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epa Research

Artificial Intelligence as an Enabler of the Circular Economy

Authors: Enya O'Connell-Hussey, Veena Grace Thomas, Valentina Rangel Leon, Carlos Garcia, David McCormack and Geraldine T. Brennan

Lead organisation: Irish Manufacturing Research

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3. Office of Evidence and Assessment
4. Office of Radiation Protection and Environmental Monitoring
5. Office of Communications and Corporate Services

The EPA is assisted by advisory committees who meet regularly to discuss issues of concern and provide advice to the Board.

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What did this research aim to address?

Artificial intelligence (AI) and the circular economy (CE) are increasingly on the agenda for both businesses and the public sector, yet these concepts are often explored separately. There is an intersection between business needs and CE goals that can be enabled by AI, which remains largely untapped in Ireland. The Artificial Intelligence for the Circular Economy (AI4CE) research project explored how AI could enable CE implementation in Irish businesses and aimed to:

identify potential opportunities for using AI in Irish industry to prevent or reduce waste generation and material, water and energy use;

identify barriers to and enablers of the wider implementation of AI technologies for circularity in Irish industry, with a particular focus on cross-sectoral manufacturing;

develop a portfolio of AI4CE case studies and policy recommendations for using AI in CE implementation within Irish industry.

The AI4CE project used a variety of approaches to achieve its aims. The overarching methodology focused on engaging key stakeholders (members of Irish industry) to explore the intersection of AI and the CE and provide insights and inputs into the project outputs.

What did this research find?

The AI4CE research project concluded, from desk-based research and stakeholder engagement, that Irish industry is largely unaware of AI's potential for enabling circularity. While Ireland's rate of adoption of AI surpasses the EU average, its application of AI to circularity remains in the early stages and is primarily limited to the waste management and recycling sectors.

Reported barriers to manufacturers adopting AI for CE purposes include limited awareness of AI and CE synergies, financial constraints (particularly for small and medium-sized enterprises), lack of data and data governance systems, shortages of skills, and organisational resistance to change.

Key insights and recommendations from the AI4CE project include:

- Utilisation of AI as an enabler of the CE will require investment in collaboration, knowledge sharing, training and education, and AI infrastructure.
- Industry adoption of AI for CE implementation will hinge on there being a good business case (e.g. creating new revenue streams, reducing costs/waste, increasing production efficiency).
- Policymakers should provide guidance to industry to help it follow scientifically supported best practices when using AI for CE implementation and implement AI effectively as an enabler of the CE.
- Collaboration between government departments and public entities responsible for AI and CE legislation, regulation and market surveillance should be encouraged to ensure alignment at the intersection of AI and the CE.

How can the research findings be used?

To support the development of AI as a key enabler of the Irish CE, the research project developed the following resources for policymakers and Irish industry professionals considering adopting AI and CE practices into their business:

- The AI4CE Decision Support Tool, to enable industry to explore how AI could support businesses' CE goals through a selection of case studies relevant to their needs and interests.
- The AI4CE – Best Practice & Policy Guide, to help industry stakeholders and policymakers understand the core concepts behind AI and the CE and give guidance on how the two can work together. It also details the relevant Irish and EU regulations and legal considerations regarding AI and the CE.
- The AI4CE – Status and Use of AI for Circular Economy in Ireland report, which summarises insights into industry's usage of AI in the context of scaling up the CE. It is intended for those who are interested in the opportunities at the intersection of the concepts of AI and circularity.

Project code: 2021-GCE-1065

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DISCLAIMER

This report is based on research carried out/data from April 2022 to August 2024. More recent data may have become available since the research was completed.

The EPA Research Programme addresses the need for research in Ireland to inform policymakers and other stakeholders on a range of questions in relation to environmental protection. These reports are intended as contributions to the necessary debate on the protection of the environment.

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Executive Summary

Artificial intelligence (AI) and the circular economy (CE) are increasingly on the agenda for both businesses and the public sector, yet these concepts are often explored separately. AI technology has strong potential for aiding circular practices through tasks like material sorting, predictive maintenance, resource optimisation and circular product design. There is an intersection between business needs, like reducing production costs, and CE goals, like waste elimination, that can be enabled by AI which remains largely untapped in Ireland.

This report summarises the objectives, deliverables and insights from the EPA-funded project "Artificial Intelligence for the Circular Economy" (AI4CE). The 28-month project explored how AI could enable CE implementation in Irish industry. Barriers to, risks of and opportunities and motivations for adopting AI technology for CE purposes were explored through multi-sectoral industry stakeholder engagement. The insights were disseminated through four publicly available deliverables/artefacts (available on the Irish Manufacturing Research website's AI4CE project page), namely the *AI4CE Decision Support Tool*, *AI4CE – Case Study Report*, *AI4CE – Status and Use of AI for Circular Economy in Ireland* and *AI4CE – Best Practice & Policy Guide* (the final of which was the result of a joint collaboration with the EPA-funded CircAI team at Maynooth University). All these deliverables have been tailored for both industry and public sector audiences. In addition, the project team is continuing to evolve a co-authored academic paper led by the CircAI project team at Maynooth University (Pathan *et al*., 2024).

In an Irish context, industry use of AI is relatively nascent. That said, AI usage reported by Irish manufacturers stands at 7.2% – slightly above the EU average of 6.8%. While firms use AI for a variety of business applications, the primary motivation and driver of digital transformation investments is enhancing process efficiency and continuous improvement, rather than explicitly achieving sustainability or CE goals. The AI4CE project's desk-based research and stakeholder engagement suggest that Irish industry is largely unaware of AI's potential for enabling circularity. Moreover, AI deployment in the context of circularity is primarily occurring in the waste management and recycling sectors and is in the very early stages in manufacturing and other industrial sectors of the economy. Reported barriers to manufacturers adopting AI for CE purposes include limited awareness of AI and CE synergies, financial constraints (particularly for small and medium-sized enterprises), lack of data and data governance systems, shortages of skills and organisational resistance to change. Societal and ethical concerns were acknowledged by Irish stakeholders but were ranked as less of a priority than other concerns.

Key insights and recommendations from the AI4CE project include the following:

- Utilisation of AI as an enabler of the CE will require **investment in collaboration**, **knowledge sharing**, **training** and **education** (particularly through the use of case studies) and for firms to invest in AI infrastructure (i.e. data collection and management systems). It is also important to highlight that **industry adoption of AI for CE implementation will hinge on there being a good business case** – be it creating new revenue streams, reducing costs or waste, increasing production efficiency or ensuring regulatory compliance.
- For policymakers, providing **detailed guidance for industry** could help to ensure that scientifically supported best practices are followed when using AI for CE implementation. This could include developing codes of practice and standards to help businesses understand and implement AI effectively in the context of the CE. **Collaboration between government departments and public entities** responsible for AI and CE legislation, regulation and market surveillance (e.g. the Department of Enterprise, Trade and Employment, Department of Climate, Energy and the Environment, Enterprise Ireland and the EPA) should be encouraged, to ensure alignment and pre-empt bottlenecks that may arise at the intersection of AI and the CE to maximise optimal outcomes.

The findings from this research highlight that AI has a key role to play in accelerating the deployment of industry-oriented CE practices, business models and solutions needed to achieve Ireland's circularity ambitions. AI could assist Ireland in achieving its goals of becoming a test bed for circularity by 2030 and meeting binding 2030 and 2050 climate targets. With a CE transition being highlighted as imperative to European competitiveness and a successful EU single market, AI should be considered a tool in the CE implementation architecture.

1 Introduction

The circular economy (CE) and artificial intelligence (AI) are gaining momentum in industry and policy forums. Interest is driven by the combination of the emergence of advanced technologies, more regulations seeking to drive environmental impact and climate goals becoming embedded in industrial policy. However, the level of awareness within Irish industry and the public sector of these two concepts is low and practices for implementing them remain largely siloed. The Artificial Intelligence for the Circular Economy (AI4CE) project explored these two concepts with particular emphasis on how AI can be leveraged by policymakers and businesses to enable and accelerate industry-oriented circular implementation in Ireland.

1.1 Demystifying the Circular Economy

The CE is an economic model that seeks to maintain circular stocks and flows of resources by recovering, retaining or adding to their value while contributing to sustainable development (ISO, 2024a). It is focused on eliminating waste, maximising the lifespan of resources and reducing the extraction of resources. If CE strategies were applied to just four key industrial materials (cement, steel, plastic and aluminium), global greenhouse gas emissions could be reduced by 40% by 2050 (Ellen MacArthur Foundation, 2019).

However, the CE is still relatively emergent in Ireland. This is illustrated by Ireland's "circular material use rate" (CMUR) ranking, which is a key EU indicator used to compare the progress of EU Member States. The CMUR measures the share of used material resources that come from recovered and recycled waste materials (EPA, 2022a; Eurostat, 2022).

In Ireland, the CMUR is just 1.6% (Eurostat, 2022) (Figure 1.1). This is well below the EU average of 11.6%. Ireland's CMUR has hovered around 2% for over 10 years (Eurostat, 2022). There has been recent research suggesting that Ireland's CMUR is underestimated by up to 2.4% due to methodological inconsistencies in waste categorisation across countries (McCarthy *et al*., 2024). Regardless, Ireland is not on track to realise its ambition to have an above-average CMUR by 2030.

Key barriers to the CE in Ireland include lack of data, regulatory barriers, financial costs of initiatives, behavioural barriers and operational hurdles (EPA, 2022a,b).

