RESOURCE

Regional project development assistance
for the uptake of an Aragonese circular economy

D2.1 Opportunity mapping for the Circular Economy projects

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	Circular Economy projects is the first deliverable part of Work Package 2 – Circular Economy Project Preparation. This deliverable aims to provide an overview of the progress made by the Aragon region in transitioning towards a circular economy (CE). It involves improving the current list of CE Key Performance Indicators (KPIs) used by the region, presenting criteria for selecting and integrating pilots into our project and projects of similar nature to RESOURCE, and conducting an environmental assessment and hotspot analysis of the selected pilot products. The document identifies past, current, and future initiatives of the Aragon government to facilitate and promote the transition to a circular economy. It presents the finalized list of 13 RESOURCE pilots, along with an additional 26 circular economy KPIs to be incorporated into the existing 8 KPIs currently utilized by the Aragon government. Furthermore, the LCA identifies the main contributors across 16 environmental impact categories for the assessed pilots and discusses potential improvement options. Finally, the document concludes with recommendations addressed to the Aragon authorities and RESOURCE pilots to ensure a smoother transition to a circular economy.
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EXECUTIVE SUMMARY

The Aragon region in Spain has significant potential for the circular economy due to its diverse economic sectors and natural resources. The government of Aragon has demonstrated a continuous commitment to drive the transition towards circular economy by providing support, incentives, and regulations that promote sustainable practices across sectors and encourage collaboration among stakeholders. Some notable actions include the:

- Development of a Circular Economy Strategy.
- Support for circular business models.
- Facilitating partnerships between businesses, research institutions, and public entities.
- Promoting circular procurement practices.
- Organization of workshops, training programs, and awareness campaigns to educate businesses, citizens, and students about the principles and benefits of the circular economy.

The activities developed by the Government of Aragon and the European Business and Innovation Centre of Aragon (CEEI) have as well contributed to the viability of the RESOURCE project. As of now, RESOURCE Project has evaluated 24 projects out of which 13 were selected as the final list of pilots eligible to integrate into the project. These companies' activities focus on sectors such as: waste management and recycling, agriculture, energy, manufacturing, and environment.

In parallel with the selection process for pilots in the project, efforts were made to ameliorate the current list of Key Performance Indicators (KPIs) utilized by the region. The RESOURCE partners conducted a literature review and preselected 121 KPIs. These 121 KPIs were then presented to the stakeholders during the co-creation workshop that took place in March 2023 in Zaragoza. From the initial list of preselected KPIs, the participants in the workshop identified and selected 26 KPIs that were deemed the most important and relevant for the region. 46.1% of them being environmental, 42.3% economic, 7.7% governmental and 3.9% technological.

The main trends from the life cycle assessment and hotspot analysis reported in this deliverable, highlight the importance to switch to a renewable electricity supply and to find ways to reduce the transportation distances or use cleaner means of transportation in order to reduce the environmental impacts. Addressing waste treatment is equally important as it significantly contributes to various impact categories across all products.

For a smoother transition towards a circular economy, we recommend to the Aragon region the following actions:

Recommendations concerning public authorities:

- Consider conducting a comprehensive quantification and analysis of the inflows and outflows within the 1500 local companies that hold potential for transitioning towards a circular economy. This mapping process will provide a thorough understanding of the circular synergies that can be established, where one company's waste could become a valuable resource for another company's production processes.

- Consider combining the above mapping exercise with a benchmarking analysis with other EU countries, to foster entrepreneurship in emerging sectors derived from the Circular Economy. With a clearer picture of the gaps and untapped potential, the Aragon government can strategically drive investments in underdeveloped sectors, thereby promoting the growth of the circular economy.

- Consider conducting periodic surveys at regular intervals to understand the extent of awareness and comprehension among the local companies regarding the existing online calls for funding, training, and networking opportunities. By leveraging the outcomes of these surveys, it will be possible to enhance the visibility of these opportunities according to the identified needs.

- Make use of the generated table that outlines the specific selection criteria employed by RESOURCE to evaluate the companies and their potential for transitioning to a circular business model.

- Incorporate into the existing KPIs, the chosen Key Performance Indicators (KPIs) from Task 2.1. To ensure effectiveness, companies' voluntary participation in annual data reporting aligned with these KPIs would be beneficial.

- Given the existing challenges stemming from data sensitivity and the subsequent lack of cooperation, it becomes increasingly vital for the future to prioritize the development of new systems or formats that facilitate collaboration and progress between companies and scientific consultancies.

- To effectively showcase the value of RESOURCE's methodology, it is worth considering the implementation of anonymous surveys to the pilots that are participating in the project. These surveys should be conducted at the project's conclusion and can serve two important purposes: demonstrating the benefits to non-participating companies and potentially encouraging other regions to replicate the successful methodology.

Recommendations concerning the pilots:

- Overall, in order to improve the environmental performance of the companies it is advisable to focus on:

  - Switching to a renewable electricity supply.
  - Promote and support cleaner transportation modes and/or shorten commuting distances.
  - Focus on improving waste management systems.
- Consider the adoption of Circular Economy KPIs aligned with those used by the government. Aligning KPIs with public authorities may ensure regulatory compliance, provide access to incentives and support, enhance reputation and market positioning, mitigate risks, and foster collaboration and knowledge sharing.
- It is essential for companies to provide regular training to their staff members on matters related to the circular economy. Training is vital for local companies as it increases awareness, stimulates innovation, ensures compliance, fosters collaboration, enhances reputation, and drives tangible environmental impact reduction.

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ABBREVIATIONS

CE	Circular Economy
CO2	Carbon dioxide
EC	European Commission
EF	Environmental Footprint
EU	European Union
GDP	Gross Domestic Product
GVA	Gross Value Added
ISO	International Organization for Standardization
KPIs	Key Performance Indicators
LCA	Life Cycle Assessment
LCIA	Life Cycle Impact Assessment
MOOC	Massive Open Online Courses
NUTS	Nomenclature of Territorial Units for Statistics
OECD	Organization for Economic Co-operation and Development
SOA	State of the Art
SMEs	Small Medium Enterprises
TRL	Technological Readiness Level
UNIZAR	University of Zaragoza

1. Introduction

1.1 Aragon Region and Circular Economy

The description of the Aragon Region was made in section 2 of Deliverable 1.1 (Task 1.1). As stated there, Aragon, located in the north-east of Spain, is a European NUTS 2 region[1] (in the group of “basic regions for the application of regional policies”) and one of the 17 Spanish Autonomous Communities, which are first administrative division in Spain with a very high level of autonomy for implementing economic development actions and cohesion in the region.

As explained in more detail there, Aragon has a highly diversified economic structure, with some relative specialization in the manufacturing industry and the agri-food sector. Within the industry, branches such as the automobile industry, metallurgy, machinery and capital goods, chemicals, and pharmaceuticals, as well as paper, have special importance. The strength of the agri-food industry also stands out, most prominently pork, wine, and fruit subsectors. In the services sector, tourism is particularly relevant. Other key strength in services are linked to logistics platforms that highlight the privileged geostrategic location of Aragon. In addition, Aragon reveals advanced R&D centers and universities, which favor the accumulation of human capital and the development of a competitive productive fabric.

In Deliverable 1.1 we provide an analysis of the weight of the circular economy in this region. Specifically, it studies the number of companies, workers, and the amount of Aragon economy. In this way, in Aragon there are more than 1500 companies dedicated to circular activities, the number of people working in this sector exceeds 15,000 (2.61% of total employed labor). The GVA represents almost 2% of the total of Aragon, showing itself to be a sector resilient to economic crisis situations.

All these indicators show the existence of a significant number of companies that use waste and by-products in their production processes. They also indicate that there is scope for contact between companies that can generate additional circular synergies and establish trade in recycled materials and reusable waste as raw materials to reduce dependence on external sources. It was also noted that private investment in the circular economy is still low (see section 2.2.3.1 of D1.1) and that there is a high volume of recycled materials imported as raw materials (see section 2.2.2 of D1.1).

[1] The term "NUTS 2 region" refers to a classification system used in the European Union to designate subnational territorial units for statistical and administrative purposes. NUTS stands for "Nomenclature of Territorial Units for Statistics."

The above-described situation highlights the significant circular potential that could be levied by the Government of Aragon through developing suitable policies and actions that nudge local actors and facilitate cooperation.

The Government of Aragon is committed and has worked in recent years on different sectoral plans and strategies that intrinsically already contained the underlying principles of the Circular Economy. This commitment has been consolidated with the launch in January 2020 of the Aragon Circular Strategy, with the aim of creating the political, economic, and social framework that allows the region to transition towards an innovative circular economy, efficient in the use of resources, generating quality employment.

The strategic objectives below reflect strategy, challenges, and guiding principles that Aragon's government has for its vision to be a benchmark in innovation and adaptation of transitioning to a more circular economy by 2030. These objectives consider the idea of co-responsibility within the society to cope with the significant economic and social challenges that lie ahead in the upcoming years.

- Incentivize economic activity and employment generation in Circular Economy in Aragon.
- Promote the circular economy sector as a strategic economic sector in Aragon as a dynamic and driving force for the economic and social development of the autonomous community.
- Promote entrepreneurship in the new niches of activity derived from the Circular Economy, as well as intra-entrepreneurship in existing innovative companies.
- Recognize and enhance the value of leading companies in the transition to the new economic model.
- Positioning the circular economy as a strategic sector in the economic panorama of Aragon.
- Promote specialization in the sector.

Numerous policies and initiatives have been implemented during its development, and a few of them are elaborated below.

1.1.1 Support for investment

The Government of Aragon has been promoting R&D activities in circular economy in the Aragon business network. Following the expression of interest published in 2020, in which the interest in investing in the implementation of this new economic paradigm was made clear, two calls for grants have been launched:

- In 2021, grants amounting to €4 million were called for R&D projects in circular economy to be developed in the period 2021-2023. A total of 36 projects were submitted with the participation of 68 companies and research centers, of which 13 were finally selected until the available credit was exhausted. The call has generated more than 30 million euros of investment over the period and the creation of 25 skilled jobs.

- In November 2022, the second call for applications for public aid was been definitively decided, again with 4 million euros for the period 2022-2024, obtaining the following results: a total of 16 projects involving 27 companies and research centers were selected, until the entire credit was used up again, which have promoted investments of over 26 million euros for the period indicated and have led to the creation of 49 qualified jobs.

For this year and the coming years, a project to support investment and R&D in the circular economy was presented for inclusion in the operational programme financed with ERDF funds. Finally, the project is part of the Operational Programme ERDF ARAGON 2021-2027 and involves the approval of a financial path that will allow the launch of aid for a minimum amount of 24 million euros (financed by the ERDF at 40%) until 2029. In fact, the new regulatory bases for this line of aid were published on 22 March and the first call for applications for 2023 will be launched at the end of April for an initial amount of 4 million euros. Once the deadline for the presentation of the first call has passed, a second call will be launched in advance for the period 2023-2024 with an additional 4 million euros.

As a second form of financial support for the circular economy, the Government of Aragon created in 2021 the Support Fund for Companies in the Circular Economy Sector of Aragon, managed by SODIAR (which is a public company dependent on the Government of Aragon) with 600,000 euros (and a further 300,000 euros are available) for loans under advantageous market conditions for SMEs that present viable circular economy projects. The amount of the loans reaches a maximum of 150,000 euros.

1.1.2 Recognition and positioning of companies

The first and simplest measure for the identification and positioning of Aragon companies in the framework of the circular economy is the adhesion to the Institutional Declaration of Aragon Circular, made up of 16 principles aligned with the European Union's Circular Economy Action Plan. It is a very agile procedure that is solved by e-mail in a single day and that allows companies, in addition to obtaining publicity of their commitment to sustainability, to access information on lines of aid (regional, national, or European), training activities or any support measures for the development of circularity projects. Up to the date of presentation of this document, a total of 202 Aragon companies and institutions have signed up. This instrument allows a direct and immediate contact with the companies involved in transitioning towards a circular economy and is essential to carry out activities to capture new needs such as the workshop that took place in Zaragoza on 23 November 2022, and which is described in detail in D1.2 of this project.

The second and most relevant aspect of recognition is the awarding of the "Aragon Circular Seal", which constitutes a distinctive recognition and public positioning of companies, local administrations, and entities in general, for their commitment to the circular economy model. This award is structured in two categories: companies and public administrations. To achieve this, applicants must fulfill a set of requirements specified in fourteen assessment criteria. These criteria encompass various aspects such as eco-design, enhancing circularity throughout the value chain, promoting circularity initiatives, engagement in research, development, and innovation projects, implementing water and energy efficiency measures, obtaining accreditations related to the circular economy and sustainability, providing staff training on this new economic model, and more. This recognition has a biennial duration and can be renewed every two years by providing evidence that the requirements are still being fulfilled.

In addition to the visibility and publicity it offers to companies (including a ceremony to present the diploma and corresponding award, as well as the ability to use it in documents, web pages, reports, social networks, etc.), the purpose of this recognition is to provide companies with the opportunity to earn additional points in government funding calls related to the circular economy, and it is also considered as a criterion for awarding public contracts tendered by the administration. Moreover, it allows a positive positioning of companies in relation to other companies that demand sustainability criteria from their suppliers; and finally, it also positions them positively when it comes to accessing financing through loans granted by certain financial institutions that take sustainability criteria into account.

In 2022, the first call for applications was launched, in which a total of 101 entities representing 17 economic sectors in the region participated, resulting in 72 entities obtaining recognition. In 2023, a second call for applications was published with a total of 95 entities, which is currently under assessment.

1.1.3 Training and dissemination activities

One of the objectives of the Government of Aragon, in general, but also applied to the circular economy, is the creation and conservation of talent in the Aragon business fabric. To this end, and since 2021, an "Expert Course in Circular Economy" has been held, which presents a theoretical-practical training curriculum that incorporates the latest trends in Circular Economy, from eco-design to business innovation, the promotion of new technologies such as big data or blockchain and, in the third edition, Artificial Intelligence in the field of Circular Economy. It is a tailor-made training activity designed with the aim of offering a set of notions, experiences, and learning, as well as tutoring in the development of projects, which improve the knowledge and competence of the participating professionals and companies. The duration of the course is 156 hours, and it is 80% subsidized by the Government of Aragon, so that the registration fee to be paid by interested students is less than 500 euros.

Courses related to different facets of the circular economy are also organized for unemployed people. This activity is carried out through the Aragon Employment Institute, with the aim of training unemployed people in an emerging sector in the region's economy. During 2021 and 2022, more than 50 training activities of this type have been developed with a very high attendance.

In addition, in the interests of greater and better dissemination, in collaboration with the Directorate General for Consumer Protection, regular training activities are organized for consumers and explanatory workshops are held in educational centers at all levels. The development of these dissemination activities is in line with one of the objectives set by the European Commission, which is the empowerment of consumers in the field of the circular economy.

Finally, there is a specific website on circular economy in Aragon (www.Aragoncircular.es) which, in addition to providing information on all the aforementioned activities, echoes the good practices in circular economy carried out by Aragon companies, shared with our accounts on social networks (Twitter and LinkedIn).

The aforementioned actions throughout this chapter, are among the key initiatives being implemented aiming to accomplish the following:

- Eco-design as a key basis in the circular economy.
- Proceed with the implementation of the Aragon Circular strategy, promoting the adoption of the Circular Economy as a cultural norm in business, society, and institutions. Sustain efforts in raising awareness and fostering understanding.
- Streamline administrative and bureaucratic processes to reduce management deadlines.
- Maintain the ongoing practice of issuing calls for proposals to encourage research and development in the field of Circular Economy.
- Persist in the promotion of industrial symbiosis, emphasizing the transformation of waste into valuable raw materials.
- Advocate for consumption models that prioritize repair and reuse, shifting away from disposable practices.
- Disseminate information on the benefits of the Circular Economy, highlighting exemplary practices and success stories.
- Provide training, guidance, and support to individuals and organizations through advisory services and mentoring.

Although not explicitly elaborated on in this deliverable, Government of Aragon's work is as also focused on the following issues:

- Adapt aid and legislation with Small and Medium-sized Enterprises in mind.
- Quantify waste generated by products / services, blockchain applied to process to certify traceability.
- Set up a "Committee of Experts" through Aragon Circular.
- Propose the establishment of a unified regulation that introduces the Aragon Circular Seal, ensuring compliance with all the specified requirements for products originating from non-EU countries.
- Enhance environmental licensing processes through improvements and adaptations to existing legislation.

The work towards a circular economy is currently being monitored through the Circular Economy Indicators Report. This report is produced annually in Aragon, published on the aforementioned website and whose most important aspects are described in D1.1. Work is currently underway to update the data corresponding to 2022, with the aim of publishing them at the beginning of the second half of 2023.

2. Identification and selection of the Pilots

The successful implementation of the RESOURCE project heavily relies on the careful selection and integration of pilots engaged in circular economy activities in Aragon.

This section outlines the rigorous process undertaken to identify and choose the pilots that are integrated into RESOURCE. The process was implemented by Government of Aragon and CEEIARAGON and focused on ensuring a diverse representation of circular economy activities and maximizing the potential for sustainable and impactful investments in Aragon.

