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CIRCULAR ECONOMY FOR INDUSTRIAL DEVELOPMENT IN UKRAINE

BASELINE STUDY

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1. EXECUTIVE SUMMARY

Ukraine, a middle-income country, is currently embroiled in a state of war, significantly disrupting its economy and causing a substantial decline in labour force participation across various sectors. The enduring conflict has inflicted profound scars on the civilian population, both economically and psychologically. Moreover, the environmental devastation resulting from the war is unprecedented, further exacerbating the country's challenges. The combined effects of these factors necessitate urgent action, urging a reconstruction effort that aims to improve and rectify the inefficiencies of Ukraine's pre-war economy, which heavily relied on a linear and fossil-based economic model.

The concept of a circular economy in Ukraine has gained traction, largely influenced by European frameworks like the *European Green Deal*. Despite policy developments intended to increasingly align with EU standards, such as the adoption of the Law of Ukraine on National Waste Management in June 2022, challenges persist in effectively implementing circular economy principles. While regulatory advancements have taken place in the construction sector, a comprehensive national strategy is lacking; what's more, unreliable data and low recycling rates—exacerbated by a low landfill wax—remain pervasive challenges for waste infrastructure. Material inefficiencies plague various sectors, driven by outdated infrastructure and inadequate investment, hindering progress towards circularity. Despite initiatives like the RECP Centre fostering circular business practices, access to financing remains a significant obstacle, particularly for small and medium-sized enterprises (SMEs). Overcoming these challenges and driving sustainable economic practices in Ukraine will require a well-coordinated management system, improved financing environments, and heightened awareness of circular economy principles.

This report explores in which sectors circular economy strategies can best be leveraged in Ukraine. Our methodology provides an approach for sectoral prioritisation in the context of circular economic development in Ukraine, drawing upon standard economic theory and utilising commonly used indicators from organisations such as the Organisation for Economic Co-operation and Development (OECD) and the World Bank. Building upon Circle Economy's City Scan Analysis framework, this report's methodology compares economic activities based on key metrics such as jobs, greenhouse gas (GHG) emissions, and economic output to prioritise sectors for circular economy strategies. Additionally, to contextualise sectoral prioritisation within the context of a war-torn environment, we have incorporated additional indicators for sectoral development, resilience, and circularity. This triple nexus approach, commonly used in humanitarian and peacebuilding efforts,

underscores the interconnected nature of these endeavours, particularly relevant in Ukraine's pursuit of lasting stability through integrated sustainable development strategies. This report evaluates each sector's performance across these parameters to guide strategic decision-making.

The Manufacturing sector, **and particularly subsectors like Food and beverages, Electrical and machinery, and Metal products, is the top priority for implementing circular economy solutions.** This is due to its significant economic output and high material footprint. Agriculture, forestry, and fishing follow closely behind, highlighting the importance of addressing material dependency and fossil fuel reliance within this sector. The construction sector also stands out for its low CO2 efficiency performance and material dependency. These results align with European strategies and particularly the sectoral focus of the *Circular Economy Action Plan* (CEAP), which focuses on the following key product value chains: Food, water, land; Clothing, textiles; Electronics & ICT; Household appliances; Automotive, batteries; plastics, packaging; and Construction and buildings.

This research builds on the Key Elements Framework, a framework developed by Circle Economy to categorise circular economy strategies. The strategies proposed for Ukraine encompass a wide range of initiatives aimed at **optimising resource use, promoting renewable energy, extending product lifetimes, and repurposing waste streams**. These strategies include prioritising regenerative materials and energy sources, maximising the lifetime of products and biological resources, and utilising waste as a valuable resource through recycling and energy recovery. Achieving these core strategies will require rethinking business models to prioritise durability and circularity, collaborating across industries to drive change, and strengthening knowledge and digital infrastructure. By implementing these strategies, Ukraine can foster innovation, reduce environmental impact, and promote long-term economic prosperity. These can serve as a starting point from which to develop a circular economy roadmap for Ukraine and should be appropriately tailored to the most relevant sectors, as detailed in this report.

Several key metrics were chosen to monitor circular industrial development in Ukraine up until 2030. These include material consumption, material efficiency, circular material use rate, share of renewable energy, energy intensity per GDP, GHG emissions per capita, CO2 efficiency, and waste going to landfill.

- Material consumption, measured in tonnes per capita, and material efficiency, calculated as GDP produced per kilogram of material inputs, reflect Ukraine's

economic output relative to its material use, with targets set to align with global and EU standards.

- The circular material use rate aims to measure the proportion of recycled materials flowing through the economy, with a target aligned with global goals.
- Additionally, targets for share of renewable energy and energy intensity per GDP aim to diversify Ukraine's energy mix and reduce GHG emissions.
- CO_2 efficiency indicates emissions relative to economic output, while waste going to landfill assesses waste management practices, with targets set to align with European directives and global environmental quotas.

The sector-specific indicators for monitoring the circular performance of Ukraine's key economic sectors encompass agriculture, manufacturing (food and beverages, plastics and electronics), and construction. Drawing from the EU's *Farm to Fork Strategy*, *Fit for 55* and various EU Directives, targets have been established for each sector.

- For agriculture, targets include reducing GHG emissions to align with EU goals, increasing organically farmed land to enhance competitiveness and environmental sustainability, and decreasing fertiliser use to match EU recommendations.
- In the manufacturing sector, goals entail reducing waste generation, increasing circular material use rates in textiles, and addressing plastic packaging waste by aligning with EU directives on recycling and reduction.
- Additionally, targets for waste electrical and electronic equipment (WEEE) recovery and construction and demolition waste (CDW) recovery aim to improve waste management practices in line with EU standards.

These metrics provide a comprehensive framework for evaluating Ukraine's progress towards a circular economy, and aligning as much as possible with European ambitions.

A selection of international best practices for circularity were hand-picked to inspire key Ukrainian stakeholders. They include initiatives in the food and beverages sector, innovative collection systems for domestic recycling, an initiative in the textiles industry that tackles post-consumer textile waste, and two additional case studies in the electrical and machinery sector as well as the metals sector. Together, these best practices serve to inspire and offer practical illustrations of how circular initiatives can be used to drive industrial development, reduce Ukraine’s material footprint and address policy challenges in the country.

A mix of different data sources were used to complete this report. We relied on SCP HAT, State Statistics Service of Ukraine, and EORA between 2020 and 2022. Detailed sectoral data availability in Ukraine poses a challenge overall. Numerous data gaps—particularly relating to material footprints and waste footprints—limit the detail of analysis possible. Recent updates from the UNEP SCP HAT database (2024) consider the impacts of the war and indicate an improvement in CO2 efficiency for several sectors in Ukraine. However, as specified in the report, this data cannot be considered fully reliable and warrants further investigation and complementary research.

2. INTRODUCTION

This report aims to provide a comprehensive analysis and strategic framework for the implementation of circular economy principles in Ukraine, addressing current challenges, identifying opportunities, and outlining specific actions to enhance resource efficiency and sustainability across various sectors. As an integral component of the EU-funded EU4Environment Action and Output five within the "Industrial capacity-building, policy advice and diagnostics for the green recovery of Ukraine" project funded by the German Government, its objective is to streamline the examination of existing conditions within the country and to advocate for the integration of circular economy principles. This initiative aims to highlight the potential advantages for various stakeholders, including: businesses, experts, governmental bodies, academic institutions, and civil society organisations.

This report is outlined as follows:

1. Chapter three provides an introduction to the circular economy framework and serves as an *aide-mémoire*, outlining key circular principles and their relevance to the Ukrainian context.
2. Chapter four presents a short overview of the current state of circularity in Ukraine, highlighting existing practices, challenges, and potential opportunities for advancement.
3. Chapter five summarises the priority value chains for circular economy application, outlining their significance and potential impact on circularity efforts.
4. Chapter six gives an overview of the current circular opportunities within the prioritised sectors of the economy.
5. Chapter seven provides a long list of indicators for monitoring circularity progress, including guidelines on measurement approaches, with a baseline established and projections for the year 2030 in Ukraine.

Several additional annexes provide further information:

- Annex I and Annex II provide further explanation on the sector prioritisation methodology for Chapter five, and also include more in-depth information on the priority sectors.

- Annex III is closely linked to Chapter four and provides further information on the state of industrial and technological infrastructure capacity pertinent to circular economy initiatives within Ukraine for the key sectors.
- Annex IV provides a table with a comprehensive overview of the different circular strategies explored in Chapter six.
- Annex V illustrates the different sources of data used as well as the associated data gaps and limitations of the study.

3. FRAMEWORKS FOR CIRCULAR ECONOMY ANALYSIS

There are multiple frameworks used to define and describe the circular economy concept. All share the understanding that the circular economy aims to reduce waste[1] and decouple the current economic system from the current take-make-waste model, while facilitating positive benefits for the environment, people and the economy.

Since its start, the circular economy has always aimed at yielding holistic environmental, economic and social benefits. In Ukraine's context of war and economic uncertainty, a circular economic model can be used as a means to recover and stabilise the economy, while at the same time ensuring compliance with European regulations. Generally speaking, the circular economy can support industrial development in a number of ways:

1. **Resource efficiency**: Circular economy practices aim to optimise resource use by promoting reduced consumption, recycling, refurbishing, and remanufacturing. This reduces virgin material consumption and minimises waste generation.
2. **Enhanced resilience**: Diversifying supply chains through circular economy practices can enhance the resilience of industries by reducing dependence on scarce resources and minimising the impact of price volatility.
3. **Job transformation and creation**: The transition to a circular economy often requires new business models, technologies, and skills. This can result in the creation of new jobs in areas such as recycling, remanufacturing, and waste management.
4. **Innovation**: Circular economy approaches encourage innovation in product design, manufacturing processes, and business models. This can lead to the development of sustainable and environmentally-friendly technologies.
5. **Cost savings**: Adopting circular economy principles can generate cost savings for industries. Recycling and reusing materials can be more cost-effective than extracting and processing virgin resources.
6. **Environmental conservation**: By reducing the demand for virgin materials, limiting pollution, and decreasing the need to landfill waste, the circular economy contributes to environmental conservation and helps address climate change.

[1] Waste here is understood in its broadest sense, i.e., including all forms of leakage into the environment, rather than solid waste alone.

7. **Social benefits**: Circular economy practices can have positive social impacts if they're designed with this in mind, such as improved community well-being, better waste management practices, and reduced environmental pollution.

Within the framework of the EU4Environment project, the UNIDO framework has been used to describe the circular economy, focusing on four key strategies: Reduce the environmental footprint, Generate increased income, Reduce resource dependency, and Minimise Waste. It is a useful tool to consider the way in which the public as well as private sector can consider developing circular economy policies or business models. It is also a useful tool to consider transforming existing sectors and value chains.

Figure X displays UNIDO's outline of circular economy principles (2019).

At Circle Economy, the Key Elements Framework (KE Framework) is used to describe the circular economy. The development process of the KE Framework involved mapping terms and definitions used by various frameworks and organisations (for example, the 10R framework, the Flow Framework devised by Bocken et al., and the Ellen Macarthur Foundation's principles of the circular economy), which resulted in eight 'key' elements that make up the circular economy. This framework is constantly being updated and improved. **The KE Framework is designed for a broad audience, including policy makers, educators, researchers and businesses, and thus proves useful in the context of this analysis**.

The framework comprises **three core elements** and **five enabling elements**. The core elements focus on shifting physical flows, while enabling elements to tackle obstacles to implementation.

The three core elements are:

- **Prioritise regenerative resources**: Ensure renewable, reusable, non-toxic resources are utilised as materials and energy in an efficient way.
- **Preserve and extend what's already mad**e: While resources are in-use, maintain, repair and upgrade them to maximise their lifetime and give them a second life through take back strategies when applicable.
- **Use waste as a resource**: Utilise waste streams as a source of secondary resources and recover waste for reuse and recycling.

Table X outlines the core elements of the KE Framework and shows how these align with other circular economy frameworks.

Circle Economy's core elements	**Bocken's Flow Framework**	**10R Framework**	**5R framework**	**Ellen Macarthur Foundation's principles of the circular economy**	**UNIDO's Circular Economy Framework**
Prioritise regenerative resources	Regenerate flows Narrow flows	Refuse Reduce Rethink	Reduce	Regenerate ecosystems Design out waste	Renewable resources Resource efficient and cleaner production Optimized distribution Reduced consumption Design
Stretch the lifetime	Slow flows	Reuse Repair Refurbish Remanufacture	Reuse Repair Refurbish	Keep products in use for longer	Sharing Remanufacturing and refurbishing Repair and maintenance Reuse
Use waste as a resource	Cycle flows	Repurpose Recycle Recover	Recycle	Design out waste	Segregation Collection Recycle Regeneration

The enabling elements aim to address the persistent obstacles to the implementation of core circular economy strategies. They are are:

- **Rethink the business model:** Consider opportunities to create greater value and align incentives that build on the interaction between products and services.