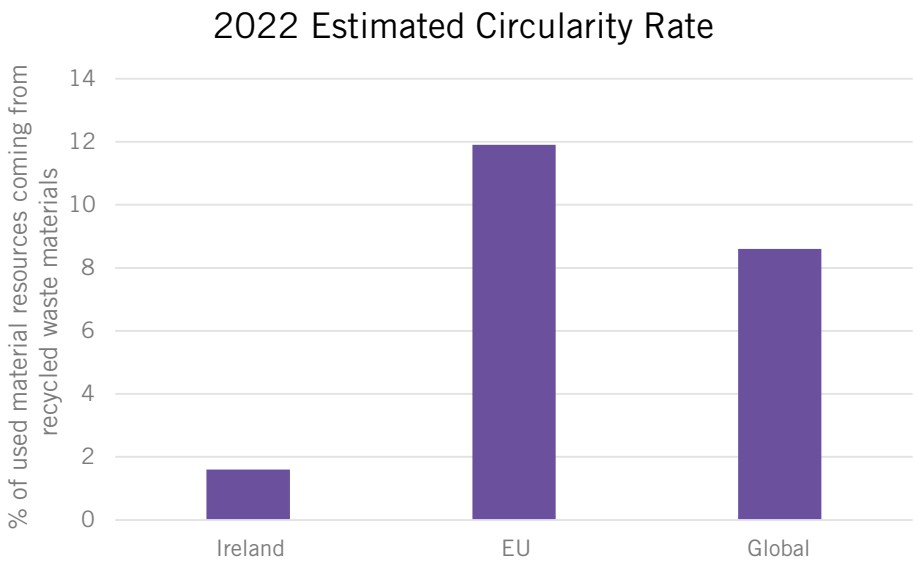

Figure 1.1. Estimated circularity rate for Ireland, the EU and globally for 2022. Based on data obtained from EPA (2022a) and Eurostat (2022).

1.2 Demystifying Artificial Intelligence

Artificial intelligence, commonly known as AI, is a term heard more and more frequently in today's technology landscape; however, the complexities involved perplex many. AI is a branch of computer science and technology dedicated to developing the theories, methods, algorithms and applications for simulating and extending human intelligence (Deng, 2018).

The core components of AI include machine learning (ML), deep learning, natural language processing, robotics and computer vision, and generative AI (Figure 1.2). ML uses algorithms to learn from data and make decisions. Deep learning is a subset of ML that focuses on neural networks with many layers. Natural language processing allows machines to understand and respond to human language. Robotics and computer vision enable machines to perceive their environment and act autonomously. Generative AI creates new content based on trained data, useful for creative industries and advanced conversational agents.

1.3 Status of Artificial Intelligence for Circular Economy Adoption in Ireland

The use of AI in Irish manufacturing is still nascent but the rate of use is higher than the European average. Within the Irish manufacturing sector (defined by Eurostat as activities that physically or chemically transform materials), 7.2% of firms use AI (with a breakdown by type of application shown in Figure 1.3), compared with the EU average of 6.8% (Eurostat, 2023). This figure includes firms that use one or more of the following functions of AI: analysing written language (text mining); text-to-speech technology; generating written or spoken language (natural language generation); identifying objects or people based on images (image recognition and image processing); ML for data analytics; automating workflows and assisting in decision-making (process automation); and autonomous movement of machines based on observations of surroundings (autonomous robots, drones and vehicles) (Eurostat, 2023).

If we consider AI to be a subset of digitalisation, we can examine some of the current trends and attitudes in the manufacturing sector regarding digital and AI technologies. In 2023, 7 in 10 manufacturing firms considered digitalisation a top priority (Ibec, 2023). The main reasons Irish firms are investing in digitalisation are for increased efficiency, continuous improvement and cost reduction (Ibec, 2023). Irish firms are generally investing in digitalisation (and, as a subset, AI) for process efficiency and continuous improvement, rather than specifically for sustainability and CE implementation.

This is consistent with findings from outside Ireland, which show that, although manufacturing and supply chain businesses are under pressure to become more sustainable, less than 5% of technology budgets

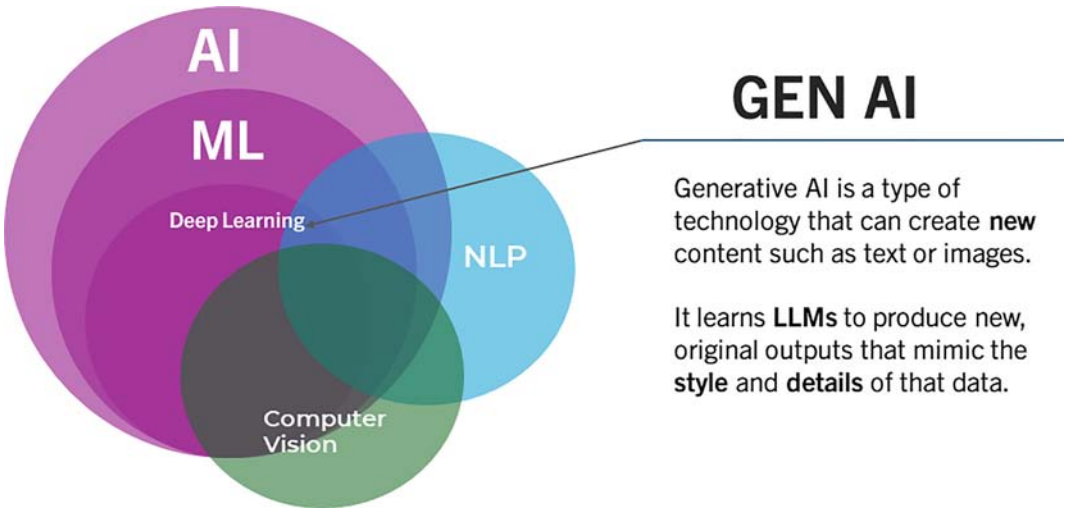

Figure 1.2. General AI technology families. GEN AI, generative artificial intelligence; LLM, large language model; NLP, natural language processing. Source: *AI4CE – Best Practice & Policy Guide* (IMR, 2024a).

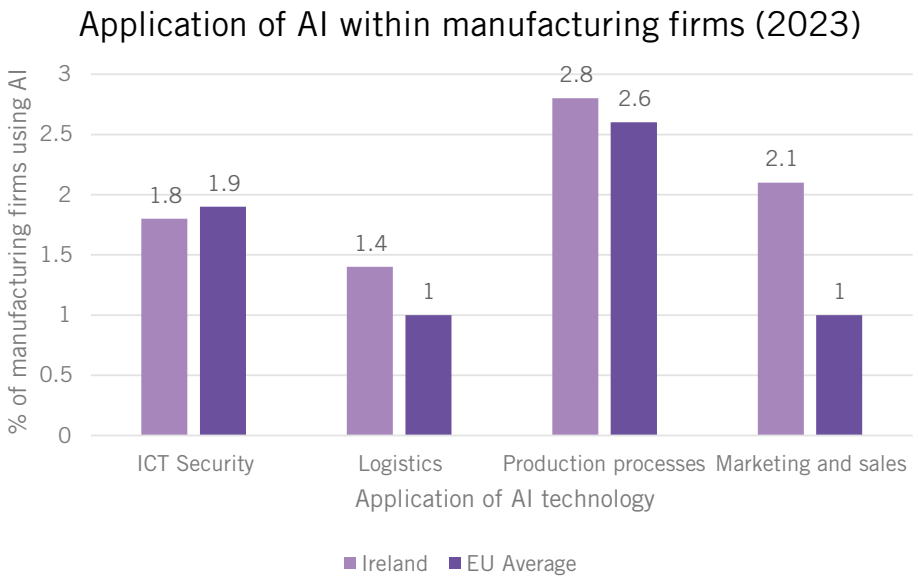

Figure 1.3. Application of AI technologies within manufacturing firms in 2023. ICT, information and communications technology. Based on data obtained from Eurostat (2023).

are allocated specifically to delivery of sustainability solutions (Avery Dennison, 2022).

AI is primarily utilised in the waste management and recycling sectors in Ireland. Key examples of companies using AI in these sectors include FPD Recycling, which employs AI-driven sorting technology, and AMCS, which uses computer vision for waste management. Using AI for CE activities in other sectors is in the early stages and is not widespread. The full potential of using AI for CE purposes is yet to be realised.

1.4 Policy Context for Artificial Intelligence and the Circular Economy in Ireland

The CE and AI are rapidly evolving concepts in the policy landscape. The transition to a CE is promoted by numerous European and national environmental policies due to its importance in contributing to climate action targets. At the same time, the rapid development of AI has led the EU to seek a harmonised legal framework that fosters AI development while protecting individuals and society (European Union, 2024a).

At the European level, the CE is central to the European Green Deal, that is, the European strategy for achieving climate neutrality by 2050 (European Commission, 2019). One key EU initiative is the new Circular Economy Action Plan, which emphasises that decoupling economic growth from resource use and shifting to circular systems of production and consumption are essential for meeting EU climate goals (European Commission, 2020). The plan aims to make sustainability products the norm, reduce the consumption footprint and harness the potential of digital technologies such as AI, big data and blockchain to accelerate circularity (European Commission, 2020). Transitioning to a CE has been highlighted in recent reports as key to a successful EU single market and European competitiveness (Draghi, 2024; Letta, 2024)

The European Union has made progress on several of the initiatives included under the new Circular Economy Action Plan and the European Green Deal, supporting the transition to a CE, and Figure 1.4 summarises some of the CE-related regulatory drivers being implemented. Key actions include cross-sectoral measures, such as the Ecodesign for Sustainable Products Regulation (ESPR) (Regulation (EU) 2024/1781), which promotes circular design by establishing new performance requirements (European Union, 2024b). Similarly, the Corporate Sustainability Reporting Directive (CSRD) (Directive (EU) 2022/2464), encourages reporting on circularity (European Union, 2022). Other initiatives include the Right to Repair Directive (Directive (EU) 2024/1799) (European Union, 2024c) and the Empowering Consumers in the Green Transition

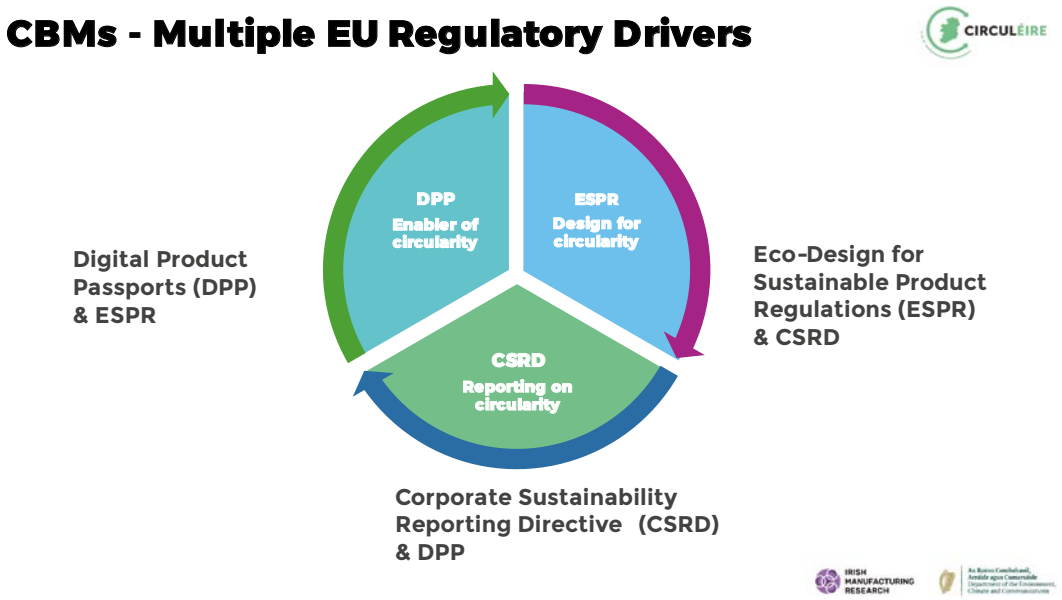

Figure 1.4. Visualisation of CE-related regulatory drivers in the context of circular business models (CBMs). Source: Brennan (2024).