The selection process adhered to a predefined timeline to ensure efficiency and maintain project milestones. The timeline consisted of the following stages:

- Identification of Potential Pilots
- Workshop with Pre-selected Pilots
- First Evaluation and Selection
- Second Evaluation and Selection
- The final selection of the RESOURCE Pilots

2.1 Identification of Potential Pilots

To initiate the selection process, an extensive research and consultation phase was conducted to identify potential pilots in Aragon. The close connection that the Government of Aragon and CEEIARAGON maintain with circular economy projects through the Circular Economy Seal Certification (Sello Aragon Circular), made the basis for identifying the first pilots. Additionally, various sources were utilized, including government reports, industry databases, stakeholders' interviews, and experts' recommendations.

The objective of this phase was to identify a broad range of circular economy activities that could benefit from investment and contribute to the overall project goals. To fulfill that objective, the pre-selection criteria for the pilots were carefully defined to ensure that the chosen projects would effectively contribute to the circular economy in Aragon and attract private investment. The initial considered criteria included:

- Alignment with Circular Economy Principles: Projects that demonstrated clear alignment with circular economy principles, such as resource efficiency, waste reduction, and sustainable production and consumption, were given preference.
- Sustainability: The projects' potential for long-term sustainability, considering environmental, social, and economic aspects, was a key criterion.

- Innovation: Projects that showcased innovative approaches, technologies, or business models that could disrupt and transform traditional practices were highly regarded.
- Scalability: The scalability and potential for replication or expansion of the projects were evaluated to assess their ability to make a substantial impact in the circular economy.
- Investment Potential: The projects' attractiveness to private investors, including their financial viability, return on investment, and market potential, were considered.

The evaluation committee reviewed the project proposals and shortlisted the most promising ones.

2.2 Workshop with Pre-selected Pilots

Following the project consortium meeting held in Zaragoza in November 2022, RESOURCE took advantage of the gathered momentum and organized a dedicated workshop for all the shortlisted pilots (reported in this article: RESOURCE brings together in a workshop 10 pilot projects seeking investment to reinforce its circular model). This workshop complemented the discussions and activities of the consortium partners.

The workshop took place at the facilities of the Government of Aragon and coincided with the International Congress on Circular Economy "Challenges and commitments of the circular economy: from Aragon to the world." It provided a valuable opportunity for each company to deliver a presentation, highlighting their capabilities, current status, and expectations regarding RESOURCE's offer.

The primary objective of the workshop was to foster collaboration, knowledge sharing, and networking opportunities among the companies.

During the workshop, each company had the platform to showcase their project's unique features, discuss its potential impact on the circular economy, and outline their specific needs and goals. The session enabled project proponents to receive feedback, guidance, and support from RESOURCE as well as from stakeholders including government representatives, industry experts, and research institutions.

2.3 First Evaluation and Selection

The received project proposals were evaluated based on predefined criteria, including the project's alignment with circular economy principles, sustainability, innovation, scalability, and potential for private investment. A dedicated evaluation committee assessed each proposal in order to shortlist the most promising projects. This included representatives from relevant government departments, industry associations, research institutions, and non-governmental organizations specializing in circular economy. Their expertise and perspectives were invaluable in assessing the potential impact and feasibility of each pilot project.

During the RESOURCE project's drafting phase for submission to the call, a prerequisite was established, specifying that the funding would be up to the amount of 20 million euros for circular economy projects across multiple sectors such as infrastructure operators, utilities, services, and industries. The ultimate criteria for their selection primarily centered around the following points:

- That they were solvent projects, either because they had obtained CE certifications from the Government of Aragon, or because they were projects that had been presented to us and that the Government of Aragon had decided to support due to their socio-economic impact.
- Coverage of various sectors of activity or differentiated value chains (waste management, textiles, agri-food, health, etc.).
- Distribution across the entire region instead of being focused solely in Zaragoza.
- Expressed interest in participating in the RESOURCE project.

The existence of a defined market, either because they were consolidated in this market, or because, although their development was incipient, they already had clients.

Table 1 below summarizes the five selected companies from a preselection of ten companies in this first evaluation phase.

Table 1. List of companies selected during stage I

Company	Activity focused on:
THERMOWASTE	Waste management
MONDOTUFTING	Sports equipment
CENTRO EUROPEO DE RECICLAJE FOTOVOLTAICO (CERFO)	Waste management
FELTWOOD ECOMATERIALES	Biowaste management
BUGCLE	Agrifood

2.4 Second Evaluation and Selection

The second selection phase was conducted to ensure that the RESOURCE project could effectively meet its objectives by including a sufficient number of pilots. After the initial evaluation and selection of five pilots from the first phase, it was necessary to identify and select additional pilots to fully leverage the potential of the European project and maximize its impact on the circular economy in Aragon.

This second selection phase provided an opportunity to explore a broader pool of pilots, considering their alignment with circular economy principles, scalability, and potential for attracting private investment. The evaluation committee carefully assessed each pilot against the defined criteria to ensure that the final selection included pilots that would add significant value and contribute to the overall success of the European project.

Drawing from the insights gained during the initial selection phase, the project consortium acknowledged the significance of enhancing the evaluation process for the subsequent phase. One of the added criteria was to ensure pilots' willingness to raise private funding (we eventually focused more on projects targeting a minimum of 500.000 euros, in order to reach the objective of 20 million euros) and their potential quality to attract private investment. To ensure a more comprehensive and detailed assessment, an elaborate table of criteria was developed. This refined set of criteria provided a structured framework for evaluating and selecting the final projects.

The table below presents the refined selection criteria including specific parameters that enabled a more nuanced evaluation of each project:

Table 2. The refined list of selection criteria

Name of the project (and company): **Sector/Value chain:** **Place (Zaragoza/Huesca/Teruel):**	**Partner:**
Eligibility criteria: • CE and Innovative project • Need for fundraising and can be helped for investment readiness. • Maturity and overall coherence of the project (matching objectives/means & skills)	
Possible examination points and overall score	*Feedback and comments*
Technological Potential • Nature and Degree of innovation and novelty • Technological Risk • Technological Readiness Level (TRL) • Implementation of key technologies in the new CE model • Barrier to entry (Patent/ software registration / know-how or expertise) • Internal mastery of techno dev & independence/freedom to operate. • Advancement of research/development • Potential for technological evolution • Compliance with legal and regulatory constraints **Overall rating** /4	
Market Potential ☐ Knowledge of the environment and the market ☐ Interesting market size and volume ☐ Market dynamics (growth rate) ☐ Favorable competitive intensity ☐ Significant competitive advantage ☐ Defined and solid business model ☐ Known and reasonable market accessibility for the company ☐ Knowledge and anticipation of the purchase decision cycle ☐ Potential for diversification / deployment ☐ Fallback strategies under consideration ☐ Market engagement: clients already engaged + perspectives and	

timing. **Overall** rating /4	
Financial Evaluation ☐ Income has started or is rapidly achievable. ☐ Clear financing plan ☐ Clear and quickly mobilizable needs ☐ Support already gained (CEEI support / public grants.) **Overall** rating /4	
Managerial Evaluation of the EC project team ☐ Skills required: manager, scient/techno, business/management. ☐ Entrepreneurial ability of a team member (leadership, adaptability and anticipation, ability to listen and question, network/contacts) ☐ Personal commitment team/teacher (in time, financially) ☐ Same vision is shared with the global company. ☐ Clear partition of roles in the EC project team **Overall** rating /4	
High level impact and excellence ☐ Scalability evidence with a clear timeline ☐ Excellence: creates new market or strongly impacts existing ones ☐ Quality and efficiency of implementation ☐ High level of impact on CE: enhances capacity, strengthens the regions' competitiveness, environmental/social/economic impact. ☐ Business Model impact: integration of the project in the value chain **Overall** rating /4	
Overall Comment:	
Final score	**/20**

By incorporating these detailed criteria, the evaluation committee was able to assess the pilots more holistically and objectively. The refined table of criteria provided a robust framework for comparing and evaluating the pilots based on their merits and potential contributions to the circular economy in Aragon.

During the second selection phase, the reasons for rejecting pilots were similar to those observed in the first phase. Pilots were rejected if they did not meet the defined criteria or lacked the necessary requirements for integration into the European project. Overall, the evaluation process during the second selection phase upheld the same standards and considerations as the first phase, resulting in the selection of projects that were best suited to advance the circular economy in Aragon and attract private investment.

Table 3 below summarizes the additional eight selected companies from a preselection of fourteen companies in this second evaluation phase.

Table 3.List of pilots selected during stage II

Company	Activity focused on:
SMARTMOSS	Air pollution
CADIUCO	CO2 management
CTR SOLUTIONS	Industrial recycling
RECICLA Y SUMA	Recycling engagement
GREEN FOUNDRY	Industrial recycling
ECOHELP EWM	Biowaste management
BIOGAS DT (BIOGROUP)	Bioenergy
EQUIMODAL	Containerized solutions

2.5 The final selection of the RESOURCE Pilots

Following a comprehensive evaluation and selection process, the final list of pilots chosen for integration into the European project supporting circular economy activities in Aragon was determined. The conclusive roster comprises thirteen pilots that will receive support from RESOURCE to further enable their development and strive towards the desired accomplishments outlined in their proposed endeavors.

Table 4 below summarizes the final selection of the RESOURCE Pilots.

Table 4. The final selection of RESOURCE pilots

Company	Activity focused on:
THERMOWASTE	Waste management
MONDOTUFTING	Sports equipment
CENTRO EUROPEO DE RECICLAJE FOTOVOLTAICO	Waste management
FELTWOOD ECOMATERIALES	Biowaste management
BUGCLE	Agrifood
SMARTMOSS	Air pollution
CADIUCO	CO2 management
CTR SOLUTIONS	Industrial recycling
RECICLA Y SUMA	Recycling engagement
GREEN FOUNDRY	Industrial recycling
ECOHELP EWM	Biowaste management
BIOGAS DT (BIOGROUP)	Bioenergy
EQUIMODAL	Containerized solutions

The final selection emphasized a balanced representation of different circular economy activities, ensuring diversity in sectors such as renewable energy, waste management, and resource recovery.

To facilitate the progress and next steps of the RESOURCE project, a summary table was created to provide an overview of each selected pilot. The table included essential details such as the project/company name, sector, project description, expected outcomes, investment requirements, and projected timeline. This table served as a concise reference tool for RESOURCE stakeholders to gain a quick understanding of each pilot's profile and potential. Due to the confidentiality agreements in place, it is not feasible to disclose the contents of the table.

2.6 Discussion and main takeaways

Overall, a total of twenty-four pilots were analyzed for the RESOURCE project, ten evaluated during the first phase and fourteen during the second selection phase. From this pool, five pilots were selected during the initial selection phase. Subsequently, the second selection phase led to the selection of another eight pilots.

As previously mentioned, not all pilots that were considered during the selection process were ultimately integrated into the RESOURCE project. Several factors contributed to the exclusion of certain pilots from the final selection. One significant factor was the realization that some of the initially shortlisted pilots had no immediate need for private investment or were not interested in receiving external funding at the current moment. As a result, their inclusion in the RESOURCE project would not have provided the desired impact in terms of facilitating investment for circular economy activities in Aragon. The exclusion of certain pilots that did not require investment or were not interested in external funding should not undermine their value or importance in the context of circular economy practices in Aragon. Many of these pilots are already making valuable contributions to the region's sustainable development through their existing funding models or self-sustainability.

The selection process for the pilots in the RESOURCE project highlighted the importance of having clear objectives and criteria in ensuring a transparent and systematic evaluation process. Furthermore, the incorporation of a wide range of stakeholders during the development of the selection process criteria significantly enhanced the evaluation standards. The comprehensive table containing the final selection criteria, as outlined in section 2.4, serves as an output that can be utilized by other regions seeking to implement a similar project within their own area. These criteria can be modified depending on a regions' existing circular economy strategy and future vision.

3. Defining Circular Economy key indicators and targets for the Aragon region

The establishment of Key Performance Indicators (KPIs) is imperative for a thorough comprehension of the methodology. KPIs are defined as quantifiable metrics that facilitate the monitoring and evaluation of an organization's advancement toward accomplishing specific aims or goals. In the realm of Circular Economy, KPIs play a pivotal role in monitoring the progress toward circularity and identifying areas that require enhancement. Measuring KPIs enables organizations to evaluate the impact of their circular practices and identify prospects for innovative and efficient measures (Circular Economy Indicators Coalition (CEIC), 2023).

More specifically, implementing and tracking KPIs in the context of Circular Economy is crucial for (European Academies Science Advisory Council (EASAC), 2016):

- **Progress Monitoring:** KPIs enable organizations to monitor and track their progress towards achieving circularity goals. By measuring and reporting on KPIs, organizations can identify areas where they are excelling and areas where they need to improve.

- **Opportunity Identification:** KPIs aid organizations in identifying opportunities for improvement and innovation. By monitoring KPIs related to resource efficiency, waste reduction, and product lifetime, organizations can identify opportunities to optimize their operations and reduce their environmental impact.
- **Innovation Driving:** KPIs incentivize organizations to innovate and develop novel solutions for circularity. By setting ambitious KPIs, organizations are challenged to find new ways to reduce waste, increase resource efficiency, and extend product lifetime.
- **Communication of Progress:** KPIs provide a framework for communicating progress towards circularity goals to stakeholders. By sharing KPI data with customers, investors, and other stakeholders, organizations can demonstrate their commitment to circularity and build trust and credibility.
- **Regulatory Compliance:** In some instances, KPIs are mandated by regulations or certifications. By implementing KPIs and monitoring progress, organizations can demonstrate compliance with these requirements and maintain their certification or regulatory status.

3.1 Current indicators identified by the Aragon region

The control panel of the ARAGÓN CIRCULAR economic strategy is the management tool that allows monitoring the established objectives and knowing the evolution in Aragon of the strategic sector of the circular economy. This scorecard includes eight indicators, the measurement of which will make it possible to monitor the sector, the strategy and review compliance with the objectives and commitments it contains, as well as make the modifications deemed necessary to achieve it (Gobierno de Aragon, 2023).

- Number of companies in the Circular Economy sector in Aragon
- Average number of workers per company
- Turnover of companies in the Circular Economy sector in Aragon
- Trade of recyclable raw materials. EC Monitoring Framework Key Indicator No. 8
- Private investment, jobs and gross value added: recycling sector; repair and reuse sector. EC Monitoring Framework Key Indicator No. 9
- Number of students who take training activities with specific contents in Circular Economy
- Number of patents related to recycling and raw materials. EC Monitoring Framework Key Indicator No. 10
- Contribution of recycled materials to the demand for raw materials. EC Monitoring Framework Key Indicator No. 7

3.2 Methodology

The KPIs identification methodology was executed in three distinct phases as illustrated in the chart below:

Figure 1. KPIs identification methodology

- **Identification phase:** This involved analyzing the State of the Art (SOA) to identify a comprehensive set of KPIs that could be useful in the project. Various sources of literature were consulted during this process. The task has been mainly developed by ULEI with the support of AITIIP, GoA and CEEI.

- **Cogeneration phase:** A workshop was organized in Zaragoza where the KPIs obtained from the Identification phase were presented by AITIIP to the participants. Additionally, the project was introduced to the audience by the Aragon Government (GoA).
- **Prioritization phase:** During this phase, we provided the participants with a questionnaire containing all the KPIs. The stakeholders were asked to prioritize the most relevant KPIs for the Aragon region as per their perspective.

3.2.1 SOA Analysis (Identification)

Achieving the best and most accurate analysis of the SOA requires a holistic approach that considers the entire lifecycle of the system, from inputs to outputs. This means that KPIs must be identified from a micro and macro perspective. A comprehensive understanding and identification of the KPIs is crucial for the correct development of this work package.

The analysis drew upon significant resources, primarily acquired through secondary research. The primary sources of information concerning key performance indicators (KPIs) include the OECD Inventory of Circular Economy Indicators and the Aragon Circular website.

- The OECD Inventory of Circular Economy Indicators (OECD, 2020) is a comprehensive framework developed by the Organization for Economic Co-operation and Development (OECD) to monitor the transition towards a more circular economy. The framework offers an exhaustive set of indicators that can be utilized to measure progress towards circular economy goals and to facilitate policy development and evaluation.
- The Aragon Circular website (Gobierno de Aragon, 2023) is a government portal established by the Aragon region with the objective of becoming a leader in circular economy practices in Europe. The website provides extensive information regarding circular economy initiatives, including the KPIs currently being utilized in the region. Additionally, the website outlines Aragon's circular economy goals and future plans and offers further information pertaining to the topic.

Additional resources were utilized during the research and identification phase of the project. The gathered information was consolidated to derive the KPIs. It is pertinent to note that the Aragon Government, being one of the project partners, has implemented KPIs that were not initially included in the preliminary list.

The final phase involved categorizing the KPIs into distinct categories to facilitate comprehension and provide context.

Environmental indicators

An environmental indicator is a numerical value that helps provide insight into the state of the environment or human health. Indicators are developed based on quantitative measurements or statistics of environmental condition that are tracked over time. Environmental indicators can be developed and used at a wide variety of geographic scales, from local to regional to national levels (Balasubramanian, 2020).