- **Design for the future**: Account for the systems perspective during the design process, to use the right materials, to design for appropriate lifetimes and to design for extended future use.
- **Team up to create joint value**: Work together throughout the supply chain, internally within organisations and with the public sector and communities to increase transparency and create joint value.
- **Incorporate digital technology**: Use digital, online platforms and technologies that provide insights to track and optimise resource use, strengthen connections between supply chain actors, and enable the implementation of circular models.
- **Strengthen and advance knowledge**: Develop research, structure knowledge, encourage innovation networks and disseminate findings with integrity.

The KE Framework will be used throughout this study to best assess the most promising opportunities for the circular, sustainable development of the Ukrainian economy.

4. OVERVIEW OF THE CURRENT STATE OF CIRCULARITY IN UKRAINE

Although the circular economy has achieved more policy attention in Ukraine in recent years, it is still in an early stage of development.

4.1 Policies supporting the circular economy

Since the onset of the war, a number of policy developments have taken place. These have been largely inspired and supported by the European framework for a circular economy and the *European Green Deal*, with the condition of Ukraine-EU integration. The earlier Association Agreement of 2014 between the EU and Ukraine have already supported the adaptation of Ukraine's regulatory body to the EU's. In the Agreement's section 'Economic and Industrial Cooperation', it outlines that Ukraine needs to adapt its legislation to numerous Directives and Regulations.

The most relevant piece of legislation for the circular economy is the adopted *June 2022 Law of Ukraine on 'National waste management'*,[2] regulating the relations in connection to the management of waste generated in Ukraine, transported through the territory of Ukraine, exported abroad and imported into Ukraine for the purpose of recovery or recycling. The *National Waste Management Plan until 2030*,[3] adopted in 2019, identifies tasks and practical measures designed to enable Ukraine to switch to a new model of waste management by 2030. Now that the June 2022 law on a national waste management architecture has been voted on, regional administrations are in the process of developing regional plans for waste management, up to 2025, as demonstrated by the *Zaporizhzhia Oblast*[4] and the regulation for regional waste management as well as local waste management plans. These should be developed and approved in 2023 and 2024–2025, respectively. Nevertheless, it

[2] DLF. (2023). Waste Regulation in Ukraine: New Legal Regulation. Retrieved from: DLF Website

[3] Ministry of Environmental Protection and Natural Resources of Ukraine. (2019). Ostap Semerak: Government approves National Waste Management Plan until 2030. Retrieved from: The Cabinet of Ministers of Ukraine Website

[4] Запорізької обласної державної адміністрації . (2024). РЕГІОНАЛЬНИЙ ПЛАН УПРАВЛІННЯ ВІДХОДАМИ ДО 2035 РОКУ ЗАПОРІЗЬКОЇ ОБЛАСТІ РОЗРОБЛЯТИМЕТЬСЯ ВІДПОВІДНО ДО НОВОГО ЗАКОНУ УКРАЇНИ «ПРО УПРАВЛІННЯ ВІДХОДАМИ», ЯКИЙ НАБРАВ ЧИННОСТІ У ЛИПНІ ЦЬОГО РОКУ. Retrieved from: Zaporizhzhya Regional State Administration Website

has been noted that the understanding and application of the circular economy across legal and regulatory documents in Ukraine is still limited.

According to our research, some of the persistent problems relating to the proper implementation of circular economy policy include:

- No comprehensive strategy for transitioning to a circular economy in Ukraine;
- Limited or nonexistent sectoral circularity objectives or regulation, particularly for the construction sector (see Box X);
- Fragmented inter ministerial/agency/municipal collaboration; and
- Lack of a coordinated approach for monitoring waste statistics.

Box X outlines evolving regulations for circularity and waste management in the construction sector.

The construction industry in Ukraine has undergone regulatory changes to align with EU standards. Initiatives such as the *National Strategy on Waste Management until 2030* and the *National Plan on Waste Management* were introduced before the war—in 2017 and 2019, respectively. Notably, the law *On providing construction products to the market* was passed in 2023, emphasising sustainable resource use, and Ukraine adopted over 500 national standards aligned with EU construction product standards in 2021, including:

- The prohibition of asbestos in new building materials in 2022;
- New procedures regarding demolition waste;
- New updates to national building standards regarding energy conservation and thermal modernisation.

However, despite these positive steps, **a comprehensive national strategy for circularity in the construction industry is still lacking.**[5] The recently enacted laws have been deemed 'moderate' and more recommendatory than prescriptive, with control mechanisms either 'undefined' or 'ineffective'[6]. For instance, challenges persist in addressing hazardous waste, such as asbestos in existing buildings.

According to experts, more attention is needed to **establish national standards for secondary and recycled building materials**, outlining requirements to transform these materials into marketable products.

[5] Niemeyer, M., & Kozub, N. (2023). New European Bauhaus, circular housing in Ukraine (Project B). Retrieved from: New European Bauhaus Website

[6] Niemeyer, M., & Kozub, N. (2023). New European Bauhaus, circular housing in Ukraine (Project B). Retrieved from: New European Bauhaus Website

4.2 Waste infrastructure

Ukraine lacks reliable statistics and data on waste management overall, so it is difficult to present a complete picture of reuse, recycling and disposal rates in the country. Reports[7] have pointed to the fact that Ukraine had no effective waste management in place before the war. The war has further complicated this situation, with rising levels of construction debris and toxic and hazardous waste. Overall, most of Ukraine's domestic waste is either landfilled or incinerated, and its industrial waste is largely landfilled or abandoned. According to data from Ukrstat, the vast majority of household waste was landfilled in 2020.[8] Secondary recovery/recycling rates were very low (below 1%), and it should be noted that statistics do not always distinguish between energy recovery use and other recovery methods, such as recycling. The composting rate was unavailable. Comparatively, in the EU, nearly half of municipal waste is recycled.[9]

It is important to note that the landfill tax in Ukraine is far below EU levels (€0,15 per tonne versus for instance €107 per tonne in the Netherlands).[10] Increasing this tax, however, would necessitate caution so that the burden of the economic handling of waste is not borne by the consumer but rather by the companies placing the products/materials on the market.

4.3 Material efficiency across sectors

Across various sectors in Ukraine, low efficiency persists as a significant challenge. Ukraine's material efficiency is currently low: a recent study from UNIDO points to above-average CO2 emission intensity in the manufacturing sector, as well as raw material consumption intensity in comparison to neighbouring EU countries and even Turkey.[11] In the industrial sector, outdated infrastructure and technologies are contributing to inefficiencies in production processes, leading to higher resource consumption and increased environmental impacts. Additionally, inadequate investment in research and development has limited innovation

[7] Lindskog, T. The Present State of the Circular Economy in Ukraine. Retrieved from: Circular Innovation Lab Website

[8] Державна служба статистики України . (2020). Поводження з побутовими та подібними відходами за 2011-2020 роки. Retrieved from: UkrStat Website

[9] European Environment Agency (EEAS). (2023). Waste recycling in Europe (2020). Retrieved from: EEA Website

[10] Ministry of Agriculture in the Netherlands. (2018). Circular economy in Ukraine. Retrieved from: Ministerie van Landbouw, Natuur en Voedselkwaliteit Website

[11] UNIDO. (2024). Executive summary: Ukraine industrial country diagnosis 2023. Retrieved from: UNIDO Website

and technological advancements, further exacerbating the sector's inefficiencies.[12] There are currently no indicators being reported nationally on material efficiency across industries.

In agriculture, outdated farming practices and a lack of modernisation are hindering productivity and sustainability efforts. Farming practices prevalent in rural areas contribute to low yields and inefficient land use, perpetuating food insecurity and economic stagnation. Furthermore, insufficient access to capital and credit for farmers impedes investment in modern equipment and agricultural techniques, perpetuating a cycle of inefficiency in the sector.[13]

In the energy sector, reliance on outdated and inefficient coal-fired power plants is contributing to high levels of pollution and GHG emissions, exacerbating environmental degradation and health risks. Limited investment in renewable energy infrastructure and the slow adoption of clean energy technologies have further impeded progress towards sustainable energy production, although it can be noted that Ukraine made progress in its green energy industry, particularly solar, before the war.[14] Moreover, inadequate energy efficiency measures in residential and commercial buildings have led to excessive energy consumption and higher utility costs for consumers.[15]

Inadequate regulatory frameworks and enforcement mechanisms have also contributed to low efficiency across sectors, allowing unsustainable practices to persist without adequate accountability.

4.4 Uptake of circular business models throughout the economy

The establishment of the RECP Centre has accelerated the implementation of circular economy practices in Ukraine. Founded in 2013 and based on the previous UNIDO cleaner production initiative of 2007, with support from UNIDO and Switzerland, the Centre plays a

[12] European Commission. (2023). *Ukraine 2023 report* (pp.1-152, Rep.). Retrieved from: European Commission Website
[13] European Commission. (2023). *Ukraine 2023 report* (pp.1-152, Rep.). Retrieved from: European Commission Website
[14] UNIDO. (2024). Executive summary: Ukraine industrial country diagnosis 2023. Retrieved from: UNIDO Website
[15] European Commission. (2023). *Ukraine 2023 report* (pp.1-152, Rep.). Retrieved from: European Commission Website

pivotal role in helping companies integrate sustainable practices into their business models. A recent UNIDO enterprise survey from 2023[16] shows that mentalities may be changing in the private sector, as 41% of firms indicated they opted for strategies that use resources more efficiently in response to the conflict.

Nevertheless, challenges persist for Ukrainian firms transitioning towards sustainable business models. The main challenge is access to financing. As reported by the EU4Environment programme, barriers include high interest rates, collateral requirements, and documentation processes.[17] Although interest rates have decreased in recent years, obtaining loans remains difficult and expensive for many businesses. With SMEs increasingly seeking loans, targeted improvements are needed to enhance the financing environment and support larger production-related investments. Overcoming barriers to circular business projects, such as limited access to bank financing, still requires the development of a unified framework for assessing project effectiveness, payback, and risks, while also raising awareness and education levels. This is still lacking overall.

[16] UNIDO. (2024). Executive summary: Ukraine industrial country diagnosis 2023. Retrieved from: UNIDO Website

[17] EU4Environment. (n.d.). Boosting circular economy in Ukraine through resource efficiency (pp. 1-6, Rep.). Retrieved from: EU4Environment Website

5. PRIORITY SECTORS FOR CIRCULAR ECONOMY IMPLEMENTATION

5.1 Circular sectors in Ukraine

The selection of priority sectors to introduce a circular economy plan for economic recovery and development of Ukraine is one of the main objectives of this study. The sections below present the methodological approach that was followed as well as the main results.