Directive (Directive (EU) 2024/825) (European Union, 2024d). Additionally, sector-specific measures like the Batteries and Waste Batteries Regulation (Regulation (EU) 2023/1542) (European Union, 2023) and the revision of the Packaging and Packaging Waste Regulation will further support this effort. The text of the Packaging and Packaging Waste Regulation has been agreed on by the European Council and European Parliament and was published in the *Official Journal of the European Union* in January 2025 (European Union, 2025).

In line with European commitments, the Irish Government has pledged to achieve net-zero carbon emissions by 2050 and a 51% reduction in emissions by 2030 (European Parliament, 2023). Its Climate Action Plan 2021 outlines the roadmap, which includes a dedicated section on the CE, featuring specific targets and actions that are reviewed and updated annually (Government of Ireland, 2021a).

In December 2021, the Irish Government published the Whole of Government Circular Economy Strategy 2022–2023, the country's first national strategy designed to establish a policy framework for transitioning to a CE across all sectors and levels of government (Government of Ireland, 2021b). In 2022, the Circular Economy and Miscellaneous Provisions Act was signed into law, placing the CE strategy on statutory footing and defining the CE concept for first time in Irish law (Government of Ireland, 2022). This means that developing CE policy has become a legal requirement for the government (Government of Ireland, 2021b).

Other relevant policies supporting the transition to a CE in Ireland include the National Waste Management Plan for a Circular Economy, which recognised circularity as a key driver and uses the circularity rate as an indicator (Regional Waste Management Planning Offices, 2024). Additionally, the Green Public Procurement Strategy and Action Plan 2024–2027 identifies green procurement as a key tool for helping Ireland become a more resource-efficient CE (Government of Ireland, 2024a).

The end-of-waste and by-product regulations are key components of waste management and resource efficiency policy in Europe. The EU Waste Framework Directive (Directive 2008/98/EC) provides the legal basis for these regulations (European Union, 2008). In Ireland, these concepts were incorporated into law through the European Communities (Waste Directive) Regulations (S.I. No.126/2011) (Government of Ireland, 2011), with Article 27 addressing by-products and Article 28 focusing on end of waste. The EPA in Ireland is responsible for making decisions regarding by-products and end of waste (Government of Ireland, 2020a,b). On 11 September 2024, the Department of the Environment, Climate and Communications (now the Department of Climate, Energy and the Environment) launched a public consultation on a

draft regulation aimed at amending the end-of-waste application and decision-making process. This proposed regulation seeks to streamline the process, by encouraging more applications by industry; more information is available on the Government of Ireland website (Government of Ireland, 2024b).

In terms of AI, its rapid development has prompted European policymakers to quickly advance a legal framework that encourages AI development while protecting individuals' fundamental rights and societal values. The EU AI Act (Regulation (EU) 2024/1689), which entered into force in August 2024, is the first legal framework governing the development, marketing and use of AI within the EU, and it focuses on a risk-based approach. This regulation supports the European objectives of promoting a human-centric approach to AI and establishing the EU as a global leader in AI (European Union, 2024a).

Additionally, the EU AI Act includes a provision for the publication of a code of practice for general-purpose AI (GPAI) model providers, addressing key areas such as transparency and risk management. This code will assist GPAI providers in complying with the act and is expected to be completed by April 2025. The European Commission invited experts and GPAI providers to contribute to its development in 2024. Furthermore, the AI Office has initiated a multi-stakeholder consultation on trustworthy GPAI models to gather feedback on the code's content (European Commission, 2024).

At a national level, in 2021 the Irish Government published *AI – Here for Good: A National Artificial Intelligence Strategy for Ireland.* The strategy is built on three key principles: adopting a human-centric approach to the application of AI; remaining open and adaptable to new innovations; and ensuring good AI governance to foster innovation. The strategy's main objective is structured around three key pillars: (i) building public trust in AI; (ii) leveraging AI for economic and social benefits, including using AI to help address societal challenges such as climate action; and (iii) enabling AI through creating a supportive environment and strong ecosystem for AI innovation, research and development (Government of Ireland, 2021c).

The Irish Government published a refreshed version of that strategy on 6 November 2024, reflecting developments in AI technology and regulations since the strategy was first published (Government of Ireland, 2024c).

Furthermore, and as a specific connection point between AI and CE policy, the strategy highlights that data centres in Ireland will be encouraged and supported to integrate CE principles, as required by the EU ESPR standards.

2 AI4CE Project Overview, Objectives and Approach

2.1 Project Overview

The AI4CE project was an EPA-funded translational applied research project led by Irish Manufacturing Research's (IMR's) data analytics and CE teams. The aim was to investigate how AI could enable a CE in Irish industry, and the project ran from April 2022 to August 2024.

2.2 Project Objectives

- Identify potential opportunities for using AI in Irish industry to reduce the amounts of or eliminate the materials, water and energy ending up as waste by companies.
- Identify the barriers to and success factors for the wider implementation of AI technologies for circularity in Irish Industry, with a particular focus on cross-sectoral manufacturing.
- Conduct a literature review of current AI technologies and their potential CE applications. Use these insights to provide Irish industry with best practice examples for using AI for CE strategies.
- Develop a portfolio of case studies to showcase current examples of AI being used for CE implementation.
- Develop policy recommendations for using AI in CE implementation within Irish industry.
- Disseminate findings to key stakeholders within the Irish innovation ecosystem (e.g. the public sector and cross-sectoral industry).

These objectives were achieved over the project lifespan. The project outcomes are detailed in Figure 2.1.

2.3 Research Limitations

The AI4CE project was constrained by the paucity of publicly available data and information regarding the use of AI for CE purposes in Irish businesses at scale. Given the emerging nature of the two topics in Irish industry, many potential case studies and sources of insights were still in the pilot stages. Given time, these smaller projects and experiments within research and businesses may bear fruit. We encourage both the research and policy fields to watch the space, as AI, the CE and using AI for CE implementation are rapidly developing as somewhat experimental fields that have yet to show their full potential in Irish industry.

2.4 Overarching Methodological Approach – Stakeholder Engagement

The AI4CE project used a variety of approaches to achieve its objectives. The overarching methodology focused on engaging key stakeholders (members of Irish industry), to explore the intersection of AI and the CE, as well as provide insights and inputs into the AI4CE Decision Support Tool (DST), which informed the subsequent outputs of the project (see Figure 2.1).

2.4.1 Stakeholder engagement approach

Stakeholders were recruited through IMR's network of industry members. IMR is one of Ireland's largest engaged manufacturing networks, working with over 250 SMEs and multinational corporations across the country. IMR network members are primarily high-level members of Irish-based manufacturing organisations. A second source of stakeholder engagement was via the cross-sectoral CIRCULÉIRE network, of which IMR is the secretariat, and for which EPA was a catalyst funder via a strategic partnership from 2020 to 2022. CIRCULÉIRE is a public–private partnership with over 50 cross-sectoral industry members on the journey to transition from a linear business model to circularity.

Both IMR and CIRCULÉIRE members were invited to participate in and attend AI4CE events, workshops and feedback sessions via IMR and CIRCULÉIRE's communication channels (newsletter, emails, social media). CIRCULÉIRE and IMR have a combined following of over 20,000 people on LinkedIn and 5500 followers on Twitter/X. The IMR mailing list has over 1600 subscribers. CIRCULÉIRE's quarterly

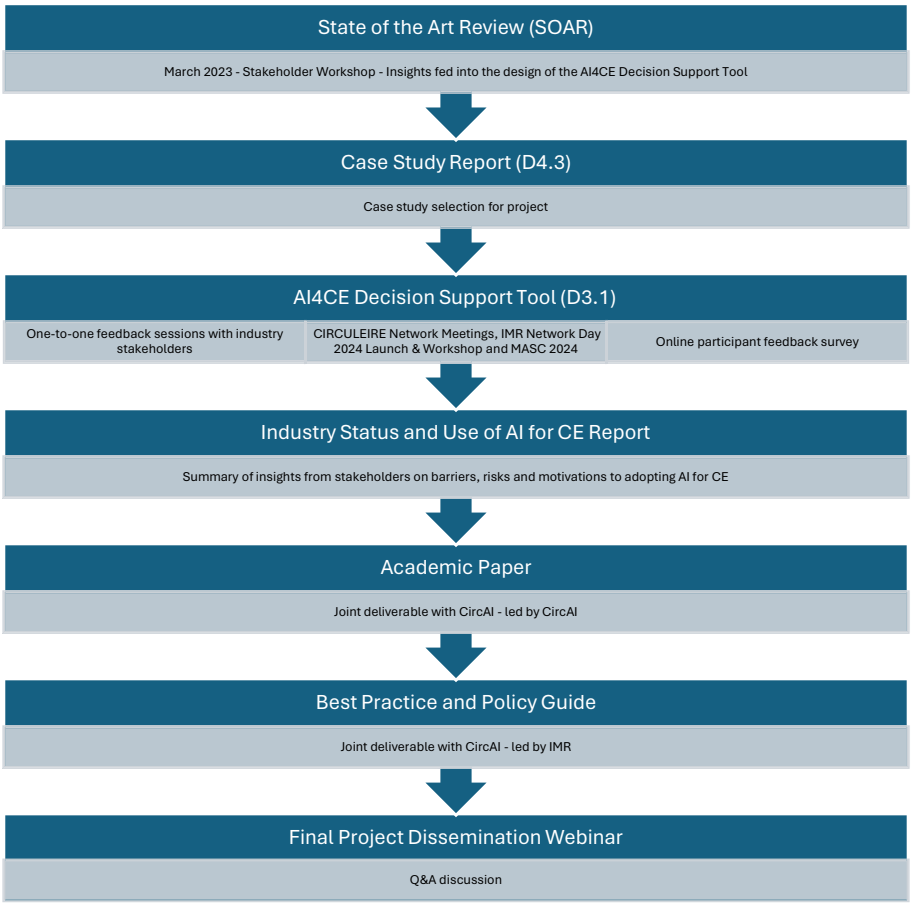

Figure 2.1. Overview of relationship between AI4CE project deliverables/outcomes.

network events were leveraged to include AI4CE project workshops as a segment, rather than creating standalone AI4CE events. This ensured that there was a guaranteed footfall of stakeholders attending events and workshops, which would not have been possible had a network been built and event attendees been recruited from scratch.