Table 5. The preselected environmental indicators

Micro KPIs	Macro KPIs	Micro/Macro KPIs
• Amount of virgin materials used per unit of product/service	• Percentage of waste diversion as a result of procurement activities	• Annual Biofuels consumption
• Amount of secondary materials (recycled material) used per unit of product/service	• Material footprint per GDP	• Annual Diesel consumption
• Amount of waste used in production per unit of product/service	• Amount of materials recovered through reuse and recycling yearly (by sector)	• Annual Gasoline consumption
• Waste production per unit of product produced	• Contribution of recycled materials to raw materials demand annually (by sector)	• Annual consumption of recyclable plastic
• Amount of renewable electricity used per unit of product/service	• Percentage of recovered waste over generated (by sector)	• Annual consumption of fossil plastic
• The share of renewables in heating per unit of product/service		• Tonnage of plastics collected in the city
• CO2 eq emissions avoided as a consequence of recovery and reuse of materials per year		• Tonnage of plastics recycled in the city
• Climate change impact per unit of product		• Amount of clothes recycled in the city
• Toxicity in ecosystems impact per unit of product		
• Non-renewable resources depletion per unit of product (fossil fuels)		
• Freshwater eutrophication per unit of product		
• Terrestrial eutrophication per unit of product		
• Carcinogenic human - toxicity impact per unit of product		
• Non - carcinogenic human toxicity per unit of product		
• Ionizing radiation impact per unit of product		
• Metals and minerals depletion impact per unit of product		
• Land use per unit of product		
• Water use per unit of product		
• Particulate matter formation, impact on human health per unit of product		
• Photochemical ozone formation,		

impact on human health per unit of product		
• Ozone depletion per unit of product		
• Share of renewable energy in the total electricity used per unit of product/service		
• Share of recyclable resources used per unit of product/service		
• Share of annual waste that goes for incineration		
• Share of annual waste that goes for landfilling		
• Share of annual waste that goes for recycling		

Governance indicators

Governance indicators monitor the capacity of the government to effectively formulate and implement sound policies; and the respect of citizens and the state for the institutions that govern economic and social interactions among them (OECD, 2020).

Table 6. The preselected governance indicators

Macro KPIs
• Number of awareness actions on search and innovation on the circular economy and their respective impact
• Number of awareness campaigns to reduce and prevent waste (specific for different sectors)
• Number of events held in collaboration with the social entrepreneurship community
• Number of companies that publish sustainability reports
• Number of international delegations and events hosted for the promotion of the circular economy
• Number of participating people/staffs on awareness raising activities
• Number of actions to divulge a long-term R&I agenda for speeding up the circular economy in the country
• Creation of a municipal or regional web platform for information on the circular economy
• Level of traffic on the web platform for information on the circular economy
• Number of awareness-raising activities carried out for plastic use reduction
• Number of staff trained on the circular economy
• Financial institutions willing to collaborate on a circular economy initiative
• Number of synergies identified / implemented by economic actors
• Number of collaborative projects implemented
• Institutions willing to collaborate on a circular economy initiative
• Number of workshops held to link up supply and demand among industrial players of different sector and boost the sharing economy
• Online launch of the MOOC "implementation of the circular economy in a city"
• Online launch of the MOOC "implementation of the circular economy in a company"
• Number of employees who took the MOOC "implementation of the circular economy in a company"
• Number of companies that responded to the call for projects on the circular economy
• Creation of a booklet and action sheets on the circular economy
• Number of circular economy researchers

• Number of Companies that have received financial assistance related to the circular economy
• Financial assistance granted to companies related to the circular economy
• Number and investment in circular-economy-related R&I projects
• Budget of pilot public contracts in circular economy developed in the Region
• Number of initiatives for reuse in different sectors (this indicator could be repeated by specifying sectors)
• Number of Protocols developed to incentivize reuse, recovery, recycling (sector specific)
• Number of pilots initiated for the development of territorial synergies between economic actors
• Patent requests in relation to new sustainable processes presented by public bodies (research centers, universities, and public bodies) and companies
• Maps of local resources
• Ecolabel Holders
• Products/services covered by circularity criteria in procurement
• Public procurement contracts with a circular economy dimension
• Number of tender books with circular criteria (production and consumption)
• Number of circular policy advisers developing circular regulations and change linear regulations
• Negotiations for circular standards
• Development of new laws and regulations that discourage linear practices
• Legal and regulatory barriers to the circular economy removed
• Number of Working group meetings with major industry players for better regulatory and legislative alignment as a boost to the circular economy
• Number of Directives adopted for research and innovation on the circular economy
• Number of network meetings for circular projects
• Number of companies/projects incorporating smart design
• Number of Circular economy vision documents

Social indicators

Social indicators are set of indicators that measure progress towards the policy objectives designed for promoting employment, combating poverty, improving living, and working conditions, combating exclusion, developing human resources, et cetera (European Environment Agency, 2023).

Table 7. The preselected social indicators

Micro KPIs	Macro KPIs	Micro/Macro KPIs
• Number of staff working in R&I on circular economy	• Number of people employed in the Circular Economy	• Human resources mobilized for the implementation of circular economy
• PhD and post-PhD grants and contracts in scientific employment on circular economy	• Number of local coordinators recruited for the development of circular economy synergies between economic actors	• Number of people actively working on the development of a circular vision in the company/city
	• Number of jobs created by promoting circular consumption in the city	

	• Green employment rate in companies	
	• Job creation from the sharing economy in the city	
	• Job creation from the reuse activities	

Technology indicators

Science, technology, and innovation indicators are an international measure, analysis, and comparison tool to support the comprehension and evolution of R&D activities and innovation systems (OECD, 2020).

Table 8. The preselected technology indicators

Macro KPIs	Micro/Macro KPIs
• Mapping of existing sites for reuse and recycling needs	• Number of waste collection devices installed for the Key Products Value Chain (Electronics and ICT, Batteries and vehicles, Packaging, Plastics, Textiles, Construction and Buildings, Food, water, and nutrients)
• Local composting plants created	• New circular products in a region/company
• Number of new reuse and repair facilities	• Share of circular products in the total number of products in a region/city
• Number of waste disposal sites with a reuse area	
• Objects collected in reuse and repair facilities	
• Number of ethical and eco-responsible fashion sales points in the city	

Economic indicators

Economic indicators include measures of macroeconomic performance (gross domestic product [GDP], consumption, investment, and international trade) and stability (central government budgets, prices, the money supply, and the balance of payments) (OECD, 2020).

Table 9. The preselected economic indicators

Macro KPIs
• Companies implementing product-as-a-service business models
• Number of companies or products with tax benefits to incentivize the circular economy
• Circular companies by total number of companies in the region
• Economic operators supported in circular economies
• Economic operators aware of the circular economy
• Number of Circular start-ups
• Percentage of companies innovating for circular reasons

• Number of Business activities involved in repair
• Number of businesses that have adopted locally standardized containers
• GDP per Total Greenhouse Gas Emissions
• Industry turnover in more circular products
• Investment in research for increasing circular knowledge and expertise
• Reduced costs through green public procurement vs. the traditional option
• Economic savings due to the reuse of furniture and equipment of the local administration
• Waste reduction economic savings
• Money saved as a consequence of recovery and reuse of materials

3.2.2 Workshop (KPIs presentation)

The cogeneration phase was conducted through a workshop organized in Zaragoza where the KPIs obtained from the Identification phase were presented by AITIIP to the participants. The workshop was organized by GOA and attended by other participating projects such as AITIIP, CEEI Aragon, and UNIZAR Chair of Circular Engineering. The event was held on March the 28th at GOA's facilities, specifically in the Jeronimo Zurita room.

The workshop commenced at 10:00 am with a welcome address, followed by a presentation and introduction of the project to the audience by GOA and CEII Aragon. The primary objective of this initial presentation was to familiarize investors, facilitators, and companies in attendance with the project. In the second segment of the event, UNIZAR Chair of Circular Engineering delivered a presentation on the circular economy in Aragon, establishing an investment framework for the participants. Additionally, AITIIP presented and elucidated the preliminary list of indicators during this phase.

The second segment of the workshop involved co-creation events, during which the attendees were divided into two groups based on the nature of their employment. The first group comprised investors, while the second group was composed of companies and facilitators.

The co-creation event was centered around a discussion amongst the participants, moderated by a facilitator, and guided by a series of questions listed below:

- What are the main bottlenecks for accessing financing for circular economy projects? How can they be overcome?
- What are the fundamental criteria to consider when accessing financing for circular economy projects?
- What are your motivations (values) for investing in circular economy projects?
- What are your criteria for investing in a project?
- What are the main risks/obstacles you see for investing in the circular economy?
- How do you think the RESOURCE project can help you?

- Would you be interested in joining our Expert Committee, participating in the co-creation workshops for the methodology, or any other RESOURCE activity?

The results of this discussion are presented in subchapter 3.3.1.

At the end of the workshop, a questionnaire was distributed to the attendees with the aim of assessing their level of interest in the list of indicators presented during the identification phase. This questionnaire played a crucial role in quantifying the degree of interest expressed by the participants towards the various indicators.

3.2.3 KPIs Selection

The selection of KPIs, considered more intriguing for the participants, was based on the questionnaire distributed during the workshop. Additionally, the same questionnaire was made available online. The participants were given one week to complete the survey, during which time, only a few companies and all investors responded. Therefore, a reminder was sent to the companies, which led to an increase in the number of responses.

Once a representative number of questionnaires were completed, the data was analyzed, and the KPIs were ranked from least to most intriguing based on the modal values of each indicator. However, the interest of the participants was not the only criterion considered in the final selection of KPIs. Project partners also considered the significance and impact of certain indicators while selecting the final KPIs.

The questionnaire data and selected KPIs can be found in section 3.3.2.

3.3 Results

3.3.1 Feedback from the co-creation workshop

One of the objectives of the co-creation event was to elicit diverse perspectives from the various economic actors present and arrive at conclusions that could enhance the list of KPIs.

The provided feedback from the first group of participants (investors) can be summarized as follows:

- Financial institutions evaluate various features of a sustainable project, including its environmental and social impact, economic feasibility, and most importantly, its ability to repay loans.
- Moreover, some financial entities view a project's participation in a circular economy as an added advantage when financing sustainable ventures.

- In addition, the availability of other forms of assistance, whether public or private, and the project's potential for disruption are also valued. Investors seek to invest in ventures with a promising future, and they attach great significance to the management team's proficiency, their comprehension of the business, and their ability to drive it forward.
- On the other hand, companies seeking funding must allow investors to participate in the firm to add value and function as an external controller, which can make investment in small and medium-sized enterprises and family businesses particularly challenging. Finally, companies must also permit the distribution of dividends, as investors' objective is to recover their investment through the company's earnings.

The provided feedback from the second group of participants (companies) can be summarized as follows:

- From the perspective of companies and facilitators, their responses highlight the existence of several bottlenecks that hinder financing in the circular economy and emphasize the need to address these issues to promote sustainable economic practices. The obstacles identified include the small size of SMEs, limited access to funding, inadequate information, a lack of reinvestment culture, poor collaboration and internal coordination, and unclear roles for facilitator system agents. It is crucial to improve efficiency and provide adequate guidance to companies seeking to adopt circular economy practices and access the necessary funding.
- There is a deficiency in the dissemination of information about the circular economy to companies, with problems such as excessive and confusing information, low awareness, and a lack of structured information for each company. It is suggested that incorporating experts and showcasing successful case studies can help demonstrate the effectiveness of circular economy practices.
- Finally, they see RESOURCE project as an opportunity to assist companies in implementing circular economy practices through digital tools, support for business initiatives, and a useful contact agenda to obtain information and guidance on the subject.

3.3.2 The selected KPIs during the workshop, divided by categories

The questionnaire revealed to us the areas of interest and focus of people in terms of indicators. After analyzing and tabulating the data generated by the survey, we identified the indicators that generated the greatest interest. It is important to note that the selected KPIs are limited to environment, governance and economics divisions.

The data selection is based on the KPIs with the highest scores in the most compelling category. All survey participants were asked to rate the indicators on a scale from no interest (0 value) to very interesting (5 value). As a result, we obtained a first category of 10 KPIs with a high level of interest and a second category with some additional indicators that generated interest, but not to the same extent as those in the first category.

Table 10. The final selection of KPIs

MOST INTERESTING KPIs		
CATEGORIES	SCALE	INDICATOR
ENVIRONMENT	Micro	Amount of water used in production per unit of product/service.
ENVIRONMENT	Micro	Percentage of renewable energy out of the total electricity used per unit of product/service.
ENVIRONMENT	Micro	CO2 emissions avoided through material recovery and reuse per year.
ENVIRONMENT	Macro	Greenhouse Gas Emissions per GDP
ENVIRONMENT	Macro	Money saved as a result of material recovery and reuse.
ENVIRONMENT	Macro	Number of waste collection devices for the Value Chain of key products (Electronics and ICT, Batteries and Vehicles, Packaging, Plastics, Textiles, Construction and Buildings, Food, Water, and Nutrients
ENVIRONMENT	Micro/Macro	Percentage of annual waste that is recycled "on-site"
GOVERNANCE	Macro	Development of action plans in circular economy
GOVERNANCE	Macro	Maps of local resources
ECONOMICS	Macro	New circular projects in a region/company

As previously mentioned, a second level of KPIs is presented, this second level includes 16 KPIs and they are the result of the KPIs with the modal values in value 4 (some interest) and has most of the votes between 4-5 values.

Table 11. Additional KPIs part of the final selection

SECOND LEVEL OF KPIs		
CATEGORIES	SCALE	INDICATOR
ENVIROMENTAL	Micro	Amount of recycled materials used per unit of product/service
ENVIROMENTAL	Micro	Amount of renewable electricity used per unit of product/service
ENVIROMENTAL	Micro	Depletion of non-renewable resources per unit of product (fossil energy)
ENVIROMENTAL	Micro	Amount of materials recovered through reuse and recycling per year (by sector)
ENVIROMENTAL	Macro	Circular businesses as a percentage of the total number of businesses in the region
ECONOMIC	Macro	Revenue of the industry in the most circular products
TECHNOLOGICAL	Micro	Mapping of existing points according to reuse and recycling needs

ECONOMIC	Macro	Number of awareness-raising actions on circular economy research and innovation and their respective impacts
ECONOMIC	Macro	Creation of a municipal or regional website providing information on the circular economy
ECONOMIC	Macro	Number of collaborative projects implemented
ECONOMIC	Macro	Number of companies that have received funding in the field of the circular economy
ECONOMIC	Macro	Amount of grants awarded to companies for circular economy projects
ECONOMIC	Macro	Number and amount of investments in circular economy related to R&D projects
ECONOMIC	Macro	Patent applications related to new sustainable processes submitted by public organizations (research centers, universities, and public organizations) and companies
ECONOMIC	Macro	Products/services covered by circularity criteria in procurement
ECONOMIC	Macro	Legal and regulatory barriers to the circular economy eliminated

3.4 Discussion and main takeaways

From an initial list of 121 preselected KPIs, 26 made it to the final selection. 46.1% of the KPIs are environmental, 42.3% economic, 7.7% governmental and 3.9% technological.

One important point that emerged from the co-creation event was the need to continue working on the development of a methodology for using the selected KPIs consistently across all regions. This methodology should consider the same aspects and criteria to ensure comparability and accuracy in measuring and reporting sustainability performance.

To address this need, AITIIP expressed its commitment to continuing to work with companies and other stakeholders to develop and implement such a methodology, being part of the Task 2.2. activities. This will involve collaboration and consultation with a diverse range of actors to ensure that the methodology is comprehensive, practical, and widely applicable. By doing so, AITIIP hopes to promote greater standardization and harmonization of sustainability reporting, which can contribute to greater transparency and accountability in the circular economy.

An identified constraint discovered during the analysis of the workshop and survey is the insufficient awareness among stakeholders. This observation stemmed from the concentration of votes mainly in the environment and economic categories, while comparatively lesser attention was given to the governance field, which holds regulatory significance in the industry, and the technology field, which offers a competitive edge and is crucial for successful entrepreneurship. The social indicators were not voted, highlighting even more the significance and necessity of organizing more co-creation workshops of this nature as a means to familiarize diverse stakeholders with the social dimension of circular economy.

The discussion with the investors, revealed that there is interest among the investing parties in projects that have a strong focus on circularity. For the investment to happen, companies that are in search of funding must be willing to enable investors to participate in the firm and allow for the distribution of dividends, as investors aim to recoup their investment through the earnings of the company.

The discussion with the companies revealed that there is a high interest to develop and transition towards more circular business models but since companies use different sources of information to educate themselves about the circular economy, there is a need to support them by providing a more centralized information, therefore enabling that everyone is on the same page. Furthermore, to this, it is crucial for the companies to receive adequate guidance with regard to access the necessary funding.

4. Life Cycle Impact Assessment and Hotspot Analysis of the participating companies in RESOURCE Project

4.1 The added value of Life Cycle Assessment (LCA) in facilitating the transition towards a Circular Economy

The utilization of Life Cycle Assessment (LCA) is highly beneficial when transitioning towards a circular economy. LCA is used to measure and analyze the environmental burden of products or services across their life cycle and highlights areas of improvement. LCA helps with identifying the stages of a product's life cycle that have the highest environmental impacts. With access to this information, companies can prioritize their efforts towards the most crucial areas that require improvement.

LCA enables the evaluation of different scenarios and strategies to achieve circularity. For example, it can compare the environmental impacts of recycling, reusing, or disposing of a product (Buttol et al., 2007; Cherubini et al., 2009; Christensen et al., 2020; Ekvall et al., 2007; Feo & Malvano, 2009; Hossain & Poon, 2018).

LCA is a valuable tool while designing products (Brezet et al., 1999; McAloone & Pigosso, 2017; Piekarski et al., 2019; Vinodh & Rathod, 2010). It helps with assessing and comparing different design choices that encourage the adoption of circular design principles such as durability, recyclability, and ease of disassembly.