5.2 Methodological approach

Our approach for designing this methodology relies on standard economic theory for sectoral priorisation, relying on most commonly used indicators to measure the importance of a sector in the economy, such as the OECD's[18] and the World Bank's[19] main economic indicators. This approach echoes the approach employed in our City Scan Analysis, which helps to prioritise sectors for circular economy strategies by comparing the country's economic activities and their impact on key metrics such as jobs, emissions and economic output.[20]

As this analysis aims to focus on circular economic development in the context of war, we have added additional indicators in order to further contextualise the sectoral prioritisation and focus on sustainable development. This resulted in the construction of three indicators covering a **triple nexus: sectoral development, circular economy and resilience**. The triple nexus is commonly used in humanitarian and peacebuilding efforts, to show the interconnected nature of humanitarian, development, and peacebuilding efforts. This approach seems to be very relevant for Ukraine, where an integrated approach to sustainable development can hopefully contribute to lasting stability.[21] The research team

[18] OECD. (n.d.). Main economic indicators (MEI). Retrieved from: OECD Website

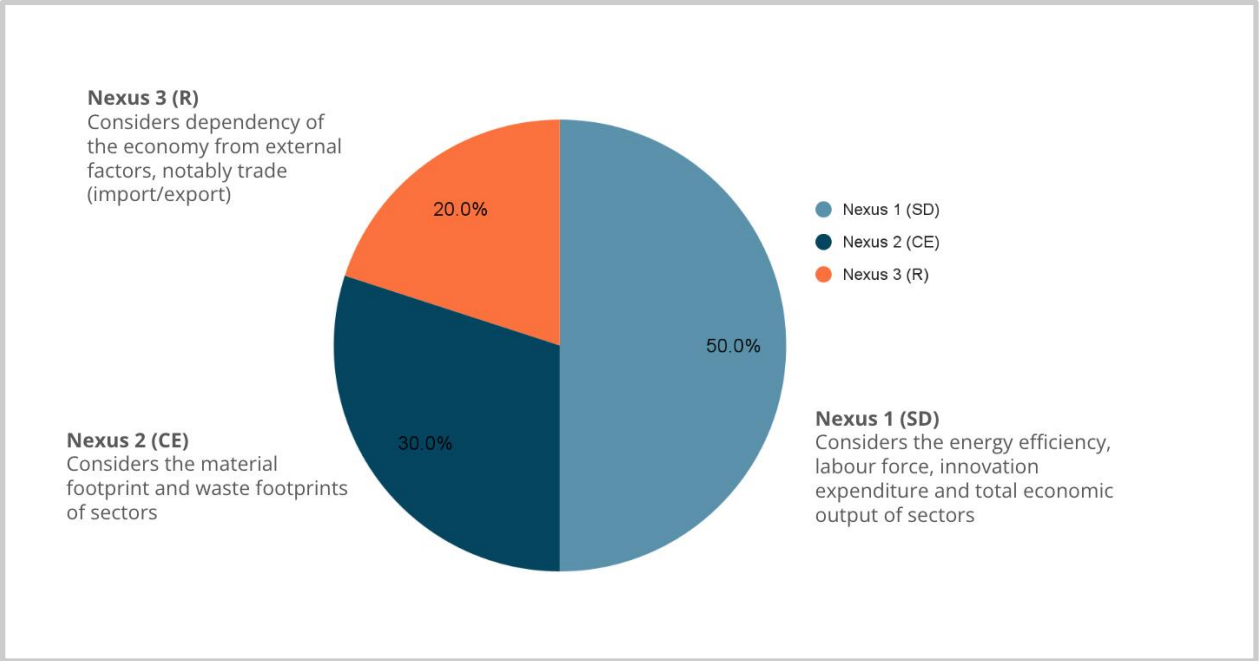
[19] World Bank. (n.d.). Indicators. Retrieved from: Word Bank Website

[20] The subsequent stages of the City Scan analysis, such as the Material Flow Analysis, are not employed in this study.

[21] Howe, P. (2019). The triple nexus: A potential approach to supporting the achievement of the Sustainable Development Goals?. *World Development*, 124(104629). doi:10.1016/j.worlddev.2019.10462

then assessed how each sector of the economy[22] performs across these different parameters.

Figure X illustrates the methodological approach for selecting priority sectors in Ukraine: the triple nexus (Sectoral development, circular economy, and resilience).



Examining sectoral development, circular economy principles, and resilience together is crucial for identifying priority sectors that can sustain long-term economic and environmental benefits. As illustrated in Figure xx, each of the three indicators was assigned a slightly different weight, but this weighting scheme does not substantially alter the resultant outcomes.

- **Sectoral development (SD)** is essential for fostering economic growth and job creation, but it must be approached with a focus on sustainability and resource efficiency;
- Integrating **circular economy (CE)** principles, which prioritise the reduction, reuse, and recycling of materials (in the form of whole products and product parts as well as raw materials), ensures that industrial processes minimise waste and environmental impact;
- Additionally, **resilience (R)** is a key factor in adapting to unforeseen challenges, such as supply chain disruptions or economic crises.

[22] ISIC Level 1

By combining these three perspectives, Ukrainian decision-makers can pinpoint priority sectors that not only drive economic prosperity but also contribute to environmental sustainability and withstand shocks. **This holistic approach acknowledges the interconnectedness of economic, environmental, and social factors**, fostering a resilient and sustainable industrial ecosystem that aligns with the needs of the present without compromising the ability of future generations to meet their own needs.

A detailed methodology is presented in the Annex II.

5.3 Main results

Table X shows the performance of each sector of the economy for each of the three indicators. **When interpreting the following results, please note that the percentages reflect ordinal rankings, not actual proportions**. Scores equalling 0% do not mean that there is no potential for the circular economy, but rather that the current performance is low, or that data for this indicator is limited or not available.

Refer to the full methodology section in Annex II for more information.

The Manufacturing sector, and in particular Food and beverages, Electrical and machinery and Metal products, emerges as the clear priority sector to implement circular economy solutions, followed by **Agriculture, forestry and fishing.** Several sectors then rank similarly overall, although they perform differently across the three key indicators. These are: the Water supply, sewerage and waste management sector, the Construction sector, the Wholesale and retail trade, the Transportation and storage as well as Accommodation and food service activities sectors.
We have nevertheless chosen to prioritise **Construction** as the third priority sector for this study, due to the major challenges posed by the construction war debris and the essential role of the construction sector in preparing for and rebuilding in a circular way.

Table X gives an overview of the performance of Ukraine's economy against the three indicators (Sectoral development, circular economy, and resilience)

Sector	Code	SD	R	CE	Final Score
Agriculture, forestry and fishing	A	25%	1%	23%	48%
Mining and quarrying	B	4%	3%	8%	16%
Manufacturing	C	44%	14%	6%	63%
Electricity, gas, steam and air conditioning supply	D	17%	6%	1%	24%
Water supply; sewerage; waste management and remediation activities	E	1%	6%	1%	24%
Construction	F	11%	8%	4%	23%
Wholesale and retail trade; repair of motor vehicles and motorcycles	G	19%	9%	0%	28%
Transporting and storage	H	14%	7%	0%	21%
Accommodation and food service activities	I	2%	20%	0%	22%
Information and communication	J	2%	6%	0%	8%
Financial and insurance activities	K	4%	9%	0%	12%
Real estate activities	L	2%	9%	0%	11%
Professional, scientific and technical activities	M	4%	9%	0%	13%
Administrative and support service activities	N	3%	9%	0%	12%
Public administration and defence; compulsory social security	O	5%	14%	0%	19%
Education	P	10%	7%	1%	18%
Human health and social work activities	Q	8%	5%	1%	14%
Arts, entertainment and recreation	R_S	3%	5%	1%	9%

Please note that conditional formatting was applied to this table. The shading is darker for higher numbers. Blue shading is indicated for the indicators, and yellow for the overall result.

Detailed results for each sector are available in Annex II, including a rough trade analysis for each sector.[23]

5.3.1 Manufacturing

Key findings

The **Manufacturing sector, and in particular the Electrical and machinery, Food and beverages and Metal products subsectors, emerges as the clear priority sector to implement circular economy solutions**, driven primarily by its low CO2 efficiency per unit GDP and high material footprint. The different sectors show contrasted levels of innovation expenditure, and overall, a relatively high material import dependency, suggesting that many materials are imported to meet the needs of this sector. Seeking alternatives to imports as well as developing local, circular products will be key to boost the economy and employment, as well as lowering sectors' material footprints.

Detailed findings[24]

The manufacturing sector shows some common characteristics across its subsectors:

- It predominantly produces and exports low-tech intermediate products, underlining the resource-heavy aspect of the economy. The Food and Beverages and Textile sectors notably exhibit low innovation expenditure according to our data from the State Statistics Service of Ukraine for 2020.
- It demonstrates relatively low levels of CO2 efficiency, signalling chronic inefficiencies in resource utilisation and energy consumption.
- It exhibits a high material footprint across sectors, with waste generation comprising an overwhelming portion for metal products (85%).
- Labour growth rates have shown considerable fluctuations over time. Statistics from the International Labour Organization (ILO) indicate that the manufacturing labour force in Ukraine shrunk by 5.8% overall between 2019 and 2021. Worryingly, all of the prioritised sectors show a declining labour force, which has likely not improved since the start of the war. Between 2019 and 2021, the Textiles and Wearing Apparel sector

[23] A rough trade data analysis (explored in further detail in the subsequent sections) shows that Russia was Ukraine's main trading partner before the war. The new situation and road to reconstruction and recovery will push Ukraine to develop new trading relationships and explore new markets. Many inflow and outflow components will be reoriented and restructured as a consequence. Ukraine must therefore prepare its industry to be more competitive, innovative and efficient, notably to meet the requirements of the EU market.

[24] Please note that the detailed results of the analysis are available in the Annex X for each sector.

fell by 9.06%, metal products by 6.40% and electric and machinery by 20.12%. None of the other manufacturing sectors grew, save for the petroleum products sector (0.30%), strongly driven by pharmaceuticals and plastics, as well as other manufacturing, including furniture (8.13%).

- In contrast to these recent declines, ILO's projected scenarios for employment growth between 2022 and 2032 in the manufacturing sector is of 14.2%,[25] the second highest estimated rate of growth after the Wholesale sector. Manufacturing also demonstrates an above-average education level for the country.
- In terms of trade, European countries such as Poland, Hungary, Germany, and Romania are primary partners for Ukraine's exports of agrifood products, metals, electrical, and machinery goods. Notably, the US also serves as an import partner for metal products. In 2022, the top four importers by value for manufacturing products were Turkey, China, Poland and Slovakia.

Furthermore, specific subsectors within the manufacturing sector display distinct traits:

- **Food and beverages**: This sector scores highly across all indicators and should be prioritised for designing circular solutions. It is characterised by a high material footprint, substantial labour force, and low innovative expenditure. It is strongly tied to the agricultural sector, making this manufacturing sector less dependent on imports than the others.
- **Electrical and machinery**: This sector showcases high innovation expenditure and final demand, with notable import dependency, particularly from China. Despite being a significant contributor to the country's economic output (12% in 2021, $US37.3 billion), a significant portion of goods is imported (48.8% of the sector's imports are coming from China).
- **Metal products**: The sector displays a high export dependency and waste footprint. It contributes significantly to the country's economic output, second to electrical and machinery ($US25.7 billion in 2021). The waste footprint of the sector is enormous, dwarfing that of all other subsectors.
- **Textiles**: The sector exhibits a high import dependency and labour force, with minimal innovation expenditure,[26] suggesting reliance on conventional methods. The

[25] ILO. (2023). Prospects for achieving Ukraine's GDP targets for 2032 in the context of the labour market. Retrieved from ILO Website

[26] Several different indicators can be considered to measure innovation. When looking at the share of innovative entreprises, ie. share of enterprises reporting some kind of innovation, the percentage

import data highlights that a substantial portion of post-consumer textiles are being imported with less than 2% being effectively repurposed. By value, close to 50% of all exported waste to Ukraine originates from China, although by volume the biggest country of origin for post-consumer textiles is the United Kingdom in 2021.

- **Wood and paper**: The sector demonstrates reasonable CO2 efficiency but lacks significant innovation. Despite contributing to the overall labour force, its economic output remains comparatively low. The sector heavily relies on imports while maintaining moderate levels of exports, suggesting that more could be done to reduce dependency on imports and boost a local market for recycled wood and paper. There is a notable absence of information regarding waste data management within this industry.
- **Transport equipment**: The sector's CO2 efficiency performance is relatively satisfactory, yet innovation remains low. Despite this, the sector makes a substantial contribution to the country's economic output. However, it heavily relies on imports, although it also plays a role in exports. Similarly to other sectors, there is a lack of available data regarding waste management practices or material footprints within this sector.

5.3.2 Agriculture, forestry and fishing

Key findings

The **Agricultural, forestry and fishing sector** appears in second place as a priority sector for circular solutions. The prioritised subsectors include the production of grain, wheat, and maize as well as ruminants. The sector boasts a large number of workers and has a particularly heavy material footprint as it imports a significant portion of its raw materials. The sector is still too reliant on fossil fuels, such as gas and oil, to operate. It needs to boost alternative energy sources, notably by tapping into its huge biomass potential, as well as turn to developing local, organic fertiliser to reduce its dependence on imports.

Detailed findings[27]

The Agricultural, forestry and fishing sector shows some common characteristics across its subsectors:

is quite high in manufacturing, as high as ±50% for pharmaceuticals and ±40% for computer products. However, actual expenditure isn't high in the currency.

[27] Please note that the detailed results of the analysis are available in the Annex X for each sector.