AI4CE workshops and presentations were designed not only to collect insights from participants but also to raise awareness and educate participants (e.g. on the basics of AI, how AI can be used in manufacturing, the basics of the CE and how a CE can serve business needs). Attracting stakeholders to engage in AI4CE events required the benefits of their time investment to be clearly set out. All AI4CE workshops and events were designed to enable participants to engage with the project materials and give their feedback and insights through interactive discussions.

2.5 Collaboration with EPA-funded CircAI (Maynooth University)

Given the mutual project goals of the EPA-funded CircAI project and the AI4CE project, IMR and Maynooth University decided to collaborate to share insights, develop joint stakeholder engagement strategies and deliver joint deliverables, which leveraged our respective expertise. Collaborative activities included a CircAI webinar (Q1, 2023) and workshops (Q1 and Q4, 2023) hosted by IMR, a joint academic paper focused on the role of AI as an enabler of CE in the context of the United Nations (UN) Sustainable Development Goals (SDGs) (Pathan *et al.*, 2024) and the joint publication of the *AI4CE – Best Practice & Policy Guide* (IMR, 2024a) (Figure 2.2).

Figure 2.2. Joint publication of *AI4CE – Best Practice & Policy Guide* (IMR, 2024a) in collaboration with the CircAI team at Maynooth University.

3 Project Outcomes

3.1 State-of-the-art Review (T2.1)

Objectives: the state-of-the-art review (SOAR) aimed to summarise key literature on the CE and AI, focusing on applications relevant to manufacturing. It highlighted potential AI applications for CE strategies across product life cycles and identified the main AI categories applicable to industry-oriented CE.

Development: developed as an internal review, the document integrated literature on CE, relevant EU and Irish policies, and various AI technologies, noting technical, organisational, financial and societal/ethical barriers to AI adoption for circular implementation.

Outcomes: the SOAR is an internal document that serves as the foundation for subsequent AI4CE initiatives, including the development of the DST and public reports, to engage stakeholders in advancing an AI-driven CE.

3.2 Case Study Identification and Report (D4.3)

Objectives: case studies were gathered to be used for subsequent project materials, to demonstrate to stakeholders how AI works in practice to achieve CE goals in industry.

The resulting case study report is a compilation of use cases that demonstrate how businesses have used AI to achieve concrete success in CE goals, while reaching their business needs (IMR, 2024b).

Development: case studies were researched through an online review of industry reports, press releases and news items.

Four primary criteria were used to select the case studies:

1. use of AI solutions;
2. adherence to CE principles;
3. relevance to business needs (cost savings, process efficiency, innovation);
4. publicly available data regarding impact outcomes in relation to these three factors.

Relevance to business needs was a key inclusion criterion, as recent Ibec research shows that most Irish businesses invest in new technology for business goals rather than necessarily for sustainability or CE goals (Avery Dennison, 2022; Ibec, 2023). Case studies were selected based on their concrete demonstration of CE principles. These principles are taken from the Kircherr *et al*. (2017) definition of a CE, which is based on a meta-analysis of 114 definitions: “an economic system that replaces the ‘end-of-life’ concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes”.

Case studies were then selected across a range of industries and at each step of a product life cycle: sourcing, design, manufacturing, distribution and usage. Case studies were also clustered into the following broad industry categories: agriculture, automotive, construction, logistics, technology, waste management and manufacturing.

Outcomes: 25 case studies met the criteria for inclusion within the AI4CE DST, and a subset of eight of these were included in the AI4CE case studies to bring to life the opportunities that correspond to the key priority areas for CE policy nationally and in the EU: packaging, textiles, food, water and nutrients, construction and buildings, electronics and information and communications technology, batteries and vehicles, retail and agriculture. These areas are included as priorities in the EPA’s 2021–2027 CE programme (EPA, 2021), the Whole of Government Circular Economy Strategy (Government of Ireland, 2021b) and the European Commission’s 2020 Circular Economy Action Plan (European Commission, 2020). While extensive efforts were made to identify Irish AI4CE case studies, there were no publicly available case studies that met the selection criteria. Irish case studies tended to be start-ups or early-stage research projects, which could not be used as mature case studies.

3.3 Stakeholder Engagement and Feedback (T4.1)

Objectives: the objectives of the stakeholder engagement workshop(s) and one-to-one sessions were to gather feedback and insights from industry stakeholders on barriers to, opportunities for and awareness of the use of AI for CE implementation. Engagement sessions were used to inform the direction of project outputs and determine what knowledge gaps the DST and related reports should fill.

Development: stakeholder feedback was gathered through four primary channels. See section 2.4 for a description of the methodology. The five key stakeholder engagement activities were as follows:

1. **Stakeholder recruitment at CIRCULÉIRE network meetings (6 March and 12 June 2024):** the AI4CE project was introduced to CIRCULÉIRE members during their Q1 2024 network meeting in Monaghan. This session was used to recruit stakeholders to give feedback and insights via one-to-one interviews to inform the development of the AI4CE DST. The AI4CE DST and preliminary insights were also presented to CIRCULÉIRE members during their Q2 2024 network meeting in Cork.
2. **One-to-one stakeholder discussions (22–26 March 2024):** follow-up meetings were held with three stakeholders to inform toolkit prototype development and gain insight on interest in AI application for the CE. Stakeholders were from the packaging, automotive and hospitality sectors.
3. **IMR Industry Members Network Event workshop (25 April 2024):** the AI4CE DST was launched at the IMR Industry Members Network Event in April 2024. The toolkit was presented in a session attended by 22 network members. Attendees were a mixture of high-level representatives from industry and academia. Attendees were invited to use the toolkit and give feedback during the workshop exercises. Feedback was collected using the AI4CE DST online survey and from worksheets completed in the session. Discussion points included **(i) the level of knowledge regarding AI and CE; (ii) whether participants' organisations had CE goals; (iii) barriers to and opportunities for AI and CE strategies within participants' businesses; and (iv) motivations to adopt AI or CE goals.**
4. **Manufacturing and Supply Chain Conference and Exhibition (28 and 29 May 2024):** the AI4CE project was featured at the IMR stand at the 2024 Manufacturing and Supply Chain Conference and Exhibition in Dublin, which hosted an estimated 3000 attendees over the 2 days. The primary objective was to gather feedback from stakeholders outside IMR and CIRCULÉIRE's networks, which could inform the development of the AI4CE best practice guide (IMR, 2024a). The secondary objective was to disseminate the project outcomes, including raising awareness of the AI4CE DST. The project and DST were featured in a keynote speech at the conference (Figure 3.1). Verbal feedback from attendees was gathered; however, uptake on the AI4CE DST and online feedback survey were limited. A possible reason for the low uptake was the time needed to complete the toolkit and survey (*c*. 10 minutes) in a fast-moving exhibition and conference environment. Verbal engagement echoed previous project findings from stakeholders regarding low levels of awareness of the role of AI in the CE.
5. **Online feedback survey (25 April to 19 July 2024):** the AI4CE DST featured a user feedback survey at the end of the tool. The purpose of the survey was to gather feedback on the tool itself and gain wider insights from stakeholders that would inform the best practice guide (IMR, 2024a). The survey had a total of 41 respondents from April to July 2024.

Outcomes: over 50 stakeholders across multiple industries in Ireland provided their insights on barriers, risks, perceptions and opportunities related to the use of AI for CE implementation in Ireland. Stakeholders were a mixture of high-level employees from SMEs, multinational corporation representatives and academics. These insights were used to design subsequent project outputs and are summarised in the report *AI4CE – Status and Use of AI for Circular Economy in Ireland* (IMR, 2024c).

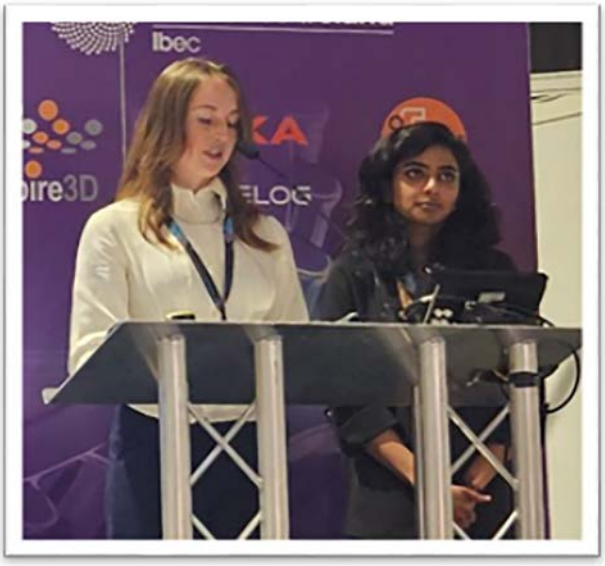

Figure 3.1. The AI4CE team delivered a keynote speech on the "Internet of Things and Industry 4.0" stage at the 2024 Manufacturing and Supply Chain Conference and Exhibition on 28 May 2024.