LCA can be applied to assess the environmental impacts of the entire supply chain and support its optimization (Bojarski et al., 2009; Khoo et al., 2019; Kleinekorte et al., 2020; Kostin et al., 2011; Laínez et al., 2008; Pieragostini et al., 2012; Reich-Weiser et al., 2008). Such an assessment helps to identify inefficiencies, waste generation, and emissions hotspots within the supply chain. By optimizing these areas, companies can reduce their environmental impact and identify opportunities for circular practices like reverse logistics, waste valorization, or product take-back systems.

LCA provides a standardized approach for communicating its results therefore facilitating their dissemination and understanding across several types of stakeholders (consumers, policymakers, investors et cetera.) (Del Borghi, 2013; Molina-Murillo & Smith, 2009; Vizzoto et al., 2021). Such transparency can inform decision-making and encourage sustainable patterns of consumption and production.

4.2 LCA applications in various sectors

Life Cycle Assessment (LCA) has been extensively applied in manufacturing and industrial sectors to assess and identify opportunities for material efficiency, waste reduction, and resource optimization (Bevilacqua et al., 2010; Filleti et al., 2017; Groot & Borén, 2010; Ponnusamy & Mani, 2022; Salieri et al., 2018; Schneider et al., 2023; Silvestri et al., 2021; Vinodh & Jayakrishna, 2014; Y. Zhang et al., 2010).

LCA has been used to evaluate building materials, entire buildings, construction processes, and to identify opportunities for resource-efficient design, incorporating recycled or renewable materials, and optimizing energy use throughout the life cycle of buildings (Cabeza et al., 2014; da Silva et al., 2021; H & S, 2022; Li et al., 2010; Martínez-Rocamora et al., 2016; Ortiz et al., 2009; Singh et al., 2010; C. Zhang, 2014).

LCA plays a crucial role in assessing the environmental impacts of electronic and electrical products as well as identifying opportunities for product longevity, material recovery, and responsible end-of-life management through strategies like repair, refurbishment, and recycling (Bauer et al., 2008; Clemm et al., 2019; Cobas et al., 1995; da Silva Müller Teixeira et al., 2021; Deng et al., 2016; Jonkers et al., 2016; Liu et al., 2014; Meyer & Katz, 2016; Rhodes, 1993; Xue & Xu, 2017).

LCA is used in the Transportation and Automotive sector as well. It can contribute to the development of more sustainable transportation systems by identifying areas for improvement in fuel efficiency, emissions reduction, material selection, and end-of-life treatment of vehicles (Arrigoni et al., 2022; Baldo et al., 1997; Dai et al., 2019; Gebler et al., 2020; Gonçalves et al., 2022; Life Cycle Assessment of Advanced Materials for Automotive Applications on JSTOR, n.d.; Neelis et al., 2004; Pegoretti et al., 2014; Tolomeo et al., 2020).

Food and Agriculture is another sector where LCA has been employed to assess the environmental impacts of various food products, farming practices, and supply chains. It helps with identifying opportunities for reducing resource consumption, minimizing food waste, optimizing packaging, and promoting sustainable agricultural methods (Andersson, 2000; Andersson et al., 1994; Dijkman et al., 2017; Harun et al., 2021; Hasler et al., 2015; McAuliffe et al., 2020; Roy et al., 2009; Van Der Werf et al., 2014).

LCA is utilized in the energy sector to assess the environmental impacts of different energy sources, such as fossil fuels, renewable energy technologies, and energy storage systems. It helps guide decisions towards more sustainable and circular energy systems by evaluating resource use, emissions, and waste generation throughout the life cycle (Balli, 2022; Ciacci &

Passarini, 2020; David et al., 2021; Fu et al., 2022; Gerber et al., 2011; Góralczyk, 2003; Hayatina et al., 2023; Hosseinzadeh-Bandbafha et al., 2020; Ingrao et al., 2019; Laurent et al., 2017; Pehnt, 2006; Rahman et al., 2020; Silalertruksa & Gheewala, 2013; Singh et al., 2013; Sobrino et al., 2011; Varun et al., 2009).

LCA is increasingly applied in the textile and fashion industry to evaluate the environmental footprint of textile fibers, clothing manufacturing processes, and end-of-life management. It supports the adoption of circular practices like recycling, upcycling, and extended product life through durability (Allwood et al., 2008; Amicarelli et al., 2022; Chopra et al., 2023; Gupta et al., 2022; Payne, 2015a, 2015b; Piontek & Müller, 2018; Resta et al., 2016; Rosa & Grammatikos, 2019; Van Der Velden et al., 2014; van der Velden et al., 2015; Zamani et al., 2017).

LCA is utilized in waste management to evaluate different waste treatment options such as landfilling, incineration, composting, and recycling. It helps to identify the most environmentally preferable strategies for waste disposal, resource recovery, and waste prevention (Buttol et al., 2007; Cherubini et al., 2009; Christensen et al., 2020; Ekvall et al., 2007; Feo & Malvano, 2009; Hossain & Poon, 2018; Laurent, Bakas, et al., 2014; Laurent, Clavreul, et al., 2014; Razza et al., 2009; Rives et al., 2010; Slagstad & Brattebø, 2012).

LCA offers support in policymaking as well. For example LCA can be used to assess the effectiveness of existing policies/regulations, support the development and implementation of sustainable circular economy strategies, to assess and develop environmental standards and certifications, sustainable procurement policies, encourage and support international cooperation and the development of robust environmental policies (Butt et al., 2015; De Benedetto & Klemeš, 2009; Du et al., 2014; Garcia, 2016; García-Gusano et al., 2017; Khoo, 2022; Kua, 2016; Pombo et al., 2019; Röck et al., 2021; Schenck, 2000; Scherz et al., 2022; Seidel, 2016; Tanaka, 2008; Tarantini et al., 2011; Vázquez-Rowe et al., 2013; Vázquez-Rowe & Iribarren, 2015; Vidal & Sánchez-Pantoja, 2019).

Overall, LCA brings valuable insights through a data-driven analysis to the circular economy transition. By understanding the environmental impacts of products and processes, companies and stakeholders can make more informed decisions and implement effective strategies to achieve a more sustainable and circular future.

4.3 Life Cycle Assessment of RESOURCE Pilots

The evaluation of the pilots using the LCA framework commenced in December 2022 and concluded in June 2023. Out of thirteen selected pilot projects, we were able to fully conduct six LCAs. Two companies initiated their involvement in December 2022, another two in January 2023, and the remaining companies joined the LCA assessment in April 2023.

From the first selection phase resulting in five pilots, only three agreed to furnish data for the assessment. Despite signing confidentiality agreements, two of the companies were unwilling to share their data due to their technologies giving them a crucial competitive advantage, and their internal policies prohibited the disclosure of such information. Due to the late entry into the project of the pilots selected from the second phase, only three of them underwent assessment through the Life Cycle Assessment (LCA) method.

Due to the delayed data provision from one of the latter joining companies, this section will focus solely on presenting and discussing the outcomes of five companies. In adherence to confidentiality agreements, the report will refrain from disclosing the names of the companies whose products were assessed, details of their systems under analysis or their specific findings. Instead, it will examine overarching patterns across these companies by analyzing the results within each environmental impact category taken under analysis. However, the detailed LCA results will be reported in the confidential technical report, and they will also be presented to the respective companies during separate workshop sessions scheduled for July 2023. In order to comply with the confidentiality agreements in place, these feedback workshops will not be open to the public.

4.3.1 Methodology

The pilot's assessment followed the Life Cycle Assessment Framework based on ISO standards (Nygren et al., 2004).

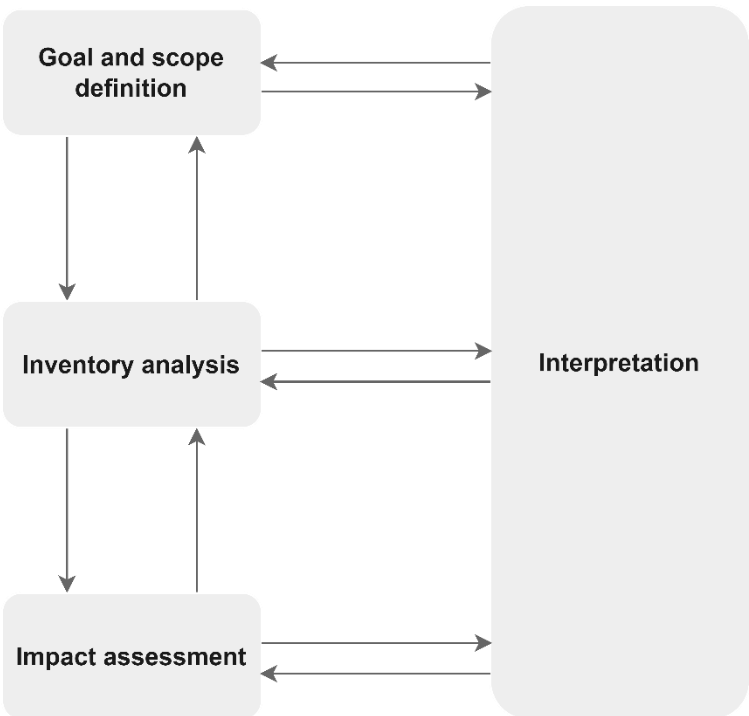

Figure 2. Life Cycle Assessment Framework

4.3.1.1 Goal and Scope Definition

This assessment aims to quantify the environmental impacts and identify the "hotspots" of each Pilot's product across their lifecycle. The geographical scope covers Spain. This study aims at being compliant with the present state of technology. The approach used to assess the potential environmental impacts is attributional, using the simplified guidelines (Nygren et al., 2004) The selected impact categories include the list of impact categories presented in table 11 in section 4.1.2.3. In adherence to confidentiality agreements, this section will not disclose details about the function and functional units of the systems under analysis.

4.3.1.2 Inventory analysis

This study uses the open source LCA software Activity Browser (AB) (Steubing et al., 2020), which is based on the brightway LCA framework (Mutel, 2017), and ecoinvent database version 3.8 cut off version (Ecoinvent Association, 2014) for the background processes through the education license provided by Leiden University. The data for the foreground processes consists of primary data collected from the Pilots, ecoinvent database 3.8 and in a small number of cases it consists of literature-based assumptions.

4.3.1.2.1 Data collection

The data collection was implemented in three stages.

- **Stage 1**: The preselected pilots were introduced with the LCA methodology, its purpose, steps, data collection template and deadlines within the RESOURCE project context. The introduction took place in Zaragoza, Spain in November 2022 through a workshop organized by Government of Aragon (GoA) and Leiden University (ULEI).
- **Stage 2:** Following the workshop, separate virtual meetings took place in between ULEI and Pilot's representatives in charge of the LCA data provision. These meetings served the following purposes:
    - Clarify any remaining questions about the LCA method.
    - Provide guidelines on how to complete the data collection template.
    - Discuss Pilots' products and systems to be taken under analysis.
    - Sent the data collection[2] template document to the Pilots following the virtual meetings.
- **Stage 3:** The first draft of data submitted by the Pilots was reviewed and further improved/detailed through follow up meetings with the Pilots. These preliminary inventories were used to relate the data to unit processes.

[2] The data collection template is available in the Appendix, chapter 6, table 16 and table 17

4.3.1.2.2 Multifunctionality

Solving multifunctionality was implemented in three steps: To begin with, goods and waste flows were defined, and functional flows were identified (input waste = functional flow; output good = functional flow). The processes with more than one functional flow were grouped under three categories of multifunctional flows: co-production, combined waste processing, and recycling. And lastly, economic and/or physical allocation was applied. In the cases when economic allocation was necessary, the data were provided by the Pilots.

4.3.1.3 Impact Assessment

In this step, the collected inventory data is evaluated in terms of potential environmental impacts. An LCIA method is applied to assess the contributions of the different inputs and outputs to various impact categories. These impact categories help identify potential environmental hotspots and areas of concern. For our pilots the impact assessment made use of the Environmental Footprint (EF) methodology (European Commission & JRC, 2021), a comprehensive approach developed by the European Commission to ensure accurate and consistent measurement and communication of environmental performance. For the LCIA assessment we used the EF v3.0 method coupled with the EN 15804 standard which treats biogenic emissions the same as fossil emissions and considers the removal of CO2 from the atmosphere.

The EF methodology encompasses a wide range of impact categories to measure environmental impacts. In this case we are using the midpoint level of impact assessment. The midpoint level of impact assessment focuses on quantifying and characterizing the environmental stressors or emissions generated by a product or process (Finnveden et al., 2009).

Table 12. List of LCIA impact categories (European Commission & JRC, 2021)(Ecochain. (2023)

Environmental Impact Category	Description	Unit
Climate change	This impact category indicates potential global warming due to emissions of greenhouse gases to the air.	kg CO2 eq (kilogram CO2 equivalent)
Acidification	This impact category indicates the potential acidification of soils and water due to the release of gases such as nitrogen oxides and sulphur oxides.	mol H+ eq (moles of hydrogen ion equivalents)
Ecotoxicity, freshwater	This impact category assesses the impact on freshwater organisms of toxic substances emitted to the environment.	CTUe (Comparative toxic units for aquatic ecotoxicity impacts)
Energy resource depletion, non-renewable	This impact category quantifies the consumption and depletion of energy resources that are not naturally replenished within a human-relevant timescale. It focuses on the depletion of non-renewable energy resources throughout the life cycle of a product or process such as fossil fuels (coal, oil, natural gas) and	MJ (Megajoule)

	nuclear energy.	
Eutrophication, freshwater	This impact category quantifies the excessive nutrient enrichment of freshwater ecosystems, which can cause overgrowth of algae, oxygen depletion, and disruption of aquatic ecosystems.	kg P eq (kilogram Phosphate-equivalent)
Eutrophication, marine	This impact category quantifies the excessive nutrient enrichment of marine ecosystems, which can cause overgrowth of algae, oxygen depletion, and disruption of aquatic ecosystems.	kg N eq (kilogram nitrogen-equivalent)
Eutrophication, terrestrial	This impact category quantifies excessive nutrient inputs to terrestrial ecosystems, leading to water quality degradation and ecosystem disruption.	Mol N eq (Mol nitrogen-equivalent)
Ozone depletion	This impact category quantifies emissions to air that cause the destruction of the stratospheric ozone layer.	kg CFC-11 eq (kilogram trichlorofluoromethane-equivalent)
Human Toxicity, carcinogenic	This impact category assesses the potential adverse effects of toxic substances on human health through exposure during the life cycle of a product or process.	CTUh (Comparative Toxicity Unit for humans)
Human Toxicity, non-carcinogenic	This impact category assesses the potential adverse effects of toxic substances on human health through exposure during the life cycle of a product or process.	CTUh (Comparative Toxicity Unit for humans)
Water use	This impact category assesses the water resource depletion associated with the product or process, including both direct and indirect water usage.	m3 water eq of deprived water
Land use	This impact category measures the changes in soil quality.	Soil quality index
Minerals depletion	This impact category assesses the consumption of finite resources such as minerals throughout the life cycle.	kg Sb eq (kilogram antimony-equivalent)
Particulate Matter	This impact category assess the potential incidence of disease due to particulate matter emissions.	disease incidences
Ionizing radiation, human health	This impact category quantifies the emissions of radionuclides throughout the life cycle of a product or process.	kBq U-235 eq. (kilobecquerels of uranium-235 equivalent)
Photochemical ozone formation, human health	This impact category focuses on the formation of ground-level ozone (tropospheric ozone) as a result of chemical reactions involving air pollutants, primarily nitrogen oxides (NOx) and volatile organic compounds (VOCs), in the presence of sunlight.	kg NMVOC eq. (kilogram of non-methane volatile organic compounds equivalent)

4.3.1.4 Interpretation

The final step involves interpreting the results of the LCIA and presenting them in a clear and understandable manner. This includes identifying opportunities for improvement and communicating the findings to stakeholders. The findings are presented and analyzed in the next subchapter.

4.3.2 Results

This section will present the results of the LCA per impact category. Due to confidentiality agreements in place, this report will not disclose any absolute results, nor the names of the companies involved in the assessment. For every impact category, we present a contribution analysis by life cycle stage across five products.