- The agricultural sector is still heavily reliant on oil and natural gas to operate. Overall, three subsectors, Cereals, Vegetables, Roots and tubers, and Raising of cattle are responsible for over 50% of the sector's consumption of oil and natural gas, **making these three subsectors a priority for the energy transition in the agricultural sector**.[28]
- The agricultural sector employs a large number of workers. Although the sector has experienced a labour decline in recent years, its expected growth rate between 2022 and 2032 to meet expected GDP targets is 12.6%, one of the highest overall. The sector relies on a predominantly low-skilled workforce overall.[29]
- Ukraine's vast fields have a huge capacity for extensive biomass usage, which is currently extremely underutilised (less than 2% in the country's overall energy mix).
- Ukraine ships its wheat, cereals and oil seeds all over the world. Its agricultural exports are overwhelmingly dominated by the export of cereals, followed by various oil seeds. Its key markets include China, Turkey, various EU Member States as well as countries in the Middle East.
- The sector is also reliant on several imports, namely fertiliser, fish, fruit and nuts as well as beverages/drinks. There is hence a wide opportunity for Ukraine to develop local, sustainable organic fertiliser through circular approaches—by utilising local waste to create compost, for instance.
- Waste data was not available for the various subsectors, which does not allow us to gather further insights on the different agricultural waste categories (for example, organic, solid, liquid, gaseous) that can be repurposed for environmental purposes. Data is also missing on the significant amounts of manure generated from poultry and ruminant animal farming.

Furthermore:

- Cereals have the most important waste footprint, pointing to a considerable need for reducing waste and finding avenues to valorise it.
- Considering the growing of cereals represents the bulk of the material footprint, and consequently the bulk of energy requirements, small innovations in this space may have the most impactful savings overall. That being said, smaller overall energy consumers in the agricultural sector have relatively higher energy requirements per tonne produced. Producing wheat requires approximately 2.6 gigajoules per tonne,

[28] UNEP (2024). SCP-HAT database v3.0. UN Life Cycle Initiative, UN One Planet Network, UN International Resource Panel. Paris. Retrieved from Website

[29] ILO. (2023). Prospects for achieving Ukraine's GDP targets for 2032 in the context of the labour market. Retrieved from ILO Website

which is on par with but slightly behind Germany and the Netherlands.[30] **There is an opportunity to diversify sources of energy and to tap into the vastly underutilised biomass**.

5.3.4 Construction

Key findings

The **Construction sector** has a poor CO2 efficiency as well as a high material import dependency, suggesting that there is potential to start using alternative materials in the sector, notably to lower the dependency on non metallic minerals. The CO2 efficiency is also low, suggesting that production methods are not as efficient as they could be. The sector does not report on waste data, which is also problematic. Accurate monitoring of waste, waste prevention strategies and the proper management of flows for toxic and non-toxic waste should be a priority.

Detailed findings

- The labour statistics for the sector indicate a notable decline in various subsectors between 2019 and 2021, most notably for civil engineering. This suggests a significant downturn in infrastructure development activities. Projected labour growth rates for the sector stand at 8.8%.
- From the reported primary energy consumption in the sector for the construction of buildings, roads and railways, the principal energy input going into the sector is mainly coal and natural gas.
- Looking at the raw material use, the sector predominantly relies on the use of non-metallic minerals, such as cement, sand and asphalt (86% of all material use). There is virtually no use of biomass (around 2%), which points to strong opportunities for developing alternative, local building materials (for example, timber).
- In the State Statistics Service of Ukraine, no reported data was available for the construction sector. This is very problematic as most waste treatment channels prior to the war were unestablished, making the current management of construction and demolition waste quite unmanageable.

[30] UNEP (2024). SCP-HAT database v3.0. UN Life Cycle Initiative, UN One Planet Network, UN International Resource Panel. Paris. Retrieved from Website

- The main trading partners for Ukraine as an importer were Poland, Turkey and China. As an exporter, Ukraine's main trading partners were Poland, Spain and Romania in 2022.

5.4 Alignment with other sectoral prioritisations

It should be noted that the current baseline study has been developed in parallel to other research work on circular economy implementation in Ukraine, namely an Exploratory Foresight exercise conducted by UNIDO as well as the development of a circular economy baseline and roadmap funded by the EU Delegation to Ukraine. **The current report follows a different sectoral prioritisation process, focusing on macro-level indicators as detailed in Chapter 5.2, but it is overall aligned with the findings of these organisations:**

- The Foresight Analysis relied on the EU *Circular Economy Action Plan*, and focused on the priority **Key Product Value Chains (KPVC)**: Construction, buildings; Food, water, land; Clothing, textiles; Electronics, ICT; Household Appliances; Automotive, batteries; and Plastic, packaging. It also includes three holistics **Key Industrial Factors (KIF)**: Energy systems, Minerals and metals and Waste management. It considers three horizons:
    - H1: one to five years (Recovery),
    - H2: five to ten years (Transition), and
    - H3: ten to 15 years (Transformation)
    - Through structured consultations with a large number and broad spectrum of Ukrainian stakeholders via surveys and expert panels, the foresight analysis considers how each KPCV and KIF will perform against the three chosen Horizons**.**
- The EU Delegation report prioritised five key sectors in its baseline report published in 2023: agriculture, waste, mining, construction and energy. Our current study highlights energy and waste not merely as sectors, but as cross-cutting systems with significant potential for improvement and optimisation across various sectors. It also prioritises looking into the agricultural sector to implement circular economy solutions. It should be noted that the mining sector also scores highly in our index, but has not been prioritised as a sector for circular economy development in this report. Although mines are essential to power the green transition, the sector is centred on virgin material extraction, and there are limited opportunities to make these initial extractive practices more circular. We therefore prefer to focus on construction, metals or electronics, which—although they source some virgin materials—offer more perspectives for circularity in Ukraine.

Moreover, the sectors identified in this report are also aligned with key national strategies (*National Economic Strategy until 2030*, the *Ukraine Recovery Plan*) and Ukraine-EU integration processing, supporting Ukraine further in implementing its *Association Agreement*. The significance of this lies in its facilitation of changes or adaptations to regulations and institutions, as initiatives within these sectors will be prioritised and financially supported by either external or national donors.

5.5 Sectors as part of value chains

The value chain and sector perspectives are complementary views to study the economy. In its *Circular Economy Action Plan* (CEAP) (2020), the EU takes a value chain approach to develop the circular economy and identifies key product value chains that will be addressed as a matter of priority. Value chains, which cover multiple sectors, look at the interrelationships between them, and provide the opportunity to study the flow of a product or service through multiple sectors. Interventions at the value chain level are more complex as they require collaboration up and down the chain. Interventions at the sector level can be simpler but can lead to unintended effects in other sectors up and down the value chain.

The priority value chains of Food and Textiles, for instance, cross through many sectors in the economy, from Extractive industries (Agriculture and Mining) through to Manufacturing and to Wholesale and Retail Trade. A value chain like Construction and Buildings is also dependent on extractive industries, utilities, and goes on to 'serve' all other sectors of the economy in the creation and operation of buildings in which all other activities take place.

Table X shows the relationship between sectors and the Key Product Value Chains identified in the CEAP. The relationship intends to show, for illustration purposes, the degree to which sectors are integrated inside the value chain.

For example:

- The Food value chain has high relation to the Agriculture, forestry and fishing sector and to Food services, and medium relation to Manufacturing, Utilities, Trade and Transportation.
- The Textiles value chains obtains virgin materials for textiles from a variety of sources, including natural (plant based fibres) and man made (polyester), as well as requiring metals for hardware on clothing (such as zippers, *etcetera*)

Note for all value chains, some similarities are revealed:

- Every value chain is dependent on extractive industries (Agriculture and Mining) for resources, though to differing degrees. Even Food and Textiles, for instance, depend on Mining for the metals that form part of the machinery and equipment used in the manufacturing, storage and transportation of food and textile intermediates and products.
- All value chains are dependent on the electricity and water sectors, and the Manufacturing sector is present in every value chain, as the means to produce the actual goods. The exact specifics of dependency would need to be analysed quantitatively in the context of Ukraine.
- Past the Secondary industries—into the Services sectors—all value chains have a similar relationship to all service sectors. This is because service sectors largely represent office-work, and though they 'deal with' material goods in different ways—for instance studying, selling, financing, teaching, *etcetera*—the material impact is largely similar across all these sectors.

Table X lists the interrelationship between sectors and the seven key product value chains from the EU's CEAP.

Sector	Sector Code	Food, water, land	Clothing, Textiles	Electronics & ICT	Household appliances	Automotive, batteries	Plastics, packaging	Construction and Buildings
Agriculture, forestry and fishing	A							
Mining and quarrying	B							
Manufacturing	C							
Electricity, gas, steam and air conditioning supply	D							
Water supply; sewerage; waste management and remediation activities	E							
Construction	F							
Wholesale and retail trade; repair of motor vehicles and motorcycles	G							
Transporting and storage	H							
Accommodation and food service activities	I							
Information and communication	J							

Thus, for each value chain, in each economy, the best intervention points (or subsectors) must be selected to drive change throughout the value chain.

The sectors selected as priorities in this analysis were Manufacturing, Agriculture, forestry and fishing, and Construction. Within Manufacturing, subsectors were also evaluated in order to select priority products for which circular interventions could be designed. For each of the sectors, and Manufacturing subsectors, carefully selected interventions can spark change across the whole economy, as is further explored in Chapter six.

Ultimately, when formulating circular economy policies, the Ukrainian government should prioritise aligning with the CEAP. To facilitate the current baseline analysis, data collection focused on sectors, chosen for their relative ease of accessibility. This approach ensures that initial efforts are grounded in a solid understanding of sector-specific dynamics, allowing for targeted interventions and effective policy development aligned with broader circular economy objectives.

6. OPPORTUNITIES FOR CIRCULAR ECONOMY IMPLEMENTATION IN UKRAINE

Building on the results of the sectoral prioritisation and relying on the Key Elements (KE) Framework, we have categorised the main opportunities for circular economy implementation across different sectors in Ukraine. **It's important to recognise that these strategies are not tailored exclusively to Ukraine but rather represent broader initiatives developed to serve a wider context.**

These findings will serve to influence the indicator selection and best practices as well as the project proposals. Annex III shows the different circular strategies according to the KE Framework in further detail.

Core elements

6. 1 Prioritise regenerative resources

6.1.1 Regenerative materials

The Construction sector in Ukraine predominantly depends on non-metallic minerals, including concrete, cement, sand, and asphalt, which constitute 86% of all material usage, and much of which is imported. However, abundant local materials like timber, rye and hemp are also available. Additionally, Ukraine possesses vast quantities of reusable concrete panels, steel, and bricks salvaged from damaged buildings and infrastructure.

Prioritised circular strategies:

- Use alternative, bio-based materials and inputs
- Use materials that are not toxic or hazardous
- Use materials that can be easily reused or recycled after use
- Use materials that are renewable and not defined as critical

6.1.2 Regenerative energy

Ukraine's energy composition leans heavily towards fossil fuels. Biomass, despite its substantial potential, remains significantly underutilised. Ukraine has significant potential to expand energy generation from renewable resources, including wind and solar. The

International Renewable Energy Agency (IRENA) conducted a survey of Ukraine's renewable sector and potential in 2015. Ukraine's total wind power potential is between 16 gigawatts and 24 gigawatts, with 16 gigawatts considered economically feasible. Prior to the war, companies had significant wind capacity additions planned, with 91 turbines added in 2021.[31] Furthermore, Ukraine's economic activities are characterised by high material and energy consumption. However, there is untapped potential across all sectors to enhance energy efficiency, presenting opportunities for sustainable development and resource optimisation.

Prioritised circular strategies:

- Use renewable energy or renewable fuels like biomass, wind and solar
- Optimise energy use

6.2 Preserve and extend what's already been made

6.2.1 Maximise the lifetime of products in-use and after use

Statistics from various sectors, particularly Textiles and Electronics, reveal alarmingly low rates of reuse in Ukraine. For instance, there is an abundance of imported second-hand textiles, with less than 2% currently being recycled or repurposed.[32] The handling of waste electrical and electronic equipment (WEEE) is also inadequate, as it is poorly segregated and treated, often mixed with household waste. There is little data on available refurbishment activities for this sector in Ukraine. This highlights the need for improved strategies for the separation, treatment, refurbishment and recycling of WEEE to mitigate environmental impacts and promote resource efficiency.

The repair and installation of machinery equipment, with a declining labour force (-16.69% between 2019 and 2021), should be further supported to implement circular strategies in Ukraine.