3.4 Decision Support Tool Development (D3.1)

Objectives: the objective of the tool was to enable industry stakeholders to explore how AI could support their businesses' CE goals through a personalised selection of case studies that were most relevant to their needs and interests.

Development: the initial work plan for the development of the AI4CE DST was structured to guide users through a comprehensive journey aimed at enhancing their business analytics and enabling them to implement AI technologies effectively. The tool would ask users for detailed business analytics, such as employee efficiency or production plans, and their CE goals. Based on the responses, the tool would suggest the relevant AI technology for their goal and present a detailed breakdown of the steps that should be taken to implement the technology and the skills required. Finally, it would present a real-world case study for inspiration.

After receiving feedback from stakeholders, the approach was changed. Instead of detailing the implementation of a specific AI technology, the tool asked the user what they would like AI to do for their business – for example interpret data or detect faults. This change was made to reduce technical language and instead focus on practical uses for AI.

Two options were proposed for the visualisation mechanism of the DST: Microsoft Power BI and the Analytics Maturity Model tool developed by IMR. Both options required the creation of a database and the formulation of conditional statements to function effectively. The Power BI option focuses on user interactivity, while the Analytics Maturity Model tool involved considerations related to intellectual property rights. However, it was decided that the Power BI tool was the better choice, as it could be provided open-source and was more visual and interactive.

The Power BI dashboard creation tasks were as follows:

- **Task 1** – **database and conditional statement creation:** this task involves a cross-tabulation mapping approach, whereby all possible user input options are linked to potential outputs (case studies), with the database created being an Excel file.
- **Task 2** – **database and conditional statement review:** the second task involves all members of the team conducting a conceptual review of the database.
- **Task 3** – **dashboard design**: next, a conceptual dashboard design is developed, with the output being a visual model or a mock-up of the dashboard.
- **Task 4** – **dashboard development and deployment:** finally, the dashboard design is translated into a functional report on Power BI that can be shared publicly.

The final version of the AI4CE DST facilitates a comprehensive process that leverages case studies, categorisation, data manipulation and visualisation to help users to make informed decisions. Development involved the following steps:

1. **Selecting case studies:** case studies gathered for the case study report were used for the tool.
2. **Creating categories:** the next step was to create a set of categories to organise the information. The categories were designed to cover various aspects, including sectors (e.g. automotive, healthcare), business needs (e.g. cost reduction,

process efficiency), sustainability targets (e.g. carbon dioxide reduction, product life cycle management), product life cycle stages (e.g. design, manufacture, recycle) and AI functions (e.g. making predictions, detecting faults).

3. **Categorising case studies:** each case study was then categorised based on the predefined categories. The categorisation process ensured that each case study could be easily filtered and searched within the DST.
4. **Using the Query Editor feature in Excel to expand the database to a tabular form:** to facilitate the creation of a searchable and filterable database, the categorised case studies were expanded into a tabular form using Excel's Query Editor, which is a subset of Power Query. This step involved structuring the data into a format that could be easily imported into Power BI. The tabular form allowed for efficient data manipulation and ensured compatibility with the visualisation tools used in the DST.
5. **Uploading the tabular form database to Power BI and creating the tool:** the tabular database was then uploaded to Power BI, where the DST was built using various visualisations. The primary visualisations included tables and slicers, which allowed users to filter the case studies based on their specific interests. An image visualisation feature was also added to display relevant images associated with each case study, enhancing the user experience.
6. **Using relationships to match combinations to case study images:** in Power BI, relationships between different data fields were created to match combinations of filters to the corresponding case study images. This ensured that, when users selected certain criteria using the slicers, the DST would display the relevant case studies along with their associated images.
7. **Using the Microsoft Forms link on a button option in Power BI:** to collect user feedback and additional information, a Microsoft Forms link was integrated into the DST. A button option in Power BI directed users to the form, making it easy for them to provide their input.
8. **Automating report distribution using Power Automate:** finally, the process was automated to enhance efficiency and user engagement. When users submitted survey responses using Microsoft Forms, Power Automate was triggered to send a report to the email address provided in the form.

Outcomes: an online tool was created that introduced key concepts related to AI and the CE (IMR, 2024d) (Figure 3.2). Users are provided with a customised selection of case studies that illustrate how businesses in their sector have utilised AI to

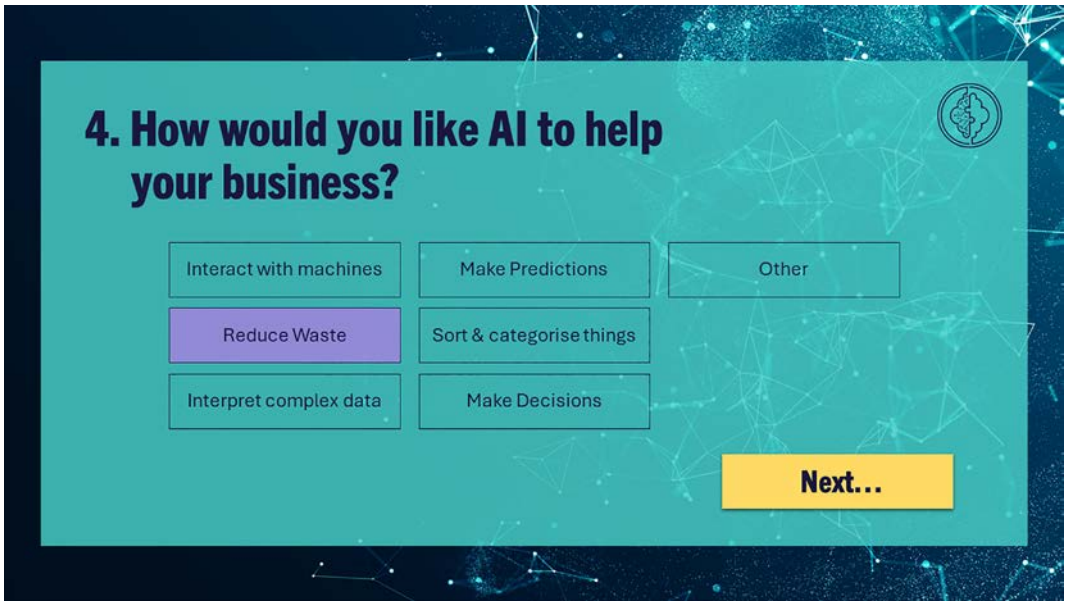

Figure 3.2. Screenshot from the AI4CE Decision Support Tool (DST).

accelerate the implementation of circularity. At least 41 users completed the DST in the period from April to July 2024. This was measured by completion of the feedback survey at the end of the tool.

3.5 Report on the Industry Status and Use of Artificial Intelligence for the Circular Economy in Ireland (D2.2)

Objectives: the objective of this report was twofold: (i) to report on the general status and use of AI in Ireland and (ii) to summarise insights from industry on perceptions of using AI for CE implementation gathered from stakeholder engagement (T4.1).

Development: the literature review and barriers to using AI for CE implementation that were gathered as part of the internal SOAR (T2.1) were used as the basis of the report and informed the stakeholder engagement workshops. The three primary stakeholder engagement events (the 2023 and 2024 workshops and the AI4CE DST survey) were reviewed and key insights were summarised based on the data gathered. Irish firms that use AI for CE implementation were identified through the CIRCULÉIRE network and via various CE events attended by the AI4CE team.

Outcomes: the report distils the current status of AI in Irish manufacturing, the potential applications of AI for CE purposes and the barriers to its adoption, and it maps Irish firms currently using AI for CE goals and strategies.

3.6 AI4CE Best Practice and Policy Guide (D4.4)

Objectives: the *AI4CE – Best Practice & Policy Guide* (IMR, 2024a) describes the opportunities for and barriers to using AI for CE strategies and gives an overview of the policy landscape for AI and the CE. It was designed to be a practical guide to help industry stakeholders and policymakers to understand the core concepts behind AI and the CE and give guidance on how the two can work together. It also details the relevant regulations and legal considerations regarding AI and the CE in the Irish and EU contexts.

Development: the SOAR was used as a starting point for identifying key literature on AI and the CE. Insights from stakeholder engagement informed the key messages underpinning the best practice guide (IMR, 2024a). Based on stakeholder engagement, it was clear that most of the target audiences had only basic knowledge of AI and the CE. The best practice and policy guide (IMR, 2024a) was drafted to clarify the concepts of AI and the CE, to dispel assumptions on the topics (such as "hype" around AI or CE goals not being applicable to their business) and to underscore why businesses should care about CE goals. Moreover, the guide was designed to focus on practical aspects of AI and the CE, rather than taking a technical approach, given the relatively low level of understanding of both topics among the target audiences (industry and public sector stakeholders). The CircAI team at Maynooth University, with whom the best practice and policy guide (IMR, 2024a) was **jointly developed as an EPA deliverable**, led the development of key sections of the guide, namely the sections on legal and ethical considerations for adopting AI and a CE, and the key considerations for policymakers and public sector actors.

Outcomes: the resulting best practice and policy guide (IMR, 2024a) provides guidance on considerations and strategies related to integrating both CE and AI into industry and insights for public sector actors interested in the intersection of AI and the CE. This guidance was developed by synthesising the insights gained through a review of the literature on CE and AI. International Organization for Standardization (ISO) standards for CE implementation and business models were released in June 2024 (ISO, 2024a,b), and highlights from these standards were also referenced in the best practice and policy guide. The guide featured the case studies that best demonstrated cross-sectoral success in terms of CE and business goals, illustrating a variety of AI solutions.

3.7 Academic Publication – Joint Deliverable with the CircAI Team, Maynooth University (D5.2)

The academic paper, a joint effort led by the CircAI team at Maynooth University, which the authors are continuing to evolve, explores the intersection of AI and CE in contributing to the UN SDGs, with a focus on sustainable development. Developed collaboratively, the paper highlights how CE practices

in manufacturing can support the achievement of SDG targets and examines AI's role in enhancing industry-focused CE practices, emphasising circularity's potential impact on the manufacturing sector (Pathan *et al*., 2024).