4.3.2.1 Climate change

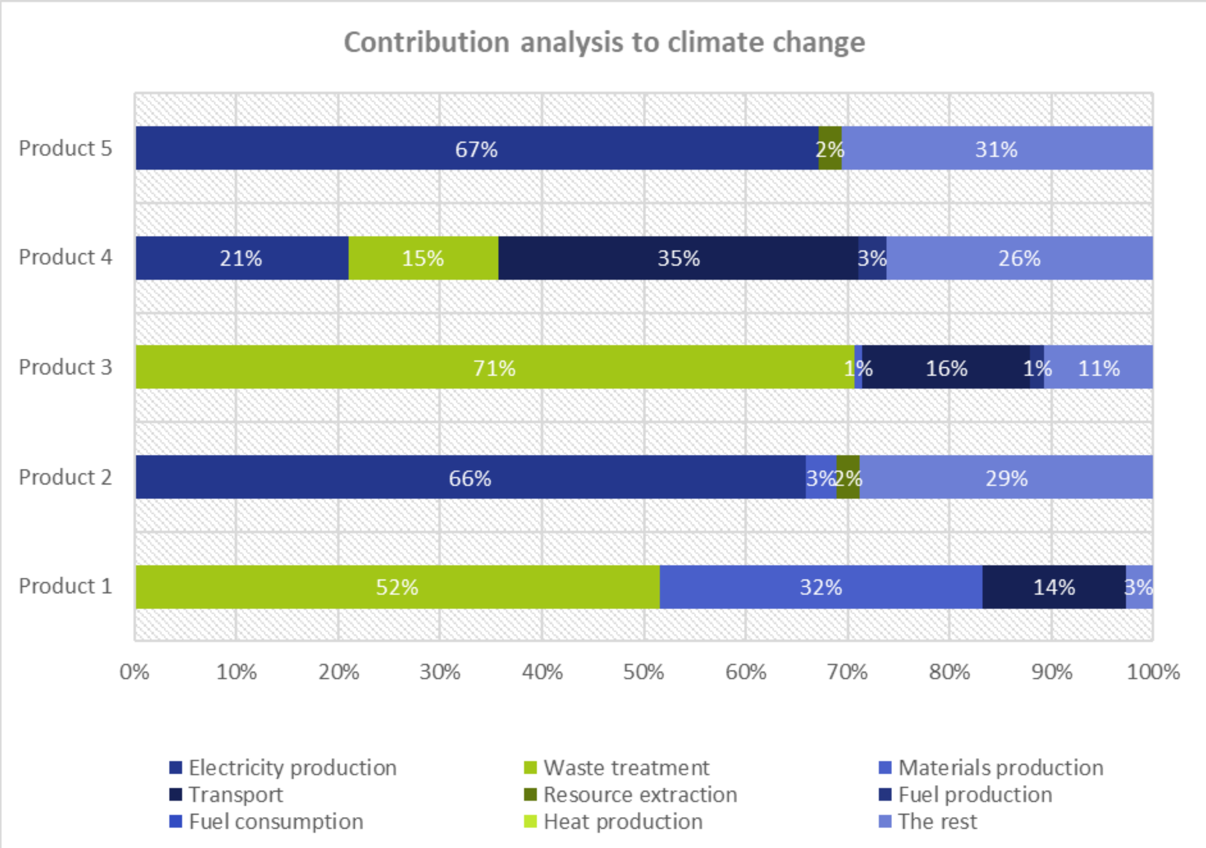

Figure 3. Contribution analysis to climate change[3]

The two dominant stages that contribute to climate change are electricity production (for product 2, 4, 5) and waste treatment (for product 1, 3, 4) followed by transportation (for product 1, 3) and materials production (for product 1 only). These four stages are responsible for 69%-88% of the impact.

[3] "The rest" category in the graph, represents the rest of the activities responsible for the impact, grouped together.

4.3.2.2 Acidification

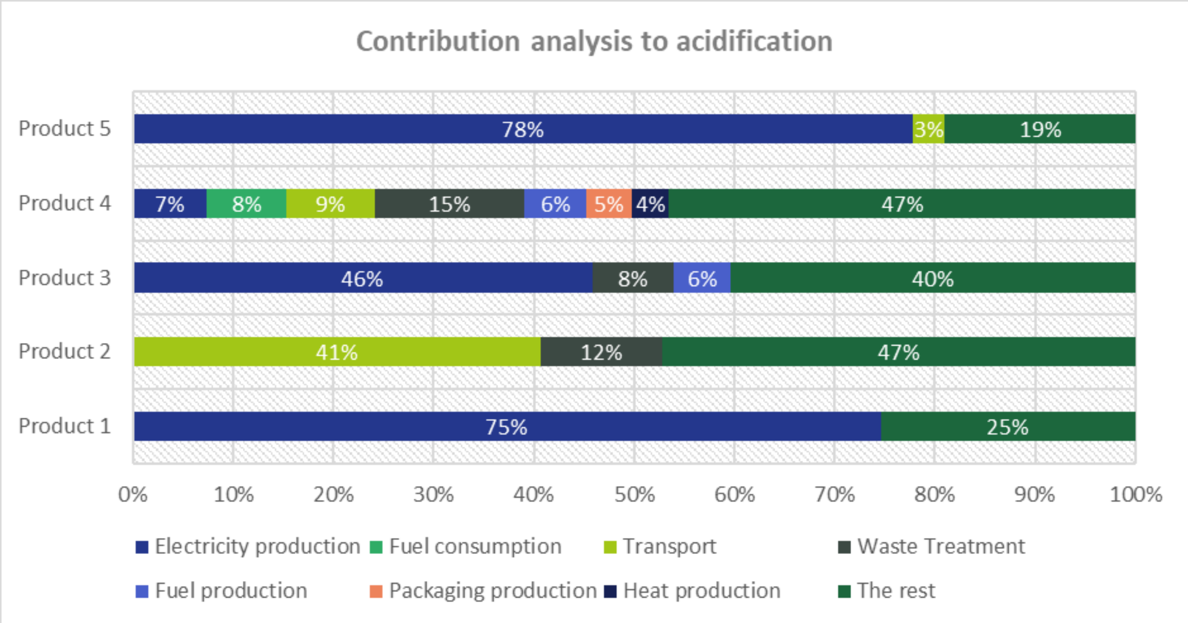

Figure 4. Contribution analysis to acidification4

The dominant stages that contribute the most to acidification across five products are electricity production, waste treatment and transport responsible for up to 81% of the impact.

[4] "The rest" category in the graph, represents the rest of the activities responsible for the impact, grouped together.

4.3.2.3 Ecotoxicity

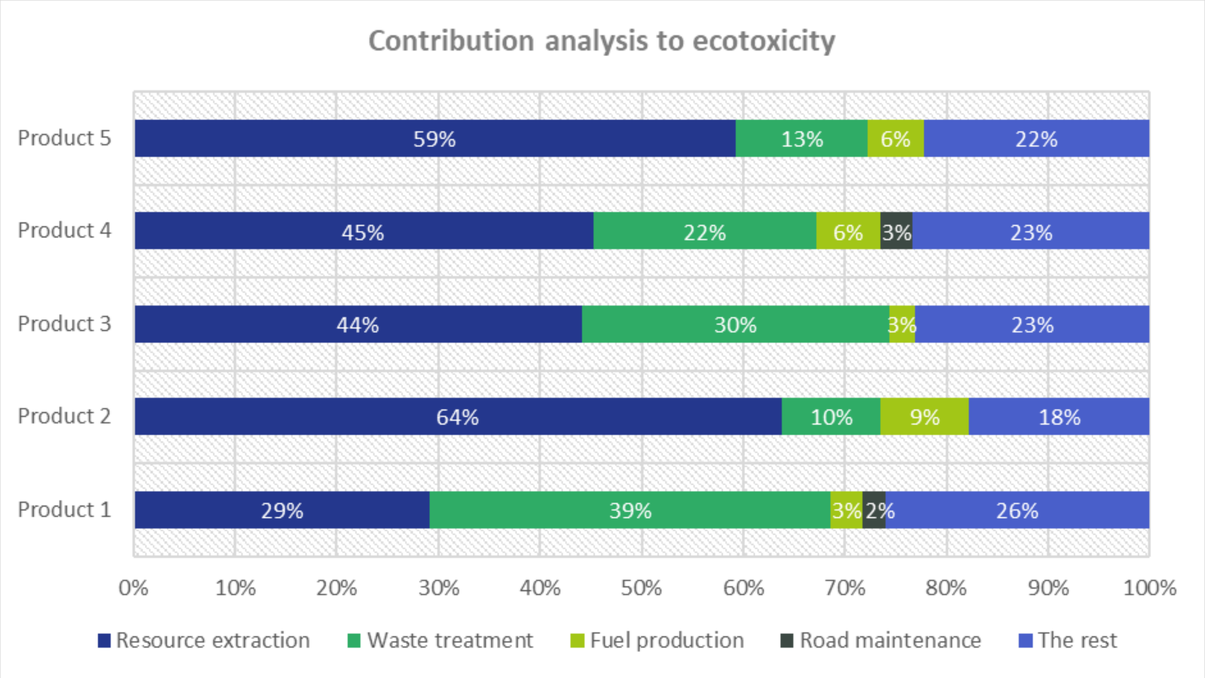

Figure 5. Contribution analysis to ecotoxicity[5]

Resource extraction and waste treatment are the two dominant stages that contribute the most to ecotoxicity, responsible for 67%-74% of the impact.

[5] "The rest" category in the graph, represents the rest of the activities responsible for the impact, grouped together.

4.3.2.4 Energy resource depletion, non-renewable

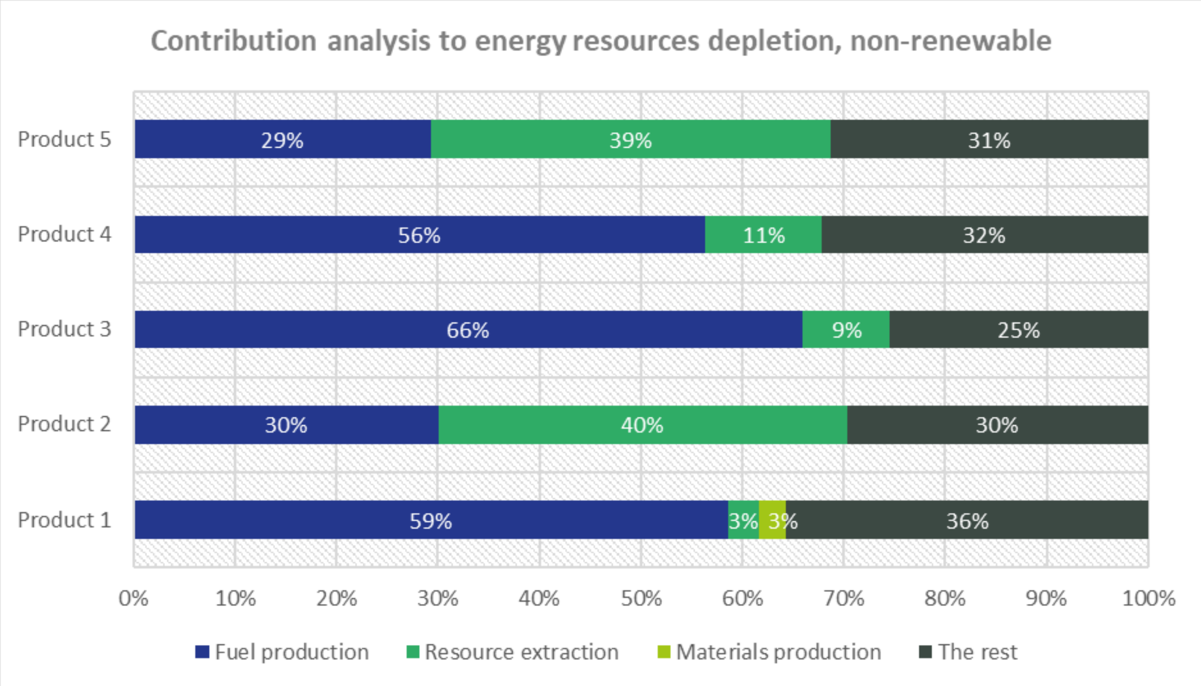

Figure 6. Contribution analysis to energy resources depletion, non-renewable[6]

Fuel production and resource extraction are the two dominant stages that contribute the most to the depletion of non-renewable energy resources, responsible for 62%-75% of the impact.

[6] "The rest" category in the graph, represents the rest of the activities responsible for the impact, grouped together.

4.3.2.5 Eutrophication, freshwater

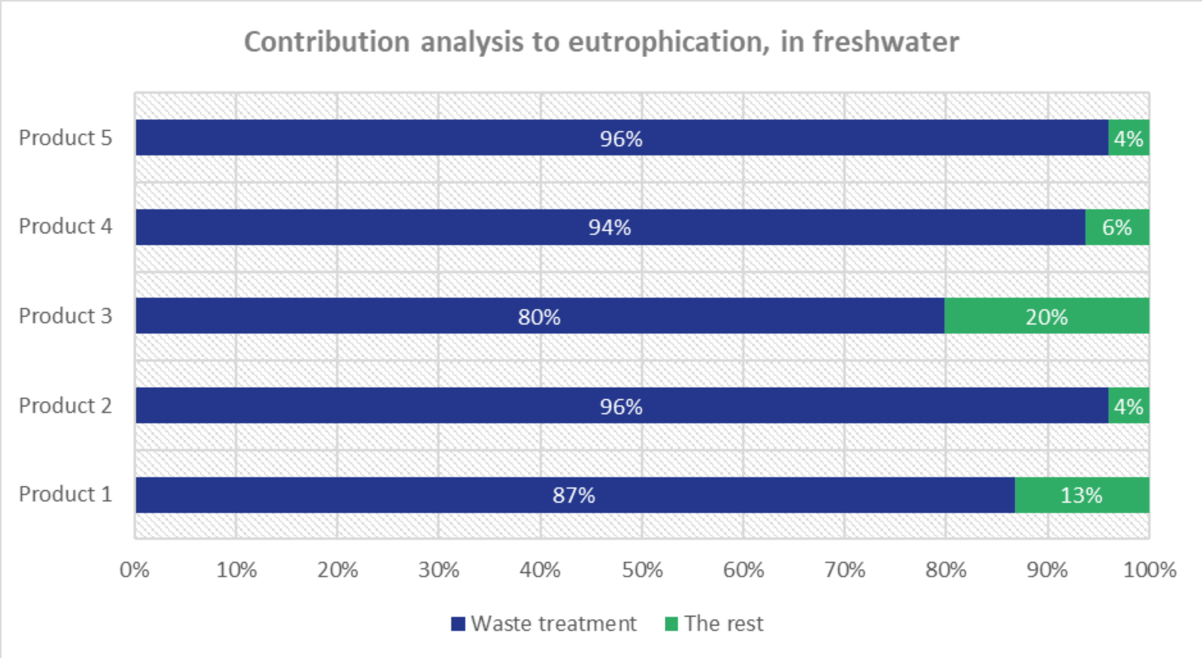

Figure 7. Contribution analysis to eutrophication, freshwater[7]

Waste treatment is the dominant stage that contributes the most to the eutrophication in freshwater responsible for 80%-96% of the impact.

[7] "The rest" category in the graph, represents the rest of the activities responsible for the impact, grouped together.

4.3.2.6 Eutrophication, marine water

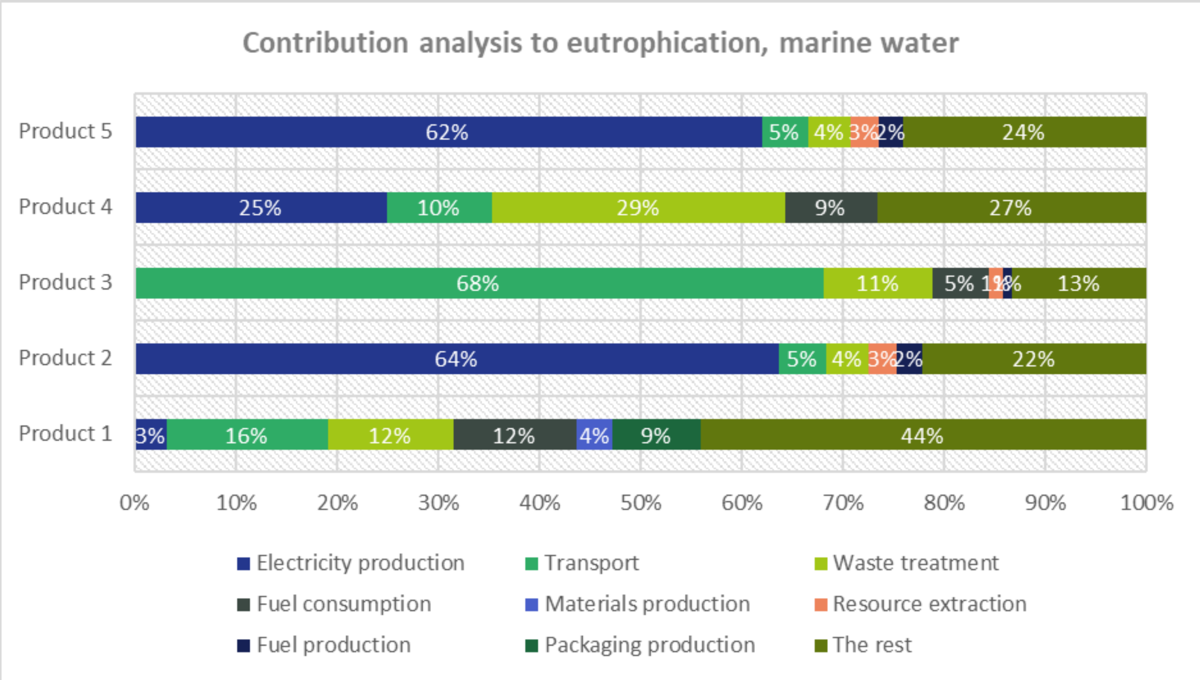

Figure 8. Contribution analysis to eutrophication, marine water[8]

Across the five products taken under analysis we can highlight electricity production, transportation and waste treatment as the dominant stages that contribute the most to the eutrophication in marine water responsible for up to 79% of the impact.

[8] "The rest" category in the graph, represents the rest of the activities responsible for the impact, grouped together.