Prioritised circular strategies:

- Provide repair services or maintenance services for products or parts
- Create or enhance marketplaces or services that enable the second-hand sale of products

[31] Cahill, B., & Dawes, A. (2022). Developing renewable energy in Ukraine. Retrieved from: CSIS Website

[32] Державна служба статистики України . (2020). Поводження з побутовими та подібними відходами за 2011-2020 роки. Retrieved from: UkrStat Website

- Enhance activities that restore products back to their original state or working conditions
- Enhance the extraction and reuse of parts from end-of-life products for use in new products

6.2.2 Maximise the lifetime of biological resources

Ukraine is a powerful agricultural country, yet in many parts of the country soils have deteriorated or become acidic, saline, or alkaline as the result of unsustainable agricultural methods, including the overuse of mineral fertilisers and outdated technologies. The situation has further deteriorated with the consequences of the war. Some of these impacts include soil structure deterioration, compaction caused by heavy machinery and tanks, contamination from explosives, chemicals, and heavy metals, disruption of irrigation systems leading to soil erosion, and displacement of farmers resulting in neglect of farmland. Additionally, the use of landmines can render large areas inaccessible for cultivation, further diminishing agricultural productivity and exacerbating food insecurity.

Despite Ukraine's rich biodiversity and extensive forest reserves, existing practices fail to prioritise soil health or sustainable forestry practices. This underscores the importance of implementing strategies that promote soil regeneration and responsible forestry management to safeguard ecological balance and agricultural productivity.

Prioritised circular strategies:

- Manage and enrich biological resources such as soil, land, *etcetera*
- Preserve and conserve biological resources such as food, forests, *etcetera*
- Repurpose organic waste to produce natural fertiliser or soil amendments

6.3 Use waste as a resource

6.3.1/ 6.3.2 Valorise waste streams (open and closed loop)

The circular strategy of repurposing organic waste has just been described. Efforts to repurpose other waste streams, those generated by the construction and mining industries, for instance, such as mine tailings and construction materials like bricks, asphalt, and steel, remain largely ineffective in Ukraine. Similarly, the country is inundated with second-hand textiles, yet only a small fraction undergoes efficient recycling processes. These challenges

highlight the need for improved waste management strategies and enhanced recycling initiatives to maximise resource utilisation and minimise environmental impact in both sectors.

This circular strategy highlights the need for the improved repurposing of materials in both closed (within one same industry) and open (across different industries) loop systems.

Prioritised circular strategies:

- Transform waste products, materials for reuse within the same/within other industries, such as construction and metals
- Increase the separate collection and sorting of used textiles and WEEE
- Use mechanical or chemical processes to regenerate textile waste streams into new textile materials, sufficiently preserving the quality of the fibre/material in order for it to be used in high value applications (for textiles: yarns, fabrics, and garments)

6.3.3 Energy recovery from waste[33]

The metal sector demonstrates low CO2 efficiency performance, with inadequate exploration of waste heat and gas recovery techniques. Similarly, the agricultural sector heavily relies on fossil fuels, while biomass utilisation[34] remains underexploited. Opportunities for repurposing organic waste within the sector are overlooked, indicating potential for improved resource management and environmental sustainability practices.

Prioritised circular strategies:

- Recover and reuse waste heat, gas, *etcetera* for energy
- Generate energy from waste through processes such as anaerobic digestion, gasification, incineration, *etcetera*.

[33] Circle Economy follows the cascade principle when looking at energy recovery techniques from waste, which involves prioritising a hierarchy of actions to maximise the value obtained from waste materials while minimising environmental impact.

[34] Similarly, Circle Economy follows the cascade principle for biomass use to maximise the efficiency and sustainability of its use. This concretely means favouring biomass for high-value applications that offer the greatest economic and environmental benefits. This typically includes applications such as food production, animal feed, and high-quality materials like wood for construction.

6.4 Enabling elements

6.4.1 Rethink the business model

The Ukrainian economy is currently concentrated in sectors with low added value. Servitisation models, such as product as a service, remain underdeveloped in Ukraine. Furthermore, Ukraine's economy relies heavily on material inputs and continues to depend on imports for various consumer goods, such as textiles, highlighting the need for strategies to enhance domestic production and value-added services.

Prioritised circular strategies:

- Sell high quality, long-lasting products
- Provide products through leasing, rental, or pay-per-use models instead of sales

6.4.2 Design for the future

In Ukraine, the construction sector faces a notable deficiency in adopting circular approaches to building materials. This is evident in the prevalent linear model of construction, where materials are often used once and then discarded, contributing to resource depletion and waste generation. The implementation of circular practices, such as designing for disassembly, promoting material reuse and recycling, and prioritising renewable and recycled materials, remains limited. There is a pressing need for the industry to prioritise the adoption of circular approaches to building materials, promoting a more sustainable and resilient construction sector in Ukraine.

Prioritised circular strategies:

- Design products to reduce waste during production and (re)use

6.4.3 Collaborate to create joint value

6.4.3.1 Industry collaboration

In Ukraine, there is scarce indication of the inclusion of green and circular criteria within public procurement tenders. Furthermore, collaboration among various industry stakeholders to advocate for circular approaches is lacking, primarily due to a deficiency in knowledge and expertise. This lack of integration of sustainable practices into procurement processes and the absence of cohesive collaboration hinder the advancement of circular economy initiatives within the country's industrial landscape. Addressing these challenges requires concerted efforts to enhance awareness, build capacity, and foster partnerships

among stakeholders to drive the adoption of sustainable and circular principles in procurement practices and industry operations.

Prioritised circular strategies:

- Put purchasing guidelines in place for procurement departments and evaluate suppliers on circular economy principles
- Work together with industry peers to engage in business activities or exploratory projects that advance the circular economy, such as industrial symbiosis.

6.4.3.2 Government collaboration and public policy

While some progress has been made in implementing circular regulations and requirements (see Chapter four), significant gaps persist, and the pace of implementation remains slow. The existing fiscal system in Ukraine largely adheres to linear principles, evidenced by insufficient landfill taxes that fail to incentivise businesses to adopt circular approaches, the absence of established extended producer responsibility (EPR) schemes, and the lack of subsidies for organic or sustainable produce. These deficiencies underscore the need for comprehensive reforms to align fiscal policies with circular economy goals, fostering an environment conducive to sustainable practices and resource efficiency.

Prioritised circular strategies:

- Government bodies and policymakers to push for regulations that support the circular economy
- Adopt financial incentives to promote a circular economy

6.4.4 Strengthen and advance knowledge

6.4.4.1 Internal collaboration

A notable challenge in advancing circular economy initiatives is the prevailing lack of awareness and understanding among public service entities and within companies. Many individuals and organisations remain unfamiliar with the fundamental principles and benefits of circular economy practices, hindering their adoption and implementation. Without widespread awareness and comprehension, efforts to transition towards a circular economy may encounter resistance or fail to gain traction. Thus, there is a crucial need for targeted education and outreach programmes to enhance knowledge and promote the integration of circular economy principles into public and private sector operations.

Prioritised circular strategies:

- Provide guidance or professional training to educate civil servants/employees on how to adopt circular economy principles

6.4.4 Incorporate digital technology

6.4.1 Employ technologies to gather and analyse data to provide insights on resource use

One pressing issue hindering efficient resource management is the absence of comprehensive data and adequate monitoring systems to trace resource use across various sectors. This lack of transparency and accountability hampers efforts to optimise resource use, mitigate environmental impacts, and advance towards a more circular economy. Addressing this gap requires investment in improved data collection methods, the establishment of standardised monitoring frameworks, and the integration of innovative technologies to enable real-time tracking and analysis of resource use across sectors.

Prioritised circular strategies:

- Utilise data and models to identify, enable and/or implement circular strategies (for example, effective resource use & logistics planning, and circular business models & design)

4.4.2 Employ online platforms to connect and improve information sharing between stakeholders

Waste data and digital platforms for monitoring and controlling waste are in short supply. Data platforms can facilitate connections between waste management partners and clients to enhance transparency and collaboration in the sector. Various initiatives are underway to bridge these data gaps although none have seen the light as of yet. One attempt was recently made by the Ministry of Environmental Protection and Natural Resources to implement a waste management information system utilising blockchain technology. This system intended to track the lifecycle of waste, streamline permitting procedures, and provide a centralised platform for enterprises.[35] Nevertheless, at the time of writing of this report, no reported progress has been made on the setup of such a system.

[35] UNIDO. (2024). Executive summary: Ukraine industrial country diagnosis 2023. Retrieved from: UNIDO Website

Prioritised circular strategies:

- Develop or utilise online platforms to enable circular economy opportunities through information, product or service offering
- Develop or utilise online marketplaces to enable the peer-to-peer exchange of products and service

7. CIRCULAR ECONOMY METRICS FOR UKRAINE

8.1 Status of indicator monitoring in Ukraine

A recent study[36] reveals significant gaps in Ukraine's mechanisms for tracking progress in the circular economy compared to the EU's comprehensive Circular Economy Framework. However, most European countries are also slow in adequately monitoring and reporting on circular economy indicators. Key indicators related to green growth, such as the adoption of energy management by SMEs and pollution reduction measures, lack statistical tracking. However, recent regulations focused on waste management offer promising steps towards addressing these gaps and fostering sustainable practices in the country.

Despite efforts to monitor progress towards the Sustainable Development Goals (SDGs) through the Open SDG Platform, Ukraine faces challenges with outdated data, particularly evident in the absence of a legal definition for environmental goods, services, and technologies. Moreover, the implementation of European reporting standards on environmental goods and services remains unaddressed in the National Programme for the Development of State Statistics, further hindering comprehensive data collection and analysis.

National statistics in Ukraine, while broad in scope, often lack completeness and clarity, especially in crucial areas such as circular economy initiatives, green industrial development, and Sustainable Public Procurement (SPP). Additionally, challenges persist in gathering reliable data on waste generation, particularly within the construction sector, posing significant obstacles to effective policy-making and strategic planning.

[36] UNIDO. (2024). Executive summary: Ukraine industrial country diagnosis 2023. Retrieved from: UNIDO Website

8.2 Key metrics for circular industrial development in Ukraine

Economy wide indicators

In this section, we present a table of economy wide indicators showing baseline values for Ukraine, as well as targets. The targets are based on European targets and/or Global quotas (what is considered 'safe' environmentally). Several of these are aligned with the EU Delegation Inception report (2023), pointing specifically towards material use and energy efficiency.

Priority targets to address are **resource efficiency, renewable energy share and carbon efficiency**, as the country uses a relatively huge number of fossil fuel based energy and material inputs to produce low value economic outputs. Household consumption is below European and global averages and therefore is not the main impact focus area.

Detailed description of economy-wide indicators

The previous section provides an overview of the different economy-wide indicators that should be prioritised for measuring circular economy progress in Ukraine. This section provides a brief justification for the selection of each of these indicators.

Although Ukraine performs well in terms of material consumption compared to the global average, the country must align with raw material use to align with EU standards.

- **Material consumption (tonnes per capita)** currently stands at a little over 9.9 tonnes per capita in Ukraine.[37] Note the average worldwide is 12.45 and the EU average is 15: so **Ukraine is performing well in comparison**. However, as the target, we have selected 8, which was the global average in 1980, when Raw Material Use globally was less overall.[38] This is akin to how European targets are set, typically referencing a baseline year (1990 or earlier).