3.8 AI4CE Project Dissemination Webinar (D5.4)

Objectives: the AI4CE final project webinar was designed to be a knowledge transfer session to disseminate the project results and insights gathered over the course of the project to wider industry and public sector stakeholders in the Irish ecosystem.

Development: as part of the project's dissemination efforts, stakeholders were invited to attended through the IMR and CIRCULÉIRE networks, as well as through a mailing list created for the AI4CE project.

Outcomes: members of the IMR AI4CE delivery team (Dr Geraldine Brennan, Carlos Garcia, Enya O'Connell-Hussey, Veena Grace Thomas and Valentina Rangel Leon) delivered a public webinar entitled "Leveraging AI for the Circular Economy: Strategies & Insights for Irish Industry and the Public Sector" (IMR, 2024e). This was a public dissemination of the findings from the entirety of the project. It highlighted barriers to and enablers for adopting AI for CE implementation. The recorded webinar provided insights into CE and AI regulations coming into force. There were 56 attendees.

4 AI4CE Insights for Industry and the Public Sector

This chapter presents the insights gained from the AI4CE project. These insights were gathered from two streams. Some of the insights came from existing research on AI, CE and Irish industry. These insights are used in all the project deliverables but are primarily reflected in the SOAR, the *AI4CE – Best Practice & Policy Guide* (IMR, 2024a), the academic paper and the industry status report (IMR, 2024c).

The second stream of insights were gathered from engagement with Irish stakeholders over the course of the project, during the opportunities described in section 3.3, yielding new insights and corroborated points learned from desk research.

In the following sections, the insights are divided by current status of AI and the CE in Ireland (section 4.1), the opportunities of AI as an enabler of CE goals (section 4.2) and finally the risks and barriers identified (section 4.3).

4.1 Current Status of Artificial Intelligence and the Circular Economy in Ireland

4.1.1 Early adoption: artificial intelligence and the circular economy are at the very early stages of adoption in Ireland

Existing research details Ireland's low circularity and AI adoption rates (EPA, 2022a,b; Eurostat, 2023; McCarthy *et al*., 2024). However, although AI use in manufacturing is not widespread, with a 7.2% usage rate in 2023, the usage rate is still slightly above the EU average of 6.8%. Early adoption of AI and CE in Irish industry was corroborated by AI4CE project findings. Stakeholders showed various levels of awareness of the two concepts during discussions and feedback. As shown in Figure 4.1, most users of the DST rated their knowledge of AI and the CE as basic to intermediate (see *AI4CE – Status and Use of AI for Circular Economy in Ireland* (IMR, 2024c)).

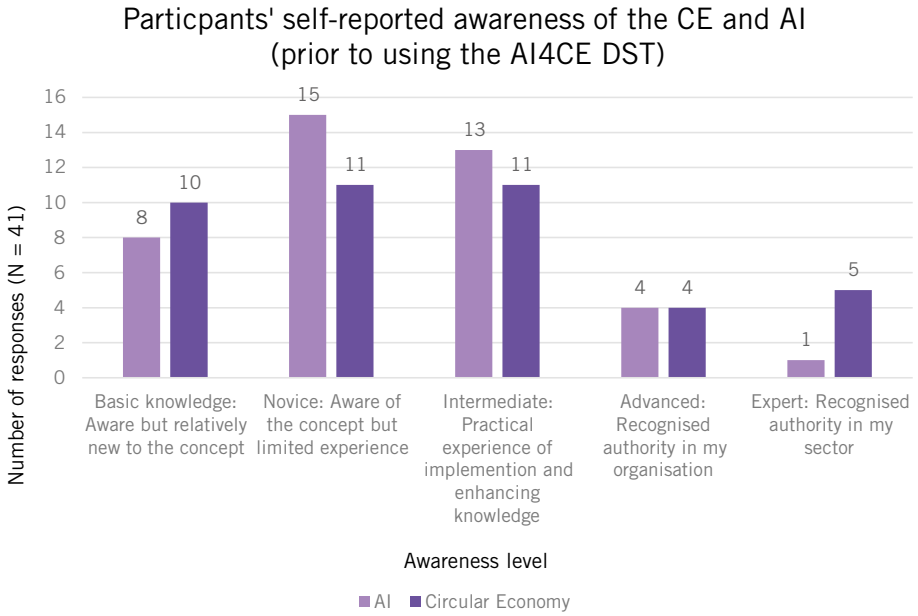

Figure 4.1. Responses to the DST feedback question: "How would you describe your awareness of the CE prior to using the AI4CE tool?". Source: *AI4CE – Status and Use of AI for Circular Economy in Ireland* (IMR, 2024c).

4.1.2 Low levels of awareness: Irish industry remains largely unaware of artificial intelligence's potential for enabling the circular economy

Research suggests that investment in digitalisation is predominantly focused on enhancing process efficiency and continuous improvement, rather than explicitly targeting sustainability or more specifically CE goals (Avery Dennison, 2022; Ibec, 2023). Publicly available data suggest that AI's application in CE practices in Ireland appears to be predominantly in the waste management and recycling sectors. Key examples include FPD Recycling, which employs AI-driven sorting technology, and AMCS, which uses computer vision for waste management. In AI4CE project-hosted discussions, stakeholders tended to be more interested in AI than the CE. However, stakeholders saw opportunities for using AI in the following activities, which would also support the CE transition: process optimisation, waste reduction, process efficiency and predictive maintenance (see *AI4CE – Status and Use of AI for Circular Economy in Ireland* (IMR, 2024c)).

4.1.3 Business needs: adoption of artificial intelligence and circular economy practices is driven by business goals

Many users of the DST worked in businesses that used traditional process improvement methods to reduce waste and inefficiencies (e.g. LEAN and Six Sigma). It is possible that these methods could shape the thinking of business owners around the CE. Waste reduction, process efficiency and optimisation were prominent CE goals noted by the DST users. Their primary motivation for adopting a hypothetical CE measure was for alignment with business needs and goals, for example to reduce costs or improve process efficiency.

4.1.4 Keen interest but varied experience in artificial intelligence

Given the current AI "hype", it is no surprise that many Irish businesses are exploring and interested in the topic of AI. Our stakeholder engagement sessions found that the majority of attendees were keenly interested in AI (see Figure 4.2), although their experience with AI technologies varied widely. There may be selection bias at play, given that the stakeholders self-selected to attend AI-themed workshops. However, industry research does indicate a strong interest in digitisation across Irish manufacturing (Ibec, 2023). Respondents to the DST feedback form were asked how they use AI. However, there was no consistent trend and responses ranged from editing reports to automation, research, image recognition and data analysis (see *AI4CE – Status*

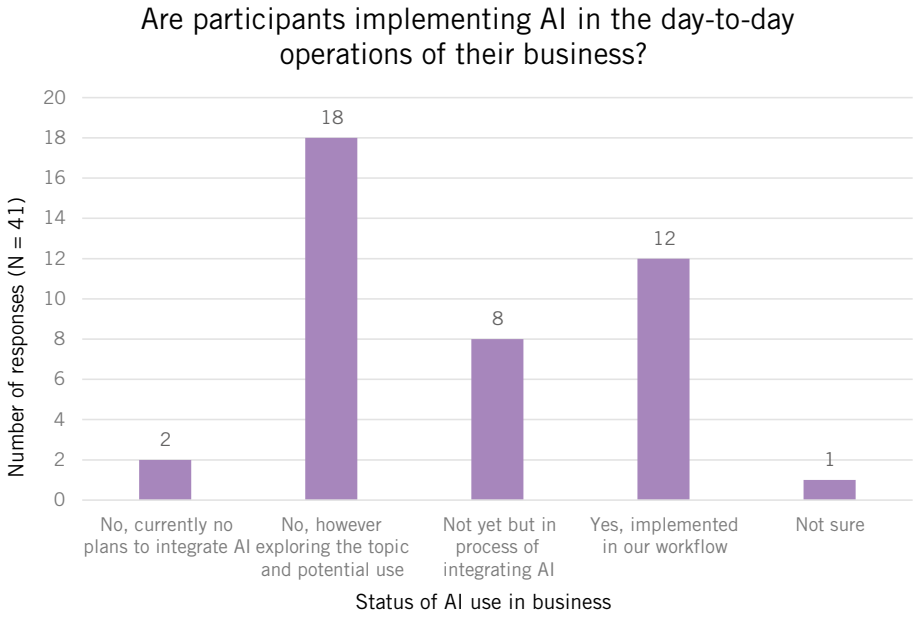

Figure 4.2. Responses to the DST feedback question: "Are you already implementing AI in the day-to-day operations of your business?". Source: *AI4CE – Status and Use of AI for Circular Economy in Ireland* (IMR, 2024c).

and Use of AI for Circular Economy in Ireland (IMR, 2024c)).

4.1.5 *Evolving landscape: artificial intelligence and circular economy-related policies and regulations are rapidly evolving*

The adoption of CE practices is increasingly being incentivised or mandated by new policies and regulations. The EU AI Act is expected to shape the ethical and legal landscape for AI in Irish manufacturing and wider industry. However, the act is still broad, and its specific implications are yet to be fully understood.

4.2 Opportunities for Artificial Intelligence as an Enabler of a Circular Economy

4.2.1 *Artificial intelligence as a tool: artificial intelligence is a tool for reaching specific goals, not a goal in itself*

While organisations can progress towards circularity without using AI, the technology presents a significant opportunity to reduce time- and labour-intensive processes. AI technologies like computer vision, ML and natural language processing can significantly enhance implementation of circular practices and help overcome barriers to scaling up circularity. For example, ML algorithms can optimise the revalorization of end-of-life products, such as electronics, plastics or textiles, by identifying reusable components, assessing their quality and determining potential second-life applications. This facilitates the efficient sorting and recovery of valuable materials, allowing them to re-enter the production cycle. Additionally, AI can support predictive maintenance, resource optimisation and circular product design, collectively contributing to waste reduction and elimination, valorisation of by-products or production residues and increased resource efficiency. However, it is important to keep in mind that there is no one quick fix to circularity and that it requires shifts across entire organisations' systems and cultures (ISO, 2024a,b).