4.3.2.7 Eutrophication, terrestrial

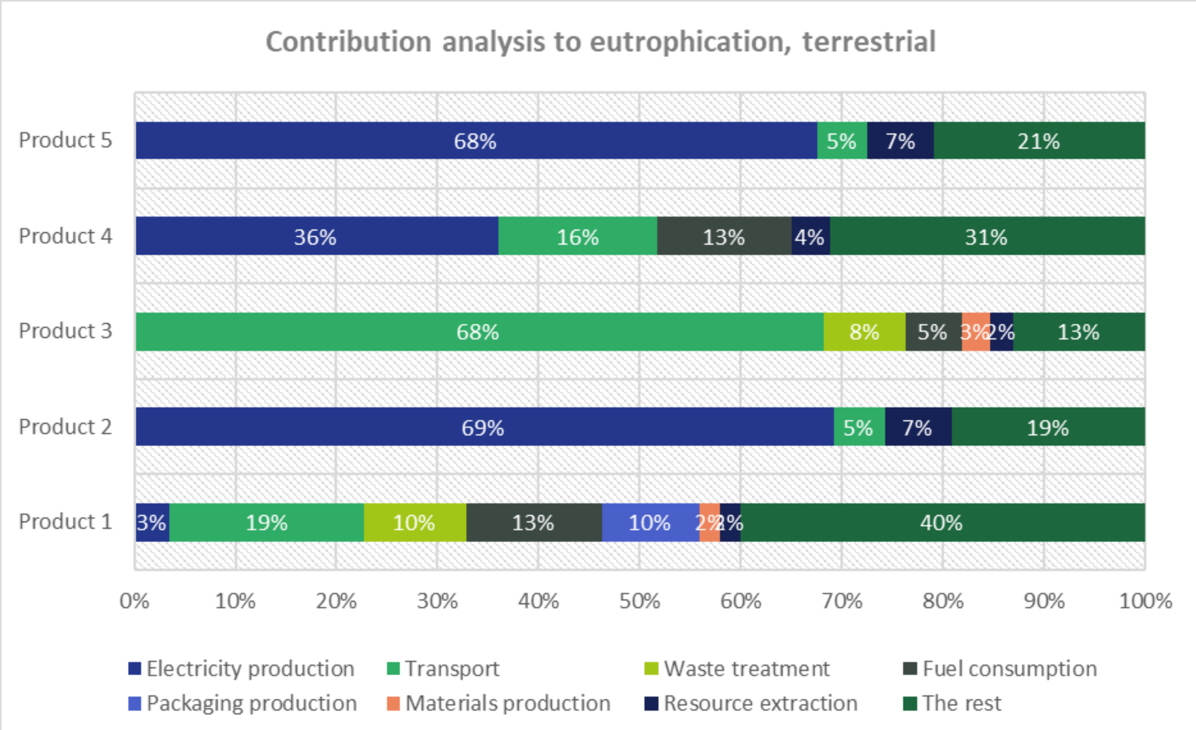

Figure 9. Contribution analysis to eutrophication, terrestrial[9]

Electricity production and transportation are the two dominant stages that contribute the most to the eutrophication in marine water followed by fuel consumption and resource extraction. In addition to this, specifically for product 1, waste treatment and packaging production are important contributors as well. Altogether they are responsible for 58%- 81% of the impact.

[9] "The rest" category in the graph, represents the rest of the activities responsible for the impact, grouped together.

4.3.2.8 Human toxicity, carcinogenic

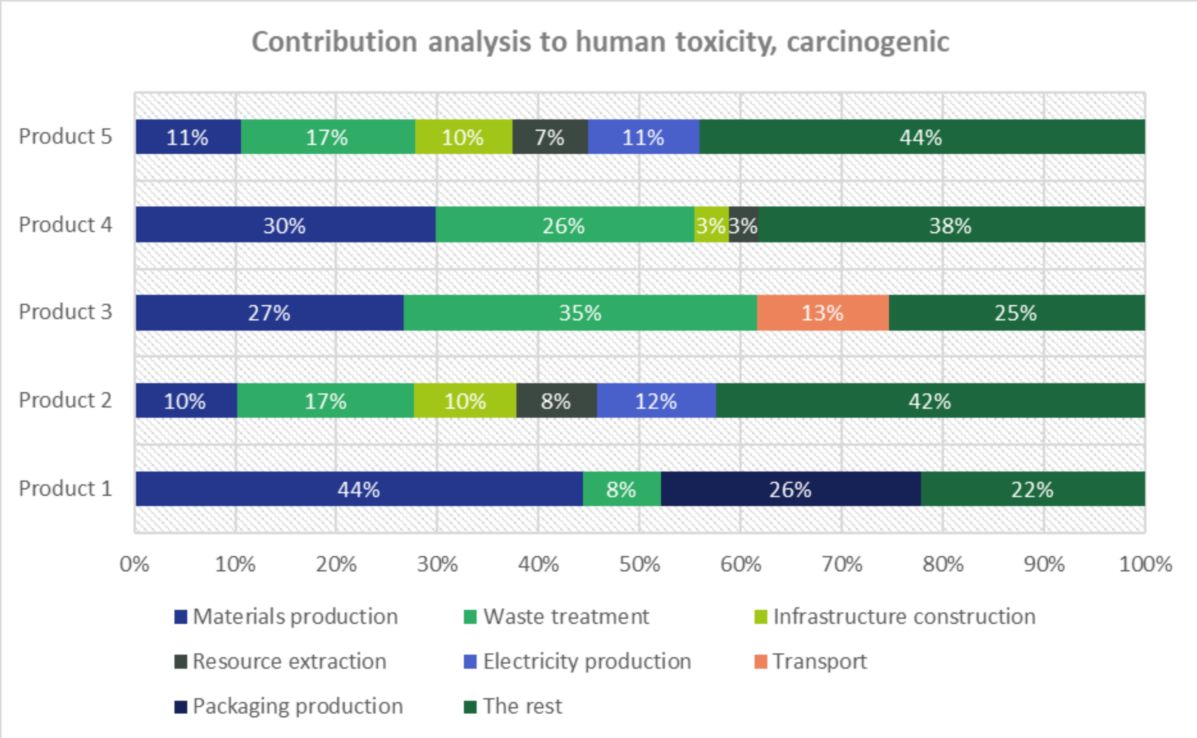

Figure 10. Contribution analysis to human toxicity, carcinogenic[10]

Waste treatment, materials and electricity production are the dominant stages that contribute the most to human toxicity (carcinogenic) followed by infrastructure construction and packaging production. Altogether they are responsible for 58%- 81% of the impact.

[10] "The rest" category in the graph, represents the rest of the activities responsible for the impact, grouped together.

4.3.2.9 Human toxicity, non-carcinogenic

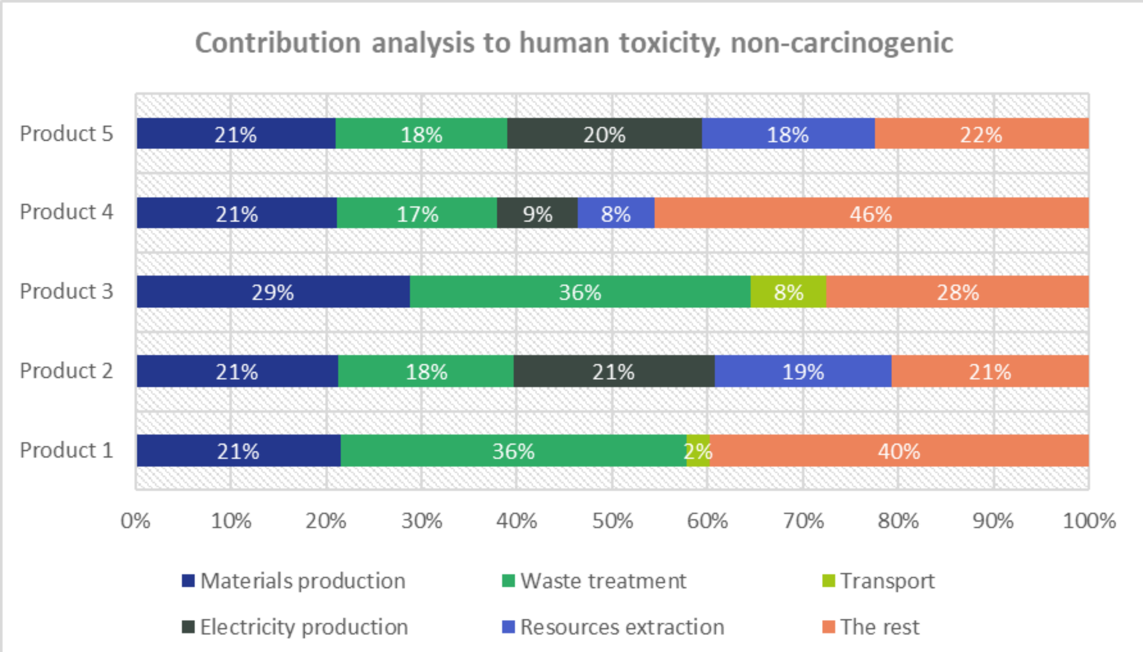

Figure 11. Contribution analysis to human toxicity, non-carcinogenic[11]

Waste treatment, materials and electricity production are the dominant stages that contribute the most to human toxicity (non-carcinogenic) responsible for up to 72% of the impact.

[11] "The rest" category in the graph, represents the rest of the activities responsible for the impact, grouped together.

4.3.2.10 Ionising radiation

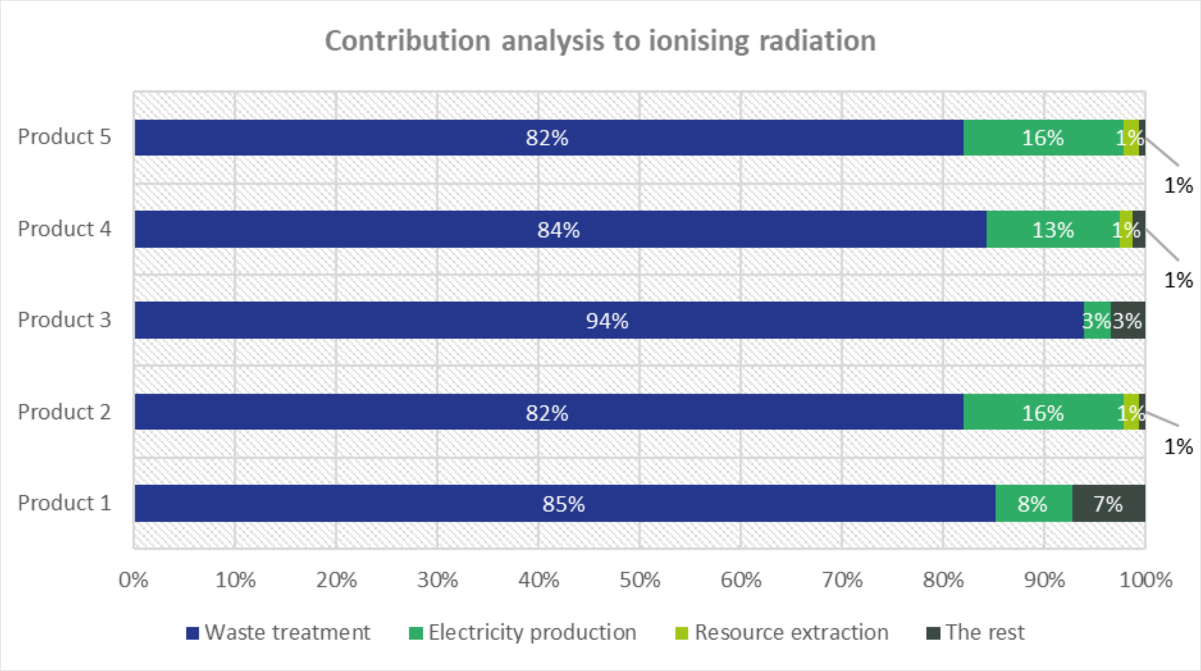

Figure 12. Contribution analysis to ionising radiation[12]

Waste treatment and electricity production are the dominant stages that contribute the most to ionising radiation responsible for 82%-98% of the impact.

[12] "The rest" category in the graph, represents the rest of the activities responsible for the impact, grouped together.

4.3.2.11 Land use

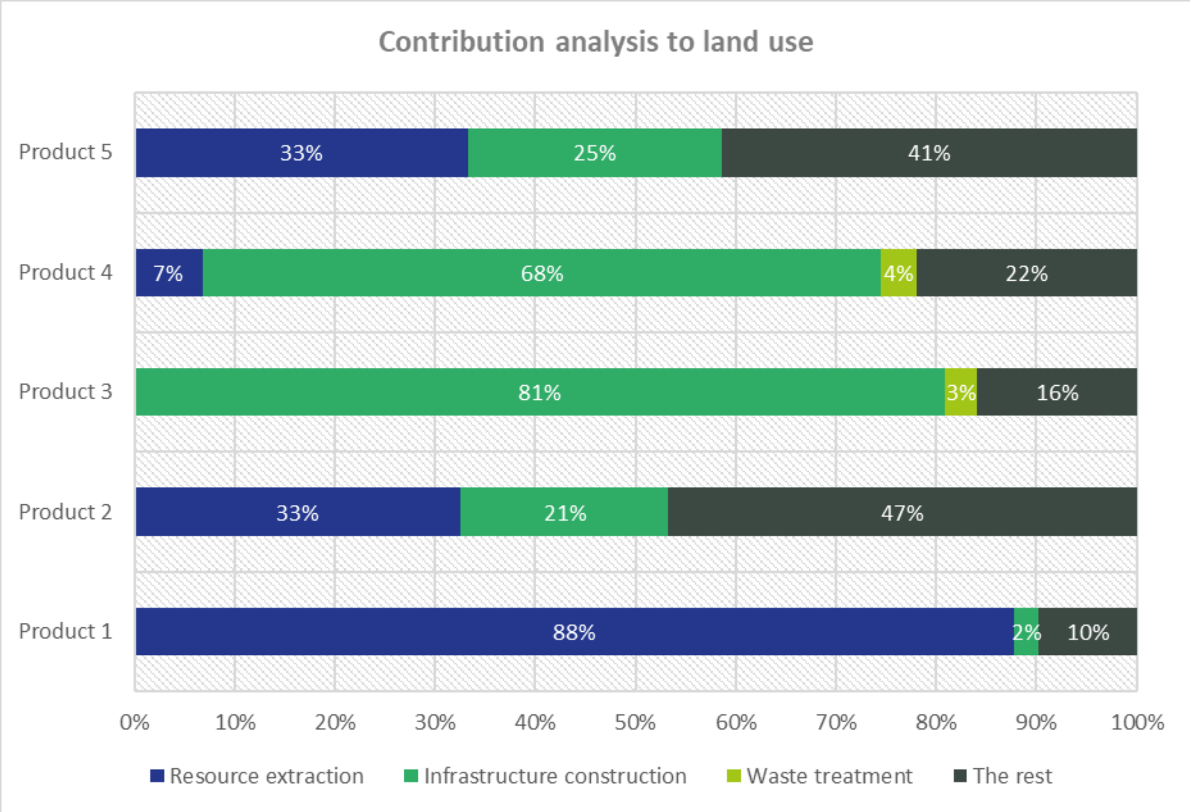

Figure 13. Contribution analysis to land use[13]

Waste treatment and infrastructure construction are the dominant stages that contribute the most to land use responsible for 54%-90% of the impact.

[13] "The rest" category in the graph, represents the rest of the activities responsible for the impact, grouped together.

4.3.2.12 Minerals depletion

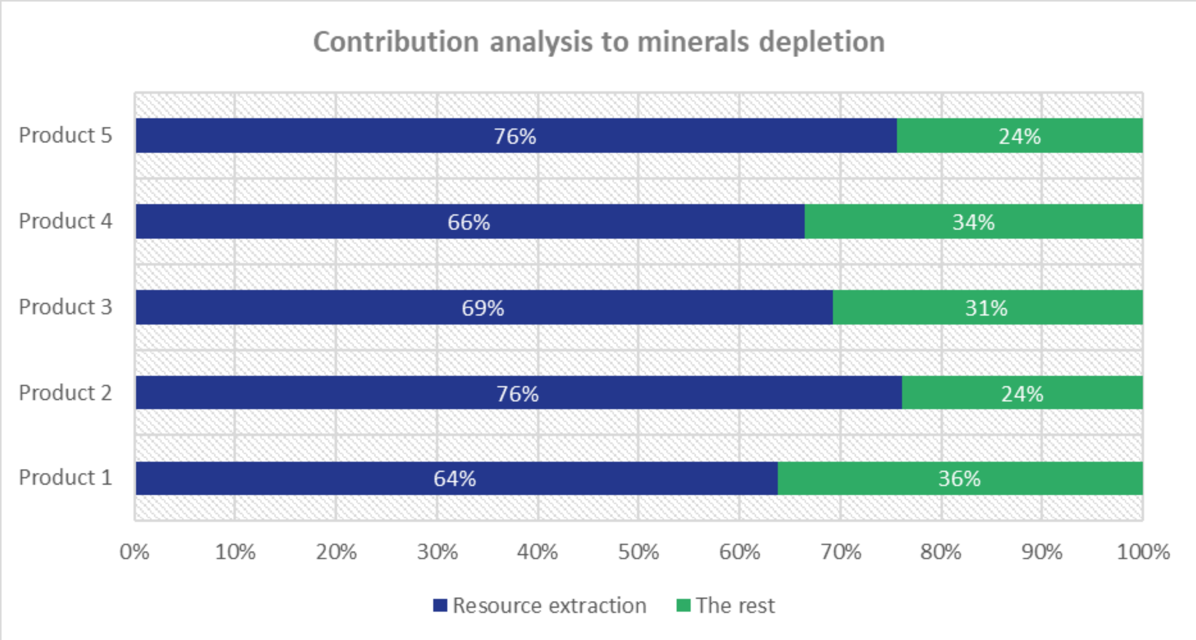

Figure 14. Contribution analysis to minerals depletion[14]

Resource extraction is the dominant stage that contributes the most to minerals depletion responsible for 66%-76% of the impact.