[37] UNEP (2024). SCP-HAT database v3.0. UN Life Cycle Initiative, UN One Planet Network, UN International Resource Panel. Paris. Retrieved from Website
[38] Lettenmeier, M. (2018). A sustainable level of material footprint — Benchmark for designing one-planet lifestyles. Aalto University. Retrieved from: Aalto University website

- **Material efficiency (euros per kilogram),** measured as the GDP produced in Euros per kilogram material inputs into the economy, was approximately €0.17 in Ukraine in 2018, which is on the low end compared to other European countries (Bulgaria, ~0.15 in 2017, Poland ~0.35 in 2017). Although the EU cites the need for a dramatic reduction in material use, it gives no explicit targets for this indicator. Therefore, we have set a target of 3, which is the median euro per kilogram value in Europe. This is an ambitious target which would require Ukraine to dramatically rethink the way its economy generates economic value from every kilogram that is used.[39]
- **The Circular Material Use Rate (CMUR)** is not currently measured in Ukraine. However, household cycling is estimated at 5%. We recommend to measure this at an economy wide level, and set a target in line with the global target of 17% by 2032, as suggested in the *Circularity Gap Report 2021*.[40] 17% is also above the European average of 11.2%[41].
- **Renewable energy share**: This indicator aims to bring Ukraine's currently very low renewable energy share (under 5%[42]) up to the 45% EU target.[43] Ukraine needs to diversify its energy mix and increase its supply of renewables in order to lower its GHG emissions. Renewables accounted for only 5% of the energy mix in 2018, and for 9% of electricity generation (13.4 kilowatt hours in 2019).
- **GHG emissions** per capita are 5.5 kilograms of CO2 equivalent (CO2e) in Ukraine, lower than the world average of 6 kilograms per capita and the Euro area average of 10 kilograms per capita. Although Ukraine is performing well relative to these benchmarks, its GHG emissions should still be reduced by over 50% to 2.3 kilograms of CO2e per capita by 2030—the quota per person deemed to be safe for the planet according to the UNEP *Emissions Gap Report 2021*.[44]
- **CO2 efficiency**, measured in kilograms of CO2e per euro (carbon dioxide equivalent per euro), represents the amount of CO2e emissions produced per unit of economic output (in euros). A lower value indicates greater efficiency in terms of emissions

[39] Europe Environment Agency (EEA). (2019). Resource efficiency. Retrieved from: EEA Website
[40] Circle Economy. (2021). *The circularity gap report 2021*. Retrieved from: Circle Economy Website
[41] Eurostat. (2024). Circular Material Use Rate. Retrieved from: Eurostat Website
[42] International Energy Agency (IEA). (2020). *Ukraine Energy Profile* (pp.1-43, Rep.). Retrieved form: IEA Website
[43] European Commision. (n.d.). Renewable energy targets. Retrieved from: European Commission Website
[44] United Nations Environment Programme (UNEP). (2021). *Resource emission gap report 2021* (pp.1-79, Rep.). Retrieved from: UNEP Website

relative to economic output. The CO2 efficiency of 2.1[45] for Ukraine indicates a moderate level of emissions relative to economic output, suggesting that Ukraine could improve its CO2 efficiency by reducing its reliance on fossil fuels and making industrial processes more efficient.

- **Waste going to landfill**, expressed as a percentage, indicates the proportion of waste going to landfill as opposed to being repurposed as a secondary source (either material or energy). Currently, Ukraine's landfill rate is over 90% (UkrStat 2020 data), which is far higher than the European average (below 50% in 2020). The EU Landfill directive aims to reduce landfilling to 10% of all waste management processes which is indicated as the target for 2030.

Table xx provides an overview of the economy-wide indicators for measuring circularity in Ukraine.

Table X lists economy-wide circular economy indicators for Ukraine.

#	Level	Indicator	Unit	Baseline	Target 2030
1	Economy wide	Material consumption	Tonnes/capita	11.2	8 (Global)
2	Economy wide	Material efficiency	Euros/kg	0.26	3 (EU)
3	Economy wide	Circular Material Use Rate	%	Unknown	16% (EU)
4	Economy wide	Renewable energy share	%	5%	45% (EU)
5	Economy wide	GHG/Capita[46]	kg CO2e/capita	5.5	2.5 (Global)
6	Economy wide	CO2 efficiency	kg CO2e/$	2.1	0.9 (Global)
7	Economy wide	% of waste going to landfill	%	90%	10% (EU)

Sector specific indicators

Our sector-specific indicators aim to monitor the circular—and more generally, sustainable—performance of the key sectors of Ukraine's economy, according to the baseline findings. These cover not only the manufacturing sector but also the agricultural and construction sectors.

[45] UNEP (2024). SCP-HAT database v3.0. UN Life Cycle Initiative, UN One Planet Network, UN International Resource Panel. Paris. Retrieved from Website
[46] Per capita GHG emissions.

Detailed description of sector-specific indicators

The following Agriculture and Food targets are drawn from the EU's *Farm to Fork Strategy*, which offers a wide range of indicators related to Agriculture and Food.[47]

- **Agriculture—GHG emissions:** This sector emitted 21.8 million tonnes of CO2e in 2022.[48] To align with the EU target of reducing emissions by 55% by 2030, the target is set at 9.8 million tonnes of CO2e.
- **Agriculture—Land under organic farming**: Currently, approximately 1% of farmland is certified organic in Ukraine, despite Ukraine being one of the top importers of organic produce in Europe.[49] Increasing the proportion of organically farmed land could offer the dual benefits of improving competitiveness and gaining rank in this export market, as well as reducing environmental impacts in the sector. The target is drawn directly from the EU's *Farm to Fork Strategy*.
- **Agriculture—Fertiliser Use**: The EU *Farm to Fork Strategy* suggests a target of 10% reduction in fertiliser use. For Ukraine, this would require a decrease from 78.5 kilograms per hectare of arable land (in 2021) to 62.8 kilograms per hectare.[50] The latter is equivalent to fertiliser usage rates in Ukraine in 2018. Therefore, an even more ambitious target could be investigated.

The following indicators for the Manufacturing sector stem from varied sources, from the EU's *Farm to Fork Strategy*, the *EU Strategy for Sustainable and Circular Textiles*, European Climate Law and objectives for 2030.

- **GHG emissions (indicators #9, #12, #18,# 20):** This indicator was used for our top sectors, Agriculture, Manufacturing (basic metals) and Construction. The baseline value was taken from UNEP for the year 2022 and the target is aligned with the EU General Target aiming to reduce total emissions by 55% by 2030.[51]

[47] European Commission. (n.d.). Farm to Fork targets - Progress. Retrieved from: European Commission Website
[48] UNEP (2024). SCP-HAT database v3.0. UN Life Cycle Initiative, UN One Planet Network, UN International Resource Panel. Paris. Retrieved from Website
[49] World Bank. (2021).Agricultural land (% of land area) - Ukraine. Retrieved from: World Bank Website
[50] World Bank. (2021). Fertilizer consumption (kilograms per hectare of arable land) - Ukraine. Retrieved from: World Bank Website
[51] European Union. (2023). Commission welcomes completion of key 'Fit for 55' legislation, putting EU on track to exceed 2030 targets. Retrieved from: European Commission Website

- **Manufacturing (Food and beverages)—Waste Generation**: Ukraine generated 4,159 tonnes of waste in this subsector in 2020.[52] In line with EU targets to reduce waste in this subsector by 10%, included in the *Farm to Fork Strategy*, the target is set to 3,743 tonnes.
- **Manufacturing (Textiles)—Circular Material Use Rate:** As previously cited, only approximately 2% of all textiles are cycled locally to be used as inputs into clothing products. This is in line with the current textile cycling rate in Europe of 1%. Nevertheless, the average collection rate of textiles in Europe is 22%, and therefore we set the target of the Circular Material Use Rate to this ambitious level, in an effort to stimulate innovation in the textiles value chain to process and handle (all collected) textile waste to be used as an input into manufacturing processes.
- **Reduce plastic packaging waste volumes**. The current production levels of plastic waste are growing exponentially. The new EU-wide packaging targets include a reduction of 5% by 2030 and 15% by 2040, while all packaging is expected to be fully recyclable by decade's end. We therefore set a reduction target of -5% by 2030, to be aligned with the EU's Single-Use Plastics Directive.
- **Recycle plastic packaging waste**. Figures for the separation and recycling of plastic waste in Ukraine are not easily available and unreliable. The EU's Single-Use Plastics Directive aims to recycle 100% of packaging by 2030 and 100% of plastic by 2035. Given the current low levels of recycling in Ukraine, we set the target to 40%, which is the current EU average for the recycling of plastics according to the European Environmental Agency in 2020.
- **WEEE minimum recovery rate**: Similarly to separate collection and recycling rates for plastics, figures for WEEE recycling in Ukraine are currently unreliable. To align with the EU's Waste electrical and electronic equipment rates and targets, Ukraine should aim for a recovery rate of 75%.[53] Nevertheless, this figure should be treated with caution, as recovery rates differ according to the different categories of WEEE.
- **Construction and demolition waste (CDW) recovery**: Construction debris has dramatically increased since the start of the war and there is currently little regulatory or business environment in place to properly recover this waste. We set a target of 70% recovery rate by weight, which was the EU's Waste Framework Directive target for Member States for 2020. Recovery activities, under this target, comprises the preparation of non-hazardous CDW for re-use, recycling and other material recovery, including backfilling operations.

[52] Derzstat. (2021). Waste generation and management. Retrieved from: Derzstat Website
[53] European Commission. (n.d.). *Summary document of the Waste electrical and electronic equipment rates and targets* (pp1-5, Rep.). Retrieved from: European Commission Website

Table X provides an overview of the sector-specific indicators for Ukraine.
As explained in the section above, targets for 2030 are not set values but estimates to align with EU recommendations.[54] This concerns all indicators save for indicator #11.

Table X lists sector-specific circular economy indicators for Ukraine.

#	Level	Indicator	Unit	Baseline	Target 2030
9	Agriculture	GHG emissions	Million tonnes CO2e	21.8	-55% (EU)
10	Agriculture	Land under organic farming	%	1%	25% (EU)
11	Agriculture	Artificial Fertiliser Use	kg/hectare of arable land	78.5	-10% (EU)
12	Manufacturing (Basic Metals)	GHG emissions	Million tonnes CO2e	0.76	-55% (EU)
13	Manufacturing (Food and Beverages)	Waste generation	Tonnes	4159	-10% (EU)
14	Manufacturing (Textiles)	Circular Material Use Rate	%	1.23%	22% (EU)
15	Manufacturing (Plastics)	Reduce plastic packaging waste volumes	%	Unknown	-5% (EU)
16	Manufacturing (Plastics)	Recycle plastic packaging waste	%	Unknown	40% (EU)
17	Manufacturing (Electronics)	WEE minimum recovery rate	%	Unknown	75% (EU)
18	Construction	GHG emissions	Million tonnes CO2e	11.3	-55% (EU)
19	Construction	Construction and demolition waste (CDW) recovery	%	Unknown	70% (EU)

8. INTERNATIONAL BEST PRACTICES FOR CIRCULAR MANUFACTURING

[54] For example, 62.8 is set as a target value for Ukraine for 2030. This builds from the EU's Farm to Fork Strategy which recommends reducing fertiliser use by 10%. We apply this 10% reduction to Ukraine's current 78.5 which leads to the 62.8.

This chapter describes a set of international best practices, selected to inspire Ukrainian stakeholders. **These are aligned with several strategies from the Key Elements (KE) Framework detailed in Chapter six for the prioritised manufacturing subsectors**.

Each best practice is structured in the same way, with an overview of the best practice, available information regarding its scope as well as an indication of its relevance and replicability potential for Ukraine.

Four best practices have been selected overall for each of the prioritised manufacturing subsectors:

- **Food and beverages**: The Smart machines for recyclable waste (SIGUREC) initiative in Romania is designed to improve the collection and recycling of various products, including in the food and drinks subsector. The SIGUREC case study highlights the importance of investing in innovative collection systems and utilising incentives to promote domestic recycling industries. It suggests that Ukraine could benefit from adopting a similar model to enhance waste management standards, foster a recycling sector, and stimulate economic growth.
- **Textiles**: The Vive Textile Recycling (VTR) initiative from Poland addresses the challenges in the textile recycling subsector, particularly the influx of imported post-consumer textile waste, aligning with circular economy principles. By recycling and reusing textiles, VTR aims to minimise waste, extend product lifecycles, and tackle the issue of inadequate waste management infrastructure. This example could help to inspire Ukraine to treat its abundance of untreated post consumer textile waste, while also boosting employment.
- **Electrical and machinery**: The success of ZIKOM,' a distributor of budget-friendly reconditioned computer equipment, in Poland highlights the potential for Ukraine to adopt a similar initiative, reducing electronic waste and creating economic opportunities through refurbishment efforts. Implementing policies such as subsidies or tax incentives could facilitate the adoption of circular business models, while efforts to ensure the availability of requisite skills within the labour market would support this transition and ensure affordable access to IT equipment for citizens.
- **Metals**: The establishment of an industrial symbiosis partnership between the steel subsector (ArcelorMittal) and the energy sector (EDP) in Spain shows how waste gases from steel production can be turned into electricity, suggesting that Ukraine could benefit from industrial symbiosis to reduce environmental impacts, improve

energy resilience, and extract value from industrial waste in its metal products subsector.

Each of these best practices are linked with several circular economy strategies from the KE Framework, presented in Table X:

Table X lists best practices and alignment with the circular strategies of the KE Framework.