4.2.2 *Artificial intelligence as an enabler of data flow for a circular economy*

Many CE efforts are hindered by a lack of data, inability to interpret data or barriers between datasets. AI solutions can analyse and interpret large numbers of data in a short period of time. They have the potential to overcome the siloing of data between different actors in a product's life cycle, provided that there are high-quality data to analyse and interpret.

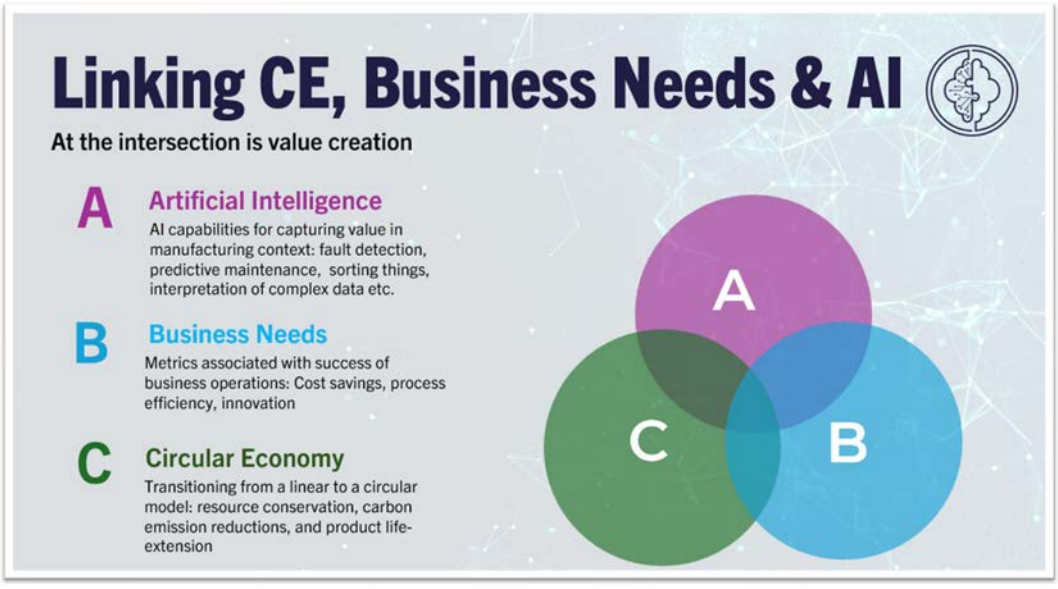

Figure 4.3. Graphic of the intersections between CE, AI and business needs. Source: *AI4CE – Best Practice & Policy Guide* (IMR, 2024a).

4.3 Risks and Barriers in the Adoption of Artificial Intelligence for a Circular Economy

The project identified several barriers to and risks of adopting AI for CE implementation in the Irish context. These have been identified across existing research and were also echoed by the attendees of workshops held by the AI4CE project team (see *AI4CE – Best Practice & Policy Guide* and *AI4CE – Status and Use of AI for Circular Economy in Ireland* (IMR, 2024a,c). Below is a summary of the main challenges identified:

- **Limited awareness:** lack of understanding about AI's role in enabling CE practices is a significant challenge.
- **High costs:** upfront investment in data management systems, infrastructure and new workflows can be prohibitive, particularly for SMEs.
- **Data quality and access:** scattered and inconsistent datasets hinder effective AI deployment, as this requires access to large numbers of high-quality data.
- **Talent gaps:** an employee talent and skills deficit is also one of the top challenges cited by major manufacturers considering adopting AI, particularly SMEs (MIT Technology Review Insights, 2024).
- **Organisational resistance:** there is a reluctance to adopt new technologies or adjust workflows.
- **Ethical concerns:** ethical concerns related to AI deployment were noted by stakeholders in the project, but were ranked as less of a concern in discussions than other concerns.

The insights presented in here highlight both the opportunities and challenges associated with adopting AI for CE practices in Ireland. These findings provide a foundation for the subsequent chapter, which summarises key takeaways and offers actionable recommendations to accelerate the adoption of AI-enabled circular implementation.

5 Conclusions and Recommendations

The AI4CE project highlights the significant yet largely untapped potential of AI to enable the accelerated deployment of CE practices in Irish industry and drive progress with Ireland's sustainability agenda. While Ireland's rate of adoption of AI surpasses the EU average, its application of AI to circularity remains in the early stages and is primarily limited to the waste management and recycling sectors. As mentioned in the previous chapter, broadening adoption faces challenges, including limited awareness, financial constraints, data accessibility issues, skills shortages and organisational resistance. Moreover, industry uptake is likely to hinge on a compelling business case tied to cost savings, efficiency improvements or regulatory compliance being demonstrated.

Despite these barriers, AI offers transformative opportunities to advance CE practices such as material sorting, circular design, predictive maintenance and resource optimisation. These applications can effectively align business objectives with CE principles, fostering both economic and environmental benefits. Based on the findings of the AI4CE project, the following recommendations aim to support the development of AI as a key enabler of the CE in Ireland:

- **Foster collaboration and knowledge sharing.** Fostering collaboration between industry, academia and the government is crucial to advancing the use of AI in the CE. Leveraging existing platforms and networks for knowledge sharing (e.g. CIRCULÉIRE, of which IMR is the secretariat) could help to overcome technical and organisational barriers.
- **Promote case studies and demonstrations.** The dissemination of successful case studies and pilot projects can provide valuable insights and demonstrate the tangible benefits of using AI for CE goals, encouraging wider adoption.
- **Promote training and education.** Promote workforce training programmes that equip employees with the skills needed to develop, implement and manage AI technologies for CE applications, with a special emphasis on SMEs and end-user industries. Businesses also need internal champions to drive the adoption and effective use of AI for circularity.
- **Invest in AI infrastructure.** To fully harness AI's potential in advancing the CE and achieving broader business objectives, strategic investment in AI infrastructure is essential. This includes developing robust data collection and management systems and upskilling employees to create and utilise high-quality datasets effectively. Such investments will also be influenced by regulatory drivers like the CSRD and the ESPR, which mandate the reporting of circularity and sustainability performance (CSRD) and the digital sharing of this information through digital product passports (DPPs).
- **Fund demonstrations.** Developing targeted funding initiatives for pilot projects that demystify the role of AI in the CE could provide practical insights and encourage wider adoption and replication.
- **Offer policy guidance and support.** Providing detailed guidance for industry would help to ensure that scientifically supported best practices are followed when using AI for CE goals. This could include the development of codes of practice and standards to help businesses understand and implement AI effectively in the context of the CE. Collaboration between government departments and public entities responsible for AI and CE legislation, regulation and market compliance (e.g. the Department of Enterprise, Trade and Employment, Department of Climate, Energy and the Environment, Enterprise Ireland and the EPA) should be encouraged, to ensure alignment and pre-empt bottlenecks that may arise at the intersection of AI and the CE to maximise optimal outcomes.

AI has the potential to play a transformative role in advancing the CE in Ireland, supporting the nation's ambition to become a test bed for circularity by 2030 and achieve its 2030 and 2050 climate goals. By tackling existing barriers, fostering cross-sectoral collaboration and cultivating a supportive policy environment, AI could unlock innovative solutions that embed CE principles into Irish business practices.

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Appendix 1 Summary of AI4CE Communication and Dissemination Activities

Date	Activity	Who/where	Further information/impact
2022–present	AI4CE web page	https://imr.ie/pages/ai4ce/	Web page with public deliverables and project overview
23 March 2023	AI and CE webinar	Online webinar hosted by CircAI/Maynooth University's Innovation Value Institute	Dr Damien Coughlan gave a presentation on AI4CE during this webinar (total attendee figures are unknown due to GDPR) Link: https://ivi.ie/webinars/ai-and-circular-economy-webinar/
30 March 2023	Public Workshop on AI for the CE	Delivered with the CIRCULÉIRE Q1 Network Meeting in Kells, Co. Meath	There were 59 registrants and 30 attendees at the workshop: 5 academia, 19 industry and 6 public sector
29 May 2023	Dublin Circular Economy Hotspot 2023 conference	Croke Park, Dublin	AI4CE displayed at IMR/CIRCULÉIRE exhibition stand at the Circular Economy Hotspot conference
31 May 2023	Article: "Industry 5.0 is key to circular economy and business success"	Article published by MediaPlanet on Businessnews.ie	AI4CE mentioned in an article by Damien Coughlan, shared by IMR and CIRCULÉIRE on LinkedIn and Twitter/X Link to article: https://www.businessnews.ie/circular-economy/industry-5-0-is-key-to-circular-economy-and-business-success/
28 June 2023	IMR Sustainable Energy Day	IMR Mullingar, Co. Westmeath	AI4CE displayed at IMR Sustainable Manufacturing exhibition stand
27 September 2023	CIRCULÉIRE stand at EPA CE conference	Aviva Stadium, Dublin City	AI4CE displayed at CIRCULÉIRE exhibition stand at EPA CE conference
9 November 2023	Sustainable fashion event at Republic of Work	Republic of Work, Cork City	AI4CE discussed at an IMR/CIRCULÉRE presentation at the Republic of Work (attendee figures unknown due to GDPR)
29 November 2023	Artificial Intelligence and the Circular Economy in Action workshop	CircAI project, Maynooth University, Co. Kildare	Dr Geraldine Brennan presented the AI4CE project workshop, with 26 total attendees: 6 from academia, 5 from NGOs, 10 from industry and 5 from other fields Link: https://www.cs.nuim.ie/~pmooney/CircAI2023/
6 March 2024	AI4CE project presentation at CIRCULÉIRE Q1, 2024, network meeting in collaboration with Monaghan LEO ESG cluster	CIRCULÉIRE industry network members and Monaghan ESG cluster, Co. Monaghan	AI4CE project overview was presented to participants at CIRCULÉIRE's Q1, 2024, network meeting, which was hosted in Co. Monaghan in collaboration with Monaghan LEO ESG cluster members, with 42 participants
15 April 2024	World Circular Economy Forum 2024	WCEF 2024, Brussels, Belgium	The AI4CE project was promoted by the CE team of IMR at the WCEF in Brussels
25 April 2024	IMR Industry Members Network Event workshop 2024	IMR Mullingar, Co. Westmeath	AI4CE display at IMR Sustainable Manufacturing exhibition stand. The AI4CE project delivery team launched the AI4CE DST during the workshop, which had 22 attendees from industry and academia
28 May 2024	MASC 2024, IMR exhibition stand	AI4CE team, Manufacturing and Supply Chain Conference, Dublin	AI4CE was included in IMR's stand demonstration
28 May 2024	Presentation: "AI Driven Circularity: Insights & Opportunities for Irish Enterprise"	Manufacturing and Supply Chain Conference, Dublin	Enya O'Connell-Hussey and Veena Grace Thomas (IMR) presented on the IoT and Industry 4.0 stage, attended by *c.*29 people