[14] "The rest" category in the graph, represents the rest of the activities responsible for the impact, grouped together.

4.3.2.13 Ozone depletion

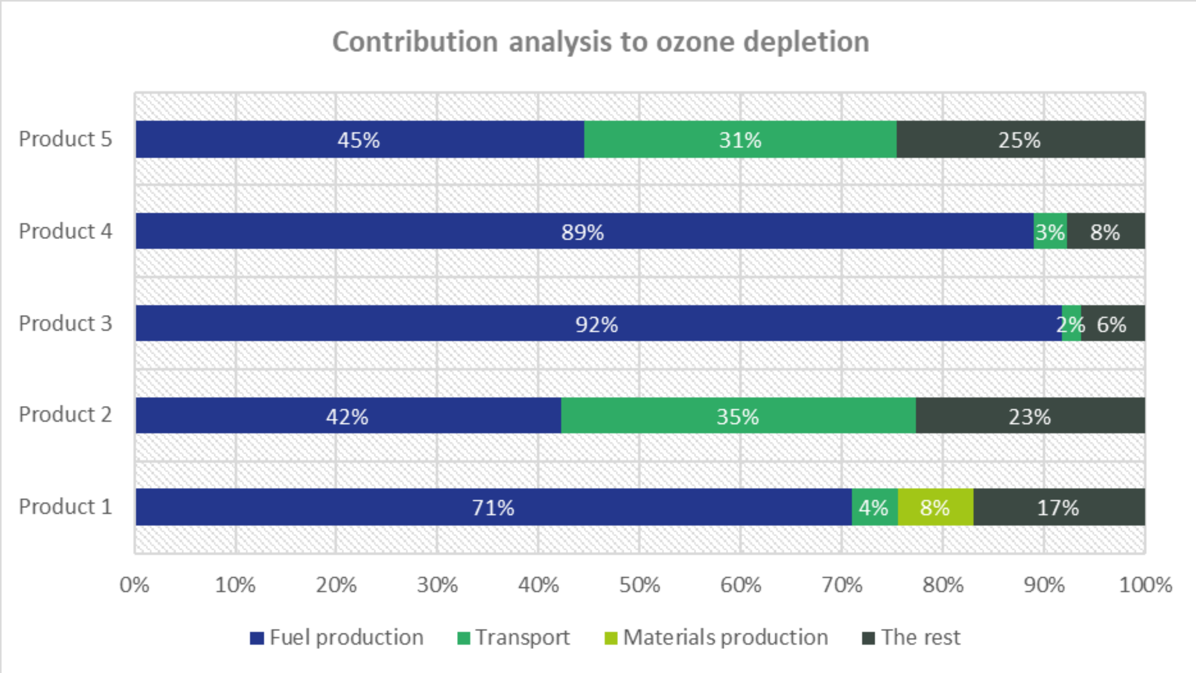

Figure 15. Contribution analysis to ozone depletion[15]

Fuel production and transport are the dominant stages that contribute the most to ozone depletion responsible for up to 67%-94% of the impact.

[15] "The rest" category in the graph, represents the rest of the activities responsible for the impact, grouped together.

4.3.2.14 Particulate matter formation, human health

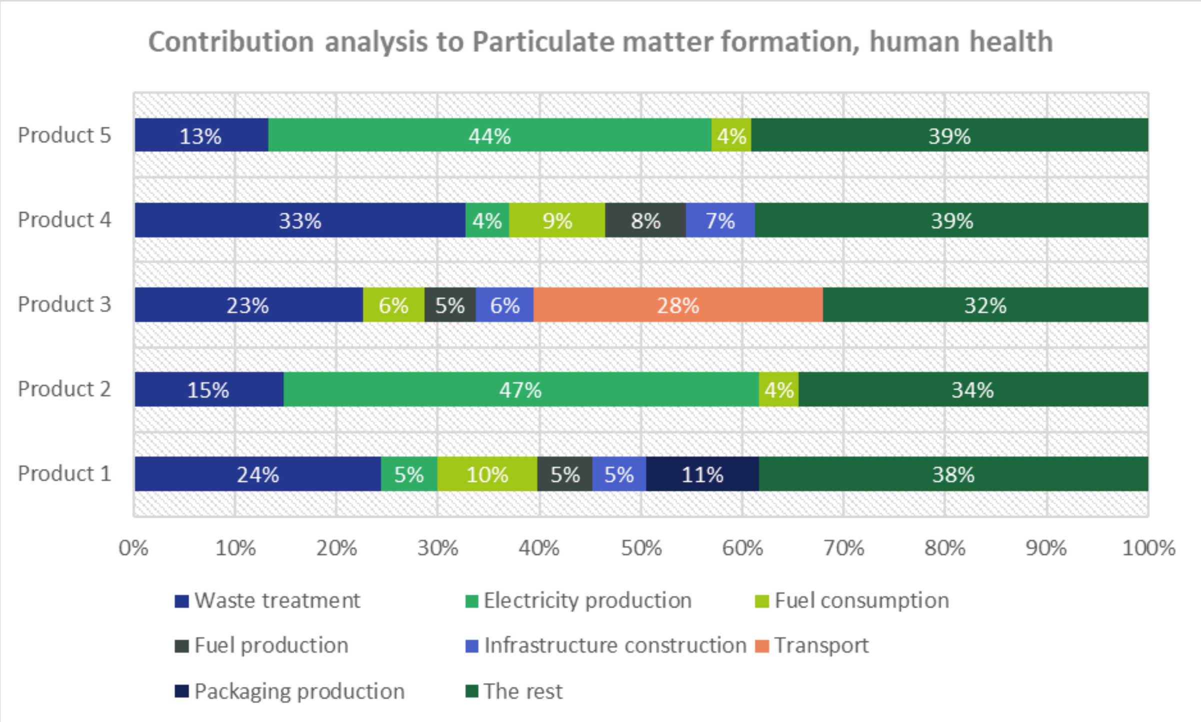

Figure 16. Contribution analysis to particulate matter formation, human health[16]

Waste treatment and electricity production are the dominant stages that contribute the most to particulate matter formation impacting human health. In some of the products (2,3,4) fuel consumption, transport and packaging production are important contributors as well. Altogether they are responsible for up to 62% of the impact.

[16] "The rest" category in the graph, represents the rest of the activities responsible for the impact, grouped together.

4.3.2.15 Photochemical ozone formation

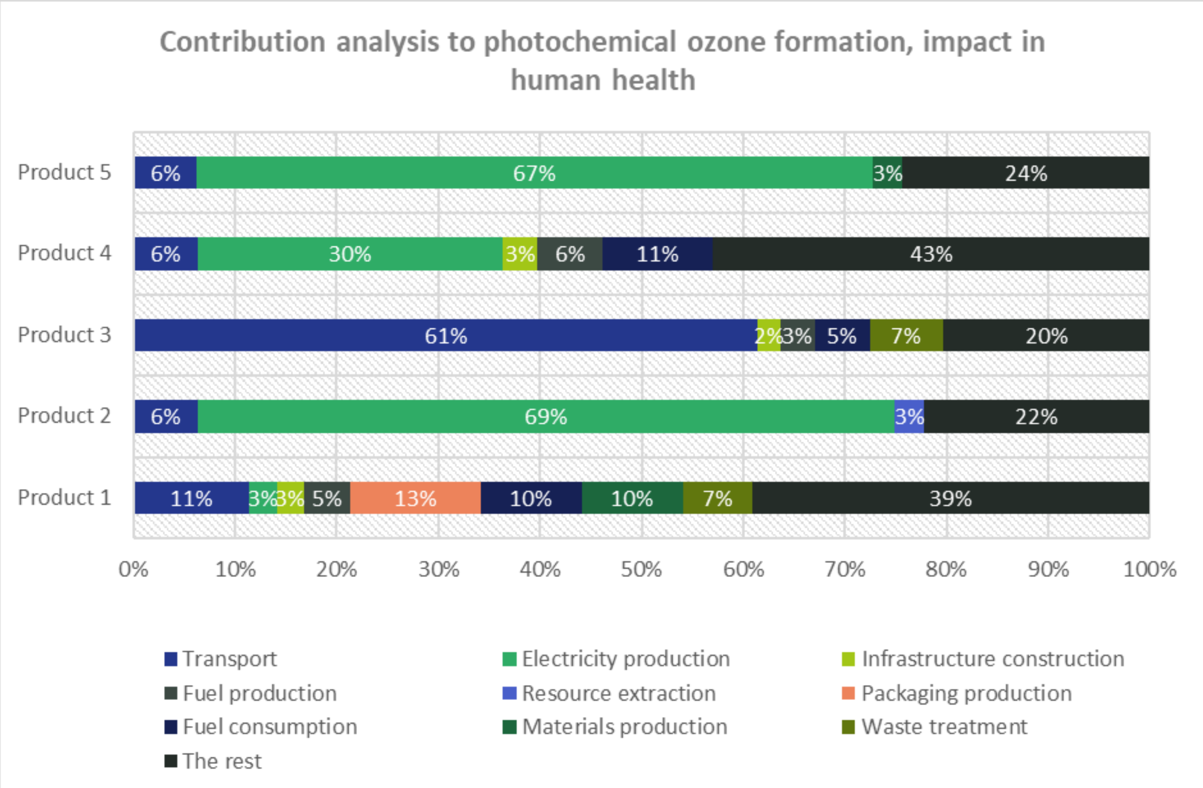

Figure 17. Contribution analysis to photochemical ozone formation, human health[17]

Electricity production and transport are the dominant stages that contribute the most to photochemical ozone formation responsible for up to 75% of the impact.

[17] "The rest" category in the graph, represents the rest of the activities responsible for the impact, grouped together.

4.3.2.16 Water depletion

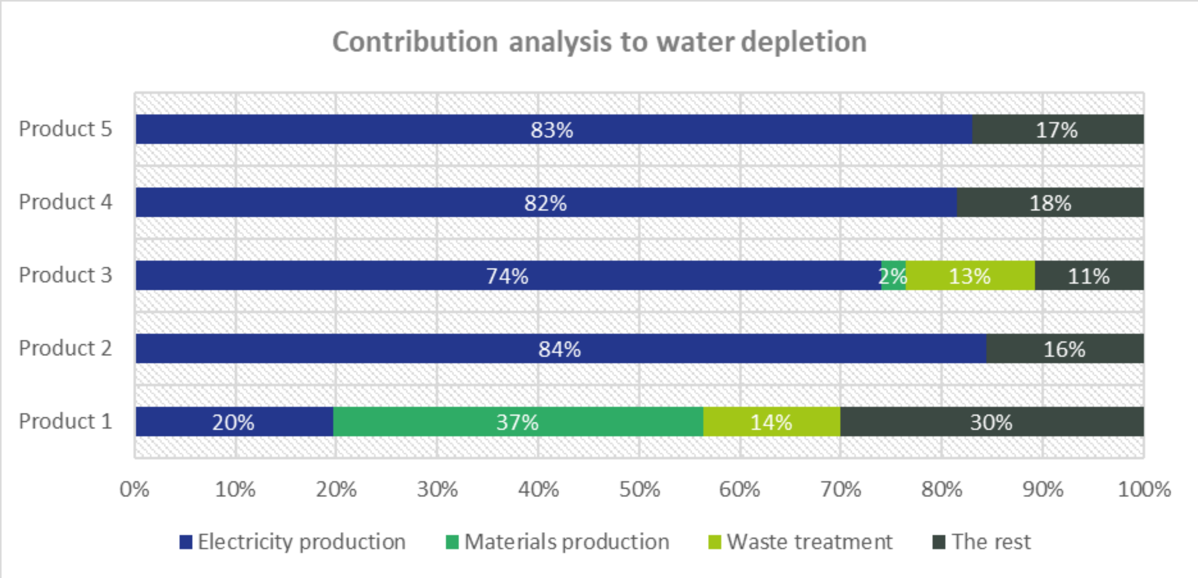

Figure 18. Contribution analysis to water depletion[18]

Electricity production is the dominant stage that contributes the most to water depletion followed by materials production and waste treatment responsible for 70%-89% of the impact.

[18] "The rest" category in the graph, represents the rest of the activities responsible for the impact, grouped together.

4.3.3 Sensitivity analysis

Based on the contribution analysis, the primary trend highlighted electricity production as one of the most important contributors across several impacts. These results were used to perform a sensitivity analysis for four out of five products. In this scenario we changed the electricity mix for all the foreground processes to entire supply through renewables. A second scenario that was tested was the reduction of travel distances (S2). After receiving the results, a comparison was made by calculating the % change from the baseline scenario presented in Table 12 and 13 below.

4.3.3.1 S1 - Changing electricity supply to renewable

Table 13. S1 - Changing electricity supply to renewable

	Product 1	Product 2	Product 3	Product 4
	% change in impact	% change in impact	% change in impact	% change in impact
acidification	-93%	-57%	-91%	-9%
climate change	-89%	-28%	-88%	-6%
ecotoxicity: freshwater	-76%	-32%	-70%	-4%
energy resources: non-renewable	-98%	-45%	-95%	-7%
eutrophication: freshwater	-89%	-61%	-87%	-8%
eutrophication: marine	-95%	-38%	-93%	-6%
eutrophication: terrestrial	-94%	-52%	-92%	-6%
human toxicity: carcinogenic	-58%	-20%	-54%	-1%
human toxicity: non-carcinogenic	-64%	-26%	-62%	-3%
ionising radiation: human health	-99%	-82%	-99%	-23%
land use	-90%	-20%	-83%	0%
material resources: metals/minerals	-5%	-3%	-5%	0%
ozone depletion	-93%	-13%	-81%	-2%
particulate matter formation	-81%	-15%	-73%	-2%
photochemical ozone formation: human health	-94%	-43%	-91%	-4%
water use	378%	124%	371%	16%

4.3.3.2 S2 - Reducing transportation distances by 50%

Table 14. S2 - Reducing transportation distances by 50%

	Product 1 % change in impact	Product 2 % change in impact	Product 3 % change in impact	Product 4 % change in impact
acidification	-18%	-0,44%	-17%	-34%
climate change	-27%	-1%	-33%	-12%
ecotoxicity: freshwater	-27%	-1%	-18%	-18%
energy resources: non-renewable	-27%	-1%	-23%	-43%
eutrophication: freshwater	-15%	-0,32%	-11%	-11%
eutrophication: marine	-14%	-1%	-12%	-40%
eutrophication: terrestrial	-21%	-1%	-13%	-40%
human toxicity: carcinogenic	-31%	-1%	-5%	-18%
human toxicity: non-carcinogenic	-27%	-1%	-15%	-14%
ionising radiation: human health	-9%	-0,16%	-14%	-44%
land use	-37%	-2%	-1%	-43%
material resources: metals/minerals	-23%	-1%	-23%	-5%
ozone depletion	-43%	-4%	-28%	-46%
particulate matter formation	-39%	-3%	-23%	-42%
photochemical ozone formation: human health	-25%	-1%	-14%	-42%
water use	-7%	-0,30%	-5%	-3%

4.4 Discussion and main takeaways

When summarizing the main contributors per impact category we get the following table[19]:

Table 15. Summary of the main contributors per impact category

	Electricity Prod.	Transp.	Waste treat.	Resource extraction	Materials prod.	Fuel prod.	Fuel cons.	Infra constr.	Packaging prod.
Acidification	√	√	√						
Climate change	√	√	√		√				
Ecotoxicity			√	√					
Energy resources depletion, non-renewable				√		√			
Eutrophication, freshwater			√						
Eutrophication, marine	√	√	√						
Eutrophication, terrestrial	√	√		√			√		
Human Toxicity, cancer; carcinogenic	√		√		√				
Human Toxicity, non-carcinogenic	√		√		√				
Ionising radiation, human health	√		√						
Land Use			√					√	
Minerals depletion				√					
Ozone depletion		√				√			
Particulate Matter Formation	√	√	√				√		√
Photochemical ozone formation,	√	√							

[19] This table summarizes the most important contributors in each impact category across all of the five products

human health									
Water use	√		√						

Out of sixteen impact categories, ten of them list electricity production, waste treatment and transport as their principal contributors. Of course, for the individual impact categories, other aspects may matter (e.g., energy resources, land use).

Electricity production stands out as a notable factor because a considerable portion of the production processes taken under study use electricity as their source of energy. Only one out of five products use 100% renewable electricity supply in their production process.

As for transportation, the results refer to the use of fossil-fuel based vehicles involved in the collection of inputs for the production processes or their product distribution in distances averaging 300-600 km.

The waste treatment activities refer to treating waste from mining activities, using spent fuels for electricity production or incineration/landfilling practices. For a complete list of the ecoinvent processes accounted for in these three life cycle stages, please consult tables 18, 19, 20 in the Appendix. For confidentiality purposes we cannot provide further details.

The sensitivity analysis displayed how changing the electricity mix reduces the environmental impact across fifteen impact categories. The biggest reduction potential is noticed in the first three products and especially with products 1 and 3. The analysis reveals potential production impacts reductions in the range of -54% to -99%. The only exception is minerals depletion impact where the reduction of impact does not surpass -5% while for water use the impact increases in the ranges of 16% to 378% across products. The notable increase of water use impact can be attributed to the electricity generated by hydropower included in the market mix that supplies renewable electricity in the ecoinvent database. If the government transitions to a 100% renewable electricity supply in the future, it is important for them to consider the potential risk of water depletion if they heavily depend on hydropower for electricity generation.