Best practice	**Link with circular economy strategy group**	**Link with circular strategy**
SIGUREC: Smart machines for recyclable waste (Romania)	Reuse, repurpose and recycle waste streams within the same industry	• Transform waste products, materials for reuse within the same industry • Transform waste products into materials and lower value products within the same industry • Collection programmes that process products and parts for reuse or recycling within the same industry
Vive Textile Recycling (VTR) (Poland)	Reuse, repurpose and recycle waste streams within the same industry	• Transform waste products, materials for reuse within the same industry • Transform waste products into materials and lower value products within the same industry • Collection programmes that process products and parts for reuse or recycling within the same industry
ZIKOM: refurbishing IT equipment (Poland)	Deliver products to customers through business models that ensure maximum value	• Sale of refillable parts • Sale of exchangeable parts • Reuse, repurpose, and recycle waste streams within the same industry
EDP Spain: From steel production waste gases to electricity (Spain)	Processing waste into fuel Generating energy from waste Engage with industry peers to create joint value and identify synergies	• Recover waste energy or generate fuels and energy from waste streams • Working together with industry peers to engage in business activities or exploratory projects that advance the circular economy, such as industrial symbiosis

9.1 Food and beverages

SIGUREC: Smart machines for recyclable waste (Romania)[55]

Best practice description

The aim of this initiative was to introduce an advanced recycling service in Romania aimed at prolonging the lifespan of products by providing various household waste collection systems throughout the country, ranging from mobile collection units, to outdoor collection stations or indoor collection points in supermarkets. These systems employed smart collection machines and facilitated recycling among consumers through the use of digital technologies.[56] The objectives of this initiative were to reduce waste, particularly from electrical and electronic equipment and packaging, and to bolster the development of a domestic recycling industry.

Key accomplishments and solutions offered by this program include the following:

- From its inception in 2012, the SIGUREC machines facilitated the collection of significant quantities of recyclable materials: 39,699 tonnes of plastic/PET, 1,164 tonnes of aluminium, 14,796 tonnes of glass, 1,781 tonnes of paper, and 15,640 tonnes of other materials. Unfortunately, reference or baseline figures for comparison are not available.
- This service introduced an innovative approach to waste management by merging technology with incentives, thereby fostering consumer engagement in recycling endeavours.

Timeline, budget, and involved actors

Initiated by Green Group, a prominent private enterprise, and backed by an investment surpassing €10 million, which includes €4 million in funding from Innovation Norway, a governmental agency of the Government of Norway, SIGUREC has been operational from 2012 to 2020.[57] It is currently unclear whether its operations are still ongoing. This endeavour has generated more than 260 employment opportunities, serving as a testament to the efficacy of a fruitful public-private collaboration involving Green Group, the Romanian Ministry of Environment, municipalities, and recycling entities.

[55] CE Stakeholder EU. (n.d.). SIGUREC: Smart machines for recyclable waste. Retrieved from: European CE Stakeholder Platform Website

[56] Green Group. (n.d.). Partner with EBRD case study – Green Group. Retrieved from: EBRD Business Website

[57] Balkan Green Energy News. (2016). Sigurec – the innovative collection infrastructure. Retrieved from: Balkan Green Energy News Website

Best practice relevance for Ukraine

SIGUREC stands as a pivotal case study illuminating the path to nurturing an emerging domestic recycling sector. It not only underscores the significance of industry collaboration but also exemplifies the effectiveness of concerted efforts in enabling the collection and recycling of diverse consumer products. From plastic packaging in food and beverages to metals from WEEE, SIGUREC demonstrates the breadth of materials that can be effectively recycled through collaborative endeavours. This initiative holds the potential to play a vital role in confronting the challenges faced by the Ukrainian food and beverage subsector, particularly concerning waste management and resource inefficiency. By drawing upon the lessons learned from SIGUREC, Ukraine can potentially revisit its approach to waste management, paving the way for a more sustainable and resource-efficient future in its food and beverage industry.

Lessons learned and possible application for Ukraine

The SIGUREC case study underscores the critical significance of investing in and implementing innovative collection systems, while also shedding light on the pivotal role that incentives play in fostering the growth of a domestic recycling industry. This case serves as a compelling example for Ukraine, showcasing how the adoption of a similar model could not only elevate waste management standards but also bolster the establishment and expansion of a thriving domestic recycling sector. By emulating such a framework, Ukraine could potentially unlock new avenues for sustainable waste management practices and stimulate economic growth.

9.2 Textiles

Vive Textile Recycling (VTR)[58] (Poland)

Best practice description

Established 26 years ago, Vive Textile Recycling (VTR) operates within Poland's textile recycling sector and boasts a comprehensive framework for textile recycling characterised by innovative technologies and digitalisation. The company is in the business of textile recycling, retail and wholesale trade of sorted and unsorted clothing imported from Western Europe, as well as processing used textiles into industrial wipers. Its operations encompass the implementation of sorting and valorisation systems for post-consumer

[58] VTR. (n.d.). About the Company. Retrieved from: Vive Textile Recycling Website

textiles, with the overarching goal of augmenting recycling and reuse rates. Furthermore, VTR strives to bolster the domestic efficiency of textile waste recycling and profit margins by investing on innovative digital technologies in its textiles processing while also establishing a nation-wide chain of second-hand retail stores.

Timeline, budget, and involved actors

With over 1,200 employees, VTR operates as the primary entity sorting 500 tonnes of raw material daily while upholding the highest quality standards of ISO 9001 and 14001. Products processed under these rigorous standards are distributed to more than 70 countries globally and to 32 VIVE Profit stores across Poland, specialising in unique second-hand clothing, owned by VTR.

Currently, it stands as a leading entity in Poland for producing alternative fuel from textiles, with Cementownia Osarów S.A. being the primary recipient. Moreover, the company has pioneered the development of an innovative textile composite for industrial applications and manufactures industrial cleaning cloths utilised by various industries.

The company achieves its objectives through the establishment of collection systems for post-consumer textiles, investment in advanced sorting technologies for nationwide textile recycling, development of new products derived from recycled textiles, and the establishment of VIVE Profit, a chain of second-hand stores throughout the country.[59] Additionally, it actively engages in advocating for relevant regulations within the sector and raising consumer awareness regarding the reuse of second-hand textiles.

Furthermore, VTR is expanding its business into transport and logistics beyond the realm of textile recycling.

Best practice relevance for Ukraine

VTR is tackling significant challenges within this subsector, particularly the considerable influx of imported post-consumer textile waste. Indeed, Poland, like Ukraine, is a significant receptor of post-consumer use textiles in the European market. Its primary focus lies in the recycling and reuse of textiles, a strategy that closely aligns with the principles of the circular economy. By minimising waste and prolonging the lifecycle of textiles, VTR addresses Ukraine's issues related to textile waste, inadequate waste management infrastructure, and the absence of a dedicated collection system or suitable treatment

[59] Vive Profit. (n.d.). Homepage. Retrieved from: Vive Profit Website

methods. Moreover, VTR stands out as a prominent employer within the textile recycling sector, further contributing to the country's economic landscape.

Lessons learned and possible application for Ukraine

The VTR case study underscores the significance of technology investment, advocacy for regulatory reform, and the establishment of a cohesive domestic textile ecosystem, wherein various streams of textiles—sorted, recycled, and reused—are interconnected. VTR not only confronts the challenges posed by textile waste but also ensures that employment in the subsector is symbiotic with the utilisation of advanced technology. For Ukraine, adopting similar strategies could catalyse the growth of a market for textile sorting, recycling, and reuse, particularly in light of the substantial influx of second-hand imports. Additionally, it has the potential to reverse the trend of declining labour force participation and knowledge retention observed in this subsector, though the relevance of these strategies may be influenced by the current geopolitical situation.

9.3 Electronics

ZIKOM: Refurbishing IT equipment (Poland)[60]

Best practice description

ZIKOM stands as one of the foremost distributors of professionally reconditioned computer equipment in Poland. Its primary goal is to harness the principles of the circular economy to extend the lifespan of IT equipment, thereby mitigating the rapid turnover and disposal typically associated with technological devices. This strategic approach is aimed at conserving valuable raw materials and curbing electronic waste by refurbishing and repurposing existing devices for continued use.

Timeline, budget, and involved actors

Since 2003, ZIKOM has established a network of stores operating under its own brand, including an online platform. It has achieved the esteemed status of being recognised as a Microsoft Registered Refurbisher, signifying that its refurbishment processes meet the stringent standards set forth by Microsoft, complete with a comprehensive one-year warranty.

[60] CE Stakeholder EU. (n.d.). ZIKOM: refurbishing IT equipment. Retrieved from: European CE Stakeholder Platform Website

Extensive efforts have been undertaken to salvage electronic waste and transform it into new materials ready for market. Since 2003, the company has garnered tens of thousands of satisfied customers, as noted on their website. Additionally, ZIKOM has initiated a 'leasing offer' tailored specifically for companies, although the exact commencement date of this service is unspecified.[61]

Best practice relevance for Ukraine

To combat Ukraine's reliance on imports within the Electrical and Machinery subsector, the implementation of refurbishing and recycling programmes is proposed. This initiative targets the enhancement of productive efficiency and the mitigation of the decline in the labour force. The overarching strategy seeks to repurpose and upgrade existing products, thereby conserving resources and promoting a circular economy ethos.

Moreover, fostering job creation and encouraging the adoption of innovative business models are key objectives of these circular economy practices. By advocating for refurbishing activities and the establishment of recycling facilities, the initiative aims to stimulate the emergence of ancillary businesses such as reverse logistics and digital platforms. Proactive policies, including subsidies or tax incentives, are envisioned to provide essential support for the proliferation of these sustainable practices.

Lessons learned and possible application for Ukraine

The success of ZIKOM in Poland as a prominent distributor of budget-friendly reconditioned computer equipment underscores the potential for Ukraine to embrace a similar circular economy strategy. By prolonging the lifespan of IT equipment, ZIKOM has demonstrated the feasibility of substantially reducing electronic waste and conserving resources through refurbishment and repurposing efforts. This approach not only addresses environmental concerns but also presents economic opportunities, including job creation within refurbishment processes and the introduction of novel business models such as leasing, while ensuring access to affordable IT equipment for its citizens. Ukraine could replicate this model by implementing policies such as subsidies or tax incentives to encourage the adoption of these circular business models, alongside efforts to ensure the availability of requisite skills within the labour market.

[61] ZIKOM. (n.d.). About us. Retrieved from: ZIKOM Website

9.4 Metals

Aboño 1: Using steel production waste gases for electricity generation[62] (Spain)

Best practice description

This case study exemplifies the effective establishment of an industrial symbiosis partnership between the steel subsector (ArcelorMittal) and the energy sector (EDP) in Asturias, Spain. This collaboration involves the utilisation of waste gases from steel production as a fuel in Aboño 1 thermoelectric plant.

The primary goals of this partnership are to diminish dependence on fossil fuels, in this case phase out carbon furnassess used in the main steel plant in the region, operated by ArcelorMittal.[63] The main accomplishment of this partnership is to successfully integrate steel gases into the energy production cycle resulting in the generation of substantial electrical energy. This initiative yields a dual benefit by also reducing CO2 emissions by approximately 1.2 million tonnes annually. EDP plans to invest €24,000 million between 2021 and 2025, with the aim of completely phasing out carbon and fossil fuel use from the Aboño 1 plant by 2025.[64]

Timeline, budget, and involved actors

Not available.

Best practice relevance for Ukraine

This case study illustrates the effectiveness of industrial symbiosis as a circular strategy within the metallurgical industry, tackling issues such as waste gas emissions and dependency on fossil fuels. By repurposing waste gases generated from steel production as fuel for electricity generation, this approach minimises the environmental footprint of the sub-sector while also valorising waste.

Lessons learned and possible application for Ukraine

[62] Eco.nomia. (n.d.). EDP Spain and the use of waste steel gases for electricity production. Retrieved from: Econ.nomia Website
[63] Europa Press. (2019). ArcelorMittal y EDP alcanzan un acuerdo para valorizar los gases siderúrgicos en la central de Aboño. Retrieved from: Europa Press Website
[64] La Voz de Asturias. (2021). EDP pone fecha a dejar de usar carbón y aclara los usos de las centrales asturianas. Retrieved from: La Voz de Asturias Website

The case study illustrates the potential of converting gases from steel production into a valuable resource for generating electricity. Encouraging industrial symbiosis within the metallurgical industry and related sectors could enable Ukraine to mitigate the environmental impacts of its industrial sectors, enhance energy resilience, and derive value from the industry's waste.