Date	Activity	Who/where	Further information/impact
12 June 2024	AI4CE project presentation at CIRCULÉIRE Q2, 2024, network meeting, which was hosted at Freefoam Building Products, Cork	CIRCULÉIRE industry network members and Zero Waste Scotland delegation	AI4CE project and AI4CE DST presented at CIRCULÉIRE's Q2, 2024, network meeting – hosted at Freefoam Building Products, Cork, with *c.*40 participants
19 July 2024	Webinar: "Leveraging AI for the Circular Economy: Strategies & Insights for Irish Industry and the Public Sector"	IMR public webinar	There were 122 registrations and 56 attendees: 6 from academia, 30 from industry and 20 from the public sector Link to recording: https://www.youtube.com/watch?v=3exNQ61ZpbQ
2022–2024	Social media promotion and mailing list	IMR and CIRCULÉIRE LinkedIn and Twitter/X	Promotion to 20,000 followers (LinkedIn), 5500 followers (Twitter/X) and 1600 combined mailing list subscribers

ESG, Environmental, Social and Governance; GDPR, General Data Protection Regulation; IoT, internet of things; LEO, Local Enterprise Office; MASC, Manufacturing and Supply Chain Conference; NGO, non-governmental organisation; WCEF, World Circular Economy Forum.

Abbreviations

AI	Artificial intelligence
AI4CE	Artificial Intelligence for the Circular Economy
CE	Circular economy
CMUR	Circular material use rate
CSRD	Corporate Sustainability Reporting Directive
DST	Decision Support Tool
EPA	Environmental Protection Agency
ESPR	Ecodesign for Sustainable Products Regulation
EU	European Union
GPAI	General-purpose artificial intelligence
IMR	Irish Manufacturing Research
ML	Machine learning
SDG	Sustainable Development Goal
SMEs	Small and medium-sized enterprises
SOAR	State-of-the-art review
UN	United Nations

An Ghníomhaireacht Um Chaomhnú Comhshaoil

Tá an GCC freagrach as an gcomhshaol a chosaint agus a fheabhsú, mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaol a chosaint ar thionchar díobhálach na radaíochta agus an truaillithe.

Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

Rialáil: Rialáil agus córais chomhlíonta comhshaoil éifeachtacha a chur i bhfeidhm, chun dea-thorthaí comhshaoil a bhaint amach agus díriú orthu siúd nach mbíonn ag cloí leo.

Eolas: Sonraí, eolas agus measúnú ardchaighdeáin, spriocdhírithe agus tráthúil a chur ar fáil i leith an chomhshaoil chun bonn eolais a chur faoin gcinnteoireacht.

Abhcóideacht: Ag obair le daoine eile ar son timpeallachta glaine, táirgiúla agus dea-chosanta agus ar son cleachtas inbhuanaithe i dtaobh an chomhshaoil.

I measc ár gcuid freagrachtaí tá:

Ceadúnú

- Gníomhaíochtaí tionscail, dramhaíola agus stórála peitril ar scála mór;
- Sceitheadh fuíolluisce uirbigh;
- Úsáid shrianta agus scaoileadh rialaithe Orgánach Géinmhodhnaithe;
- Foinsí radaíochta ianúcháin;
- Astaíochtaí gás ceaptha teasa ó thionscal agus ón eitlíocht trí Scéim an AE um Thrádáil Astaíochtaí.

Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil

- Iniúchadh agus cigireacht ar shaoráidí a bhfuil ceadúnas acu ón GCC;
- Cur i bhfeidhm an dea-chleachtais a stiúradh i ngníomhaíochtaí agus i saoráidí rialáilte;
- Maoirseacht a dhéanamh ar fhreagrachtaí an údaráis áitiúil as cosaint an chomhshaoil;
- Caighdeán an uisce óil phoiblí a rialáil agus údaruithe um sceitheadh fuíolluisce uirbigh a fhorfheidhmiú
- Caighdeán an uisce óil phoiblí agus phríobháidigh a mheasúnú agus tuairisciú air;
- Comhordú a dhéanamh ar líonra d'eagraíochtaí seirbhíse poiblí chun tacú le gníomhú i gcoinne coireachta comhshaoil;
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaol.

Bainistíocht Dramhaíola agus Ceimiceáin sa Chomhshaol

- Rialacháin dramhaíola a chur i bhfeidhm agus a fhorfheidhmiú lena n-áirítear saincheisteanna forfheidhmithe náisiúnta;
- Staitisticí dramhaíola náisiúnta a ullmhú agus a fhoilsiú chomh maith leis an bPlean Náisiúnta um Bainistíocht Dramhaíola Guaisí;
- An Clár Náisiúnta um Chosc Dramhaíola a fhorbairt agus a chur i bhfeidhm;
- Reachtaíocht ar rialú ceimiceán sa timpeallacht a chur i bhfeidhm agus tuairisciú ar an reachtaíocht sin.

Bainistíocht Uisce

- Plé le struchtúir náisiúnta agus réigiúnacha rialachais agus oibriúcháin chun an Chreat-treoir Uisce a chur i bhfeidhm;
- Monatóireacht, measúnú agus tuairisciú a dhéanamh ar chaighdeán aibhneacha, lochanna, uiscí idirchreasa agus cósta, uiscí snámha agus screamhuisce chomh maith le tomhas ar leibhéil uisce agus sreabhadh abhann.

Eolaíocht Aeráide & Athrú Aeráide

- Fardail agus réamh-mheastacháin a fhoilsiú um astaíochtaí gás ceaptha teasa na hÉireann;
- Rúnaíocht a chur ar fáil don Chomhairle Chomhairleach ar Athrú Aeráide agus tacaíocht a thabhairt don Idirphlé Náisiúnta ar Ghníomhú ar son na hAeráide;
- Tacú le gníomhaíochtaí forbartha Náisiúnta, AE agus NA um Eolaíocht agus Beartas Aeráide.

Monatóireacht & Measúnú ar an gComhshaol

- Córais náisiúnta um monatóireacht an chomhshaoil a cheapadh agus a chur i bhfeidhm: teicneolaíocht, bainistíocht sonraí, anailís agus réamhaisnéisiú;
- Tuairiscí ar Staid Thimpeallacht na hÉireann agus ar Tháscairí a chur ar fáil;
- Monatóireacht a dhéanamh ar chaighdeán an aeir agus Treoir an AE i leith Aeir Ghlain don Eoraip a chur i bhfeidhm chomh maith leis an gCoinbhinsiún ar Aerthruailliú Fadraoin Trasteorann, agus an Treoir i leith na Teorann Náisiúnta Astaíochtaí;
- Maoirseacht a dhéanamh ar chur i bhfeidhm na Treorach i leith Torainn Timpeallachta;
- Measúnú a dhéanamh ar thionchar pleananna agus clár beartaithe ar chomhshaol na hÉireann.

Taighde agus Forbairt Comhshaoil

- Comhordú a dhéanamh ar ghníomhaíochtaí taighde comhshaoil agus iad a mhaoiniú chun brú a aithint, bonn eolais a chur faoin mbeartas agus réitigh a chur ar fáil;
- Comhoibriú le gníomhaíocht náisiúnta agus AE um thaighde comhshaoil.

Cosaint Raideolaíoch

- Monatóireacht a dhéanamh ar leibhéil radaíochta agus nochtadh an phobail do radaíocht ianúcháin agus do réimsí leictreamaighnéadacha a mheas;
- Cabhrú le pleananna náisiúnta a fhorbairt le haghaidh éigeandálaí ag eascairt as taismí núicléacha;
- Monatóireacht a dhéanamh ar fhorbairtí thar lear a bhaineann le saoráidí núicléacha agus leis an tsábháilteacht raideolaíochta;
- Sainseirbhísí um chosaint ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

Treoir, Ardú Feasachta agus Faisnéis Inrochtana

- Tuairisciú, comhairle agus treoir neamhspleách, fianaise-bhunaithe a chur ar fáil don Rialtas, don tionscal agus don phobal ar ábhair maidir le cosaint comhshaoil agus raideolaíoch;
- An nasc idir sláinte agus folláine, an geilleagar agus timpeallacht ghlan a chur chun cinn;
- Feasacht comhshaoil a chur chun cinn lena n-áirítear tacú le hiompraíocht um éifeachtúlacht acmhainní agus aistriú aeráide;
- Tástáil radóin a chur chun cinn i dtithe agus in ionaid oibre agus feabhsúchán a mholadh áit is gá.

Comhpháirtíocht agus Líonrú

- Oibriú le gníomhaireachtaí idirnáisiúnta agus náisiúnta, údaráis réigiúnacha agus áitiúla, eagraíochtaí neamhrialtais, comhlachtaí ionadaíocha agus ranna rialtais chun cosaint chomhshaoil agus raideolaíoch a chur ar fáil, chomh maith le taighde, comhordú agus cinnteoireacht bunaithe ar an eolaíocht.

Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil

Tá an GCC á bainistiú ag Bord lánaimseartha, ar a bhfuil Ard-Stiúrthóir agus cúigear Stiúrthóir. Déantar an obair ar fud cúig cinn d'Oifigí:

1. An Oifig um Inbhunaitheacht i leith Cúrsaí Comhshaoil
2. An Oifig Forfheidhmithe i leith Cúrsaí Comhshaoil
3. An Oifig um Fhianaise agus Measúnú
4. An Oifig um Chosaint ar Radaíocht agus Monatóireacht Comhshaoil
5. An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tugann coistí comhairleacha cabhair don Ghníomhaireacht agus tagann siad le chéile go rialta le plé a dhéanamh ar ábhair imní agus le comhairle a chur ar an mBord.

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