When testing the scenario with shorter travelling distances, the impacts improved across all categories and products. The highest improvement is noticed in product 1 and 4 followed by product 3 while product 2 shows modest improvement.

The main trends from the contribution and sensitivity analysis reported in this deliverable, highlight the importance to switch to a renewable electricity supply as well as find ways to become more efficient at logistics, reduce the transportation distances or use cleaner means of transportation. From the data collection process, it was noticed that a considerable amount of the transportation distances concern collection of waste inputs by the companies from different local suppliers pointing out the lack of collection points for certain waste streams. The existence of waste collection points for industrial use could shorten the transportation distances. Waste treatment is another important contributor for many impact categories across all products. From the data collection, we noticed that most of the companies would either incinerate their waste or send it for landfilling. Only in one of the cases would they sell their waste for reuse, eliminating the need to treat their waste.

Assessing six companies and their product is a small sample to represent the Aragon economy and this is one of the main limitations of this assessment. Nevertheless, these case studies serve as an example of a practice that is highly recommended to be reproduced for a bigger sample of companies across all the existing sectors of the Aragon economy whose objective is the transition to the circular economy.

Given the existence of confidentiality agreements, it is not possible to discuss in detail the specific results and potential improvement options per product. However, dedicated workshops will be arranged in July 2023 for all the assessed companies and the specific potential improvements for each of the products will be discussed.

5. Conclusions and recommendations

The region of Aragon in Spain has significant potential for a circular economy transition due to its diverse economic sectors, natural resources and the available data and awareness. In the Aragon region, agriculture plays a vital role, and the adoption of circular economy principles can lead to significant benefits. Additionally, Aragon has a well-established manufacturing industry, particularly in sectors such as automotive, machinery, and renewable energy. Embracing circular economy principles in manufacturing can involve adopting remanufacturing processes, promoting product repair and refurbishment, and implementing closed-loop material recycling systems. In times of global turmoil, circularity can also contribute to reducing vulnerability and dependencies due to global supply chains. The region has significant potential for renewable energy production, particularly in wind and solar power. Emphasizing the circular economy in the energy sector can involve developing efficient energy storage systems, promoting the reuse of components from decommissioned renewable energy installations, and integrating renewable energy systems with other sectors such as agriculture or industry.

The government of Aragon has demonstrated a continuous commitment to drive the transition towards circular economy by providing support, incentives, and regulations that promote sustainable practices across sectors and encourage collaboration among stakeholders. Some notable actions include the:

- Development of a Circular Economy Strategy (with 200+ institutions and companies committed to it), to guide and promote the pathway towards a circular economy outlining region's objectives, priorities, and actions to foster circular practices across sectors.
- Support for circular business models by providing financial support and incentives to businesses adopting circular business models as well as funding for research and development, innovation projects, and investment in circular economy infrastructure.
- Facilitating partnerships between businesses, research institutions, and public entities to promote knowledge sharing, exchange best practices, and foster innovation.
- Promoting circular procurement practices, which involve considering sustainability criteria and lifecycle impacts when procuring goods and services.
- Organization of workshops, training programs, and awareness campaigns to educate businesses, citizens, and students about the principles and benefits of the circular economy.

The activities developed by the Government of Aragon and the European Business and Innovation Centre of Aragon (CEEI) have as well contributed to the viability of the RESOURCE project. As of now, the RESOURCE Project has evaluated 24 projects out of which 13 were selected as the final list of pilots eligible to integrate into the project. These companies' activities focus on sectors such as: waste management and recycling, agriculture, energy, logistics, manufacturing, and environment.

In parallel with the selection of pilots for the project, additional work was implemented to enrich the existing list of KPIs currently being used by the region. The RESOURCE partners conducted a literature review and preselected 121 KPIs. These 121 KPIs were then presented to the stakeholders during the co-creation workshop that took place in March 2023. From the initial list of preselected KPIs, the participants in the workshop identified and selected 26 KPIs that were deemed the most important and relevant for the region.46.1% of them being environmental, 42.3% economic, 7.7% governmental and 3.9% technological. The lack of social KPIs in the final list highlights the need to try and guide the attention and learning efforts towards the social dimension as well as the significance and necessity of organizing more co-creation workshops as a means to familiarize diverse stakeholders.

Out of thirteen selected pilot projects, we were able to fully conduct six LCAs. Two companies initiated their involvement in December 2022, another two in January 2023, and the remaining companies joined the LCA assessment in April 2023. From the first selection phase resulting in five pilots, only three agreed to furnish data for the assessment. Despite signing confidentiality agreements, two of the companies were unwilling to share their data due to their technologies giving them a crucial competitive advantage, and their internal policies prohibited the disclosure of such information. Due to the late entry into the project of the pilots selected from the second phase, only three of them underwent assessment through the Life Cycle Assessment (LCA) method. The main trends from the LCA reported in this deliverable, highlight the importance to switch to a renewable electricity supply as well as find ways to reduce the transportation distances or use cleaner means of transportation in order to reduce the environmental impacts. Addressing waste treatment is equally important as it significantly contributes to various impact categories across all products. Assessing six companies and their product is a small sample to represent the Aragon economy and this is one of the main limitations of this assessment. Nevertheless, the case studies serve as an example of a practice that is highly recommended to be reproduced for a bigger sample of companies across all the existing sectors of the Aragon economy whose objective is the transition to the circular economy.

Following the performed work for Task 2.1, we have compiled a few recommendations for the Aragon region that we believe are going to further facilitate the implementation of their Circular economy strategy.

5.1 Recommendations concerning Aragon authorities

- Consider conducting a comprehensive quantification and analysis of the inflows and outflows within the 1500 local companies that hold potential for transitioning towards a circular economy. This mapping process will provide a thorough understanding of the circular synergies that can be established, where one company's waste could become a valuable resource for another company's production processes. By creating a clear picture, the government can identify and leverage opportunities for circular collaborations among these companies.
- Consider combining the above mapping exercise with a benchmarking analysis with other EU countries, to foster entrepreneurship in emerging sectors derived from the Circular Economy. Implementing such exercise would enable an understanding of the activities that are already present and what can be developed. With a clearer picture of the gaps and untapped potential, the Aragon government can strategically drive investments in underdeveloped sectors, thereby promoting the growth of the circular economy.
- Consider conducting periodic surveys at regular intervals to understand the extent of awareness and comprehension among the local companies with regard to the existing online calls for funding, training, and networking opportunities. By leveraging the outcomes of these surveys, it will be possible to enhance the visibility of these opportunities according to the identified needs.
- Consider the generated table that outlines the specific selection criteria RESOURCE employed to evaluate the companies and their potential for transitioning to a circular business model.
- For efficient monitoring of the Circular Economy Transition across the region, it is advisable to incorporate into the existing KPIs, the chosen Key Performance Indicators (KPIs) from Task 2.1. To ensure effectiveness, companies' voluntary participation in annual data reporting aligned with these KPIs would be beneficial. The report does not have to be public and specify company names. This approach allows for future utilization and integration of the selected KPIs in the monitoring process.
- Given the existing challenges in implementing the LCA method stemming from data sensitivity and the subsequent lack of cooperation from almost half of the pilots, it becomes increasingly vital for the future to prioritize the development of new systems or formats that facilitate collaboration and progress between companies and scientific consultancies.
- To effectively showcase the value of RESOURCE's methodology, it is worth considering the implementation of anonymous surveys to the pilots that are participating in the project. These surveys should be conducted at the project's conclusion, aiming to understand and highlight the added value that the project has brought to the participating companies. The feedback collected can serve two

important purposes: demonstrating the benefits to non-participating companies and potentially encouraging other regions to replicate the successful methodology.

5.2 Recommendations concerning RESOURCE pilots

- Overall, in order to improve the environmental performance of the companies it is advisable to focus on:
    - Switching to a renewable electricity supply.
    - Promote and support cleaner transportation modes and/or shorten commuting distances.
        - An important aspect to consider would be to proactively assess their supply chain practices and consider working with local suppliers as much as possible.
    - Focus on improving waste management systems.
- Consider the adoption of Circular Economy KPIs aligned with those used by the government. Aligning KPIs with public authorities may:
    - Ensure that the private sector meets regulatory requirements related to the circular economy.
    - Help companies qualify and gain access to financial incentives, technical assistance, and networking opportunities.
    - Demonstrate a company's commitment to sustainability and responsible business practices that may enhance the company's reputation and market positioning, especially among environmentally conscious consumers, investors, and partners.
    - Foster collaboration between the private sector and public authorities. It may create opportunities for dialogue, knowledge sharing, and joint initiatives to drive circular economy practices forward. Collaborative efforts can result in shared research, access to expertise, and the pooling of resources, which can accelerate innovation, problem-solving, and the adoption of sustainable practices.
- It is essential for companies to provide regular training to their staff members on matters related to the circular economy. Training can help in:
    - Ensuring that companies stay informed about evolving regulations and standards related to environmental sustainability.
    - Creating opportunities for networking and collaboration among local companies. This networking can lead to collaborations on joint projects, shared resources, and knowledge exchange, fostering a collective approach to addressing sustainability challenges.
    - In addition to this, by demonstrating commitment to sustainability through training and implementing circular practices, companies can attract environmentally conscious customers, investors, and employees.

6. ANNEX: Additional data from the LCA

Table 16. LCA data collection template, part I

PRELIMINARY INFORMATION	(PLEASE FILL IN THE REQUIRED INFORMATION BELOW)
Company name	
Contact point for the LCA study	Name: Function: Contact details:
What is your product(s)/service(s) and its function?	*(Please describe your product(s) or service(s) to be taken under analysis as well as its function, purpose.)*
Have you ever had an LCA assessment done for your product/service? If yes, when?	
Please insert a "+" in all the statements below that may apply to your case	
We would be interested to get a first impression of the environmental impacts of our product/service and identify the hotspots for improving the environmental performance	
We would be interested to assess the environmental impact of product improvements, product development or technical innovations	
We would be interested to compare the environmental impacts of a few different products/services that have the same function	
List of processes	*(Please provide a list of all the processes included in the production of your product/provision of your service)*
Visualize your list of processes in a flowchart (see example below)	

Table 17. LCA data collection template, part II

PROCESS #1				
DATA NEEDS		**UNIT (please insert the unit)**	**AMOUNT**	**ADDITIONAL COMMENTS**
Name of the process	*(please fill in the name of the process)*	N/A	N/A	
Description of the process	*(please describe what happens during this process)*	N/A	N/A	
Purpose/Function of this process/step	*(please describe why is this step necessary in the overall production process of your product or provision of your service? What is its purpose/function?)*	N/A	N/A	
Synthesis route	*(This field needs to be filled in the case of chemical reactions. If applicable please enter the equations of the reaction(s) that take place. If there is more than one, please add them in separate rows)*	N/A	N/A	
Name of the output(s) of this process	*(please fill in the name(s) of this process' output(s)). If there is more than one, please add them in separate rows)*	*(please insert the unit)*	*(please insert the amount of output produced per unit of the main product OR in monthly/yearly amounts)*	
Year	*(Please provide which year do the data below represent)*	N/A	N/A	
Location	*(Please provide the name of the country(ies) the data originate from)*	N/A	N/A	
INPUTS	**MATERIALS (If applicable, please list the materials that are used for this process)**	**UNIT (please insert the unit)**	**AMOUNT (please insert the amount of material used for this process per unit of output OR in monthly/yearly amounts)**	**ADDITIONAL COMMENTS**
Materials	Material #1			
	Material #2			
	Material #3			
	…			
	…			
	…			
INPUTS	**ENERGY (If applicable, please list the forms of energy that are used by this process, e.g. heat, electricity et cetera)**	**UNIT (please insert the unit)**	**AMOUNT (please insert the amount of energy used for this process per**	**ADDITIONAL COMMENTS**

			unit of output OR in monthly/yearly amounts)	
Energy				
INPUTS	**SERVICES (If applicable, please list the services that are used during this process, e.g. transportation)**	**UNIT (please insert the unit)**	**AMOUNT (please insert the amount of service used for this process per unit of output OR in monthly/yearly amounts)**	**ADDITIONAL COMMENTS**
Services				
INPUTS	**GOODS (If applicable, please list the goods that are used during this process)**	**UNIT (please insert the unit)**	**AMOUNT (please insert the amount of good used for this process per unit of output OR in monthly or yearly amounts)**	**ADDITIONAL COMMENTS**
Goods	Good #1			
	Good #2			
	Good #3			
	…			
INPUTS	**WASTE (If applicable, please list the types of waste used during this process)**	**UNIT (please insert the unit)**	**AMOUNT (please insert the amount of waste used for this process per unit of output OR in monthly/yearly amounts)**	**ADDITIONAL COMMENTS**
Waste	Waste type #1			
	Waste type #2			
	Waste type #3			
	…			
INPUTS	**ENVIRONMENTAL RESOURCES (If applicable, please list the environmental resources used during this process)**	**UNIT (please insert the unit)**	**AMOUNT (please insert the amount of env. resource used for this**	**ADDITIONAL COMMENTS**

			process per unit of output or in monthly/yearly amounts)	
Abiotic resources (e.g. water, air, sunlight, soil, minerals, fuels, oxygen, et cetera)	…			
	…			
	…			
	…			
Biotic resources (e.g. forests, animals, birds, fish, marine organisms)				
Land occupation				
Land transformation				
OUTPUTS	**MATERIALS (If applicable, please list the materials produced by this process)**	**UNIT (please insert the unit)**	**AMOUNT (please insert the amount of material produced for this process per unit of output OR in monthly/yearly amounts)**	**ADDITIONAL COMMENTS**
Materials	Material #1			
	Material #2			
	Material #3			
	…			
	…			
	…			
OUTPUTS	**ENERGY (If applicable, please list the forms of energy produced by this process, e.g. heat, electricity et cetera)**	**UNIT (please insert the unit)**	**AMOUNT (please insert the amount of energy produced for this process per unit of output OR in monthly/yearly amounts)**	**ADDITIONAL COMMENTS**
Energy				
OUTPUTS	**SERVICES (If applicable, please list the services that are provided by this process)**	**UNIT (please insert the unit)**	**AMOUNT (please insert the amount of service produced for this process per unit of output OR in monthly/yearly amounts)**	**ADDITIONAL COMMENTS**
Services				

OUTPUTS	**GOODS (If applicable, please list the goods produced by this process)**	**UNIT (please insert the unit)**	**AMOUNT (please insert the amount of good produced for this process per unit of output OR in monthly or yearly amounts)**	**ADDITIONAL COMMENTS**
Goods	Good #1			
	Good #2			
	Good #3			
	…			
OUTPUTS	**WASTE (If applicable, please list the types of waste produced by this process)**	**UNIT (please insert the unit)**	**AMOUNT (please insert the amount of waste produced for this process per unit of output OR in monthly/yearly amounts)**	**ADDITIONAL COMMENTS**
Waste	Waste type #1			
	Waste type #2			
	Waste type #3			
	…			
OUTPUTS	**EMISSIONS (If applicable, please list the process emissions)**	**UNIT (please insert the unit)**	**AMOUNT (please insert the amount of emissions produced for this process per unit of output or in monthly/yearly amounts)**	**ADDITIONAL COMMENTS**
Chemicals to air				
Chemicals to soil				
Chemicals to water				
Radionuclides				
Waste heat et cetera				
…				
…				

Table 18. List of processes included in the electricity production life cycle stage

ecoinvent processes
electricity production, hard coal, at coal mine power plant
Electricity production, treatment of blast furnace gas, in power plant
heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014
electricity production, oil
electricity production, nuclear
electricity production, nuclear, boiling water reactor
electricity production, natural gas, combined cycle power plant
electricity production, lignite
electricity production, hydro, reservoir, non-alpine region
electricity production, hard coal

Table 19. List of processes included in the transportation life cycle stage

ecoinvent processes
transport, freight train, diesel
transport, freight, lorry >32 metric ton, EURO3
transport, freight, lorry >32 metric ton, EURO4
transport, freight, lorry 16-32 metric ton, EURO3
transport, freight, lorry 16-32 metric ton, EURO4
transport, freight, lorry 3.5-7.5 metric ton, EURO6
transport, freight, lorry 7.5-16 metric ton, EURO3
transport, freight, sea, bulk carrier for dry goods
transport, freight, sea, tanker for petroleum
transport, pipeline, onshore, long distance, natural gas

Table 20. List of processes included in the waste treatment life cycle stage

<table>
<tr><th>ecoinvent processes</th></tr>
<tr><td>treatment of copper slag, residual material landfill</td></tr>
<tr><td>treatment of drilling waste, landfarming</td></tr>
<tr><td>treatment of electric arc furnace slag,</td></tr>
<tr><td>treatment of hard coal ash</td></tr>
<tr><td>treatment of low-level radioactive waste</td></tr>
<tr><td>treatment of spent nuclear fuel</td></tr>
<tr><td>treatment of spoil from hard coal mining</td></tr>
<tr><td>treatment of sulfidic tailings, from copper mine operation</td></tr>
<tr><td>sulfidic tailings, from copper mine operation | treatment of sulfidic tailings, from copper mine operation, tailings impoundment | PE | kilogram | cutoff38</td></tr>
<tr><td>treatment of tailing, from uranium milling</td></tr>
<tr><td>treatment of uranium tailing, non-radioactive emission</td></tr>
<tr><td>treatment of waste polyvinylchloride, open burning</td></tr>
<tr><td>treatment of wood ash mixture, pure, landfarming</td></tr>
</table>

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