Annex I Sector prioritisation

Methodology of Sector Selection

The methodology to select the sectors and subsectors is determined by constructing three indices (one for each of sector development, resilience/autonomy, and circular economy) and then examining in which sectors and subsectors l these three parameters are significant. The following section outlines the construction of each index.

Nexus 1: Sector development

Industrial development refers to the ability of a sector or subsector to retain a competitive advantage, and its relative size /significance in Ukraine. The index is constructed from innovation expenditure, GDP contribution, and overall CO2 efficiency. ***We aim to identify sectors and subsectors that have medium-high expenditure, high GDP contribution, large labour force and low-medium CO2 efficiency.***

CO2 efficiency [SD_1]
This indicator measures the total volume CO2e for each sector/subsector with the aim of identifying the highest emitting sectors The data for this is coming from UNEP's SCP HAT database v3.0 for the year 2024.

Sector Innovation Expenditure [SD_2]
This indicator is a measure of the raw innovation expenditure per sector/subsector. Those spending money on innovation are more likely to be sustainable and competitive in the long term, particularly as Ukraine directs its exports increasingly towards the European market. The data source for this is the State Statistics Service of Ukraine for the year 2020. It should be noted that there are large data gaps, with no data available for numerous sectors. For this reason, in our analysis, this indicator is nuanced with qualitative findings on innovation in the sector. The weight assigned to this indicator is also low as it is less reliable.

Labour Force [SD_3]
This indicator scores the sector/subsector based on the number of FTE working in that sector/subsector with the aim of identifying those which are the largest employers. This allows us to prioritise sectors/subsectors that are employing a significant proportion of the

population and therefore providing revenue and opportunities. The raw data is normalised to 0-100%, with 1 being assigned to the sector with the highest level of employment. Data is sourced from the State Statistics Service of Ukraine for the year 2021.

Total Economic Output (value) [SD_4]
This indicator evaluates the total economic output for each sector/subsector (selling in Ukraine and outside Ukraine), as a proportion of all economic output, and normalises this % to 0-1, with the aim of identifying those that contribute the most to Ukraine's economy overall. Sectors/subsectors with a high economic output will drive economic development locally and provide opportunities for employment. Data is sourced from EORA for the year 2021.

Nexus 2: Resilience

Resilience refers to the extent that Ukraine is independent of trade in order to meet demands of its own citizens and industry. ***We aim to identify sectors/sub sectors that have a high import dependency and/or a high export dependency***.

Material Import Dependency [R_1]
The first part of this index is constructed by looking at the material import dependency to determine what proportion of inputs per sector/subsector come from abroad (in material terms). Those with a high proportion of imports may have more opportunity to become more resilient in terms of developing local economies to reduce this dependency from abroad (for example, through material substitution). Scores are normalised to 0-1. The data is taken from EORA for the year 2020.

Export Dependency [R_2]
The second part of this index examines the proportion of outputs per industry that are exported (in euro value). Industries with a high proportion of exports will have relatively more opportunity, and so could be marked as priority industries for innovation to ensure competitiveness in global markets, or for the development of local economies to reduce the trade risk associated with relying on exports. Scores are normalised to 0-1. The data is taken from EORA for the year 2020.

Nexus 3: Circular Economy

A circular economy is seen as a strategy that enables the decoupling of economic activity from resource use. Considered as such, there is an opportunity to keep economic activity the same, or even improve it whilst reducing environmental pressure. ***We aim to identify sectors/subsectors with the highest material footprints [CE_1] and waste generation [CE_2].***

Material footprints [CE_1]

Material Footprint (MF) is the attribution of global material extraction to domestic final demand of a country (sum of the material footprint for biomass, fossil fuels, metal ores and non-metal ores).[65] Sectors/subsectors with high material footprints are those consuming a significant amount of raw materials and resources either directly or indirectly and help us to prioritise where action is required. The source for this comes from UNEP's SCP_HAT database v3.0 for the year 2024.

Waste Generation [CE_2]

The Ukraine Statistical Office refers to several different indicators reporting on the generation of waste, including those from the economic activity of enterprises and households.[66] Sectors/subsectors with high waste footprints generate the largest quantities of wastes and emissions and help us to prioritise where action is required. The source for the data is the State Statistics Service of Ukraine for the year 2020.

Methodological approach

The method utilises diverse units and normalises scales across various dimensions. All numerical values are transformed, with the lowest number set to 0 and the highest to 100%. .

Importantly, the percentages reflect ordinal rankings, not actual proportions, emphasising the order without assuming equal distances between values. This approach provides a unified perspective across dimensions, offering insights into the sectors/subsectors with, for instance, the highest export dependency, while placing all elements within the same analytical framework.

[65] United Nations Environment Programme (UNEP). Indicator 12.2.1. Retrieved from: UNEP Website
[66] Derzstat. (2021). Waste generation and management. Retrieved from: Derzstat Website

Nexus Weights

The decision to assign weights to the three nexus—sectoral performance indicators, circularity, and resilience—was made based on the specific context of the project and the goals of promoting sustainable industrial development in Ukraine. A more detailed justification for why these weights were decided is provided below:

- **Sectoral Performance Indicators (50%):** As Ukraine is in a state of war and aims to reindustrialise its economy for recovery, understanding and enhancing industrial performance becomes crucial for its economic development and resilience. It therefore appears logical to assign the highest weight to industrial performance indicators. This emphasis aligns with the primary objective of the project and reflects the importance of assessing and improving industrial processes, productivity, and competitiveness.
- **Circularity (30%):** The second-highest weight is attributed to circularity, reflecting the focus of the current study on promoting a more circular economy in Ukraine. Circular economy principles emphasise minimising waste, maximising resource efficiency, and promoting sustainable consumption and production patterns. By allocating a significant weight to circularity, the research team acknowledges the importance of transitioning towards a more sustainable and resource-efficient economic model, which aligns with broader global sustainability goals and initiatives.
- **Resilience (20%):** The lowest weight is assigned to resilience, accounting for Ukraine's import/export dependency, which has been heavily impacted by the war. As Ukraine transitions away from its reliance on Russia as its primary trading partner in favour of closer ties with the European Union, the significance of resilience amplifies. Import patterns illuminate opportunities for the cultivation of local sustainable markets. Conversely, export patterns identify avenues for the development of added value, facilitating the deployment of environmental products within the European Union.

Overall, the weights assigned to each nexus reflect the project's objectives, priorities, and the specific challenges and opportunities facing Ukraine in its pursuit of sustainable development amidst geopolitical and economic complexities.

Weights per nexus		
ID	**R**	**CE**

50%	20%	30%

Weights per indicator within each nexus							
ID_1	**ID_2**	**ID_3**	**ID_4**	**R_1**	**R_2**	**CE_1**	**CE_2**
40%	10%	30%	20%	50%	50%	75%	25%

Final weights

ID_1	ID_2	ID_3	ID_4	R_1	R_2	CE_1	CE_2	Total Weight
20%	5%	15%	10%	10%	10%	23%	8%	100%

Annex II Detailed results per sector

Manufacturing

The manufacturing sector, encompassing a very wide range of activities from the food and beverages subsector to the metals subsector, emerges as the clear priority sector to implement circular economy solutions. Within the sector, **Food and beverages, Electrical and Machinery and Metal Products emerge with the highest scores**. All of these subsectors demonstrate an important economic output, a high material footprint, as well as a low CO2 efficiency.

The priority Manufacturing subsectors are therefore:

- **Food and Beverages** with a high material footprint, labour force, and innovation expenditure.
- **Electrical and Machinery** with a high innovation expenditure, final demand, import dependency and material footprint
- **Metal products,** with a high export dependency, waste footprint and innovation expenditure

In addition, we note the following performance for the other sectors:

- **Textiles** have a high import dependency and labour force.
- **Transport Equipment** demonstrates a high innovation expenditure, and both high import and export dependency
- **Petroleum, Chemical and Non-Metallic Mineral Products** have a high industrial output and relatively high export dependency.

The more detailed results are available in the table below.

Table X gives an overview of the performance of the Manufacturing sector in detail.

Manufacturing	SD_1	SD_2	SD_3	SD_4	R_1	R_2	CE_1	CE_2	Final Score
Food	72%	100%	100%	36%	0%	17%	12%	10%	43%
Beverages	10%	20%	5%	36%	0%	17%	4%	10%	11%
Textiles and Wearing Apparel	5%	0%	39%	17%	74%	19%	0%	-	18%
Wood and Paper	2%	6%	40%	6%	89%	55%	0%	-	22%

Petroleum, Chemical and Non-Metallic Mineral Products	11%	35%	10%	47%	8%	57%	1%	3%	17%
Metal Products	2%	66%	42%	69%	39%	93%	1%	1%	30%
Electrical and Machinery	5%	12%	45%	100%	89%	29%	1%	1%	30%
Transport Equipment	2%	9%	30%	2%	100%	58%	0%	-	22%
Other Manufacturing	3%	2%	26%	19%	49%	5%	1%	-	12%

Note1: The scores are normalised to the range of the manufacturing sector as opposed to that of the whole economy.

Sectoral development (ID)

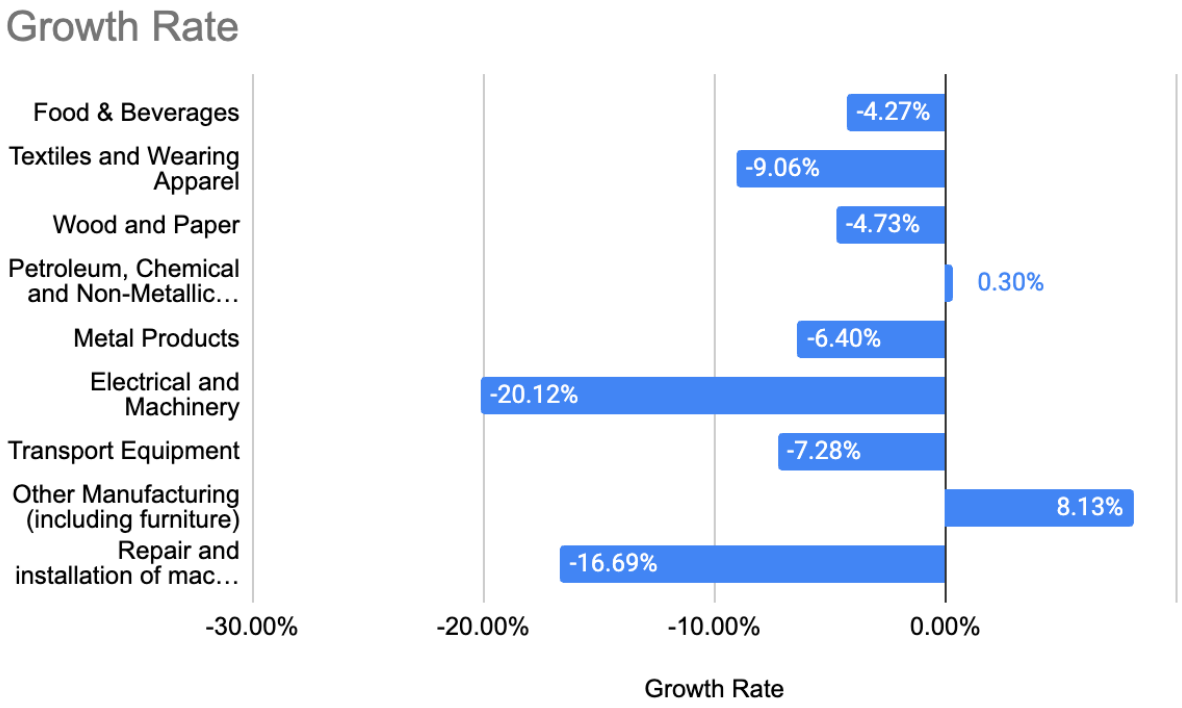
Economic output

The electrical and machinery subsector has the highest economic output, totalling 37.3 bln USD in 2021, representing 12% of total economic output in the country, followed by Metal Products (25.7 bln USD), and Petroleum and Chemical products.

Employment

The Manufacturing sector employed 2,313,200 people in 2021, which is comparable to the working force of the agriculture and wholesale and retail sectors. It is among the highest employing sectors in the country overall. Between 2019-2021, the labour growth rates across the subsectors of the Manufacturing sector fluctuated widely. Most sectors experienced decline while several saw very subtle growth. The labour force overall in the sector shrunk by 5.8%. Only the petroleum and 'other manufacturing' subsectors, including furniture, experienced a relative increase over the period (see Figure X).

Figure