

Would you be interested in discussing this further with us? Or alternatively, are you able to pass this request onto a suitable team member who would be?

How will participating benefit your [organisation/city/region]?

The data and insights you provide will be analysed to understand how feasible and practical these indicators are to measure circularity across the EU.

By participating you will be able to:

- Have your say in how circularity will be measured across the EU, individual Member States and your industry.
- Help to recommend a robust set of indicators that will allow your [organisation/industry/region] to monitor and improve its circular economy performance.
- Showcase your [city/region/industry/organisation]'s engagement in cutting edge CE research that will be presented to EU policymakers.

Please find attached a letter of support from DG-RTD which contains additional background information to the project. Do let me know if you have any questions.

Thank you for your time and assistance,

[name]

5.2   APPENDIX 2: RACER 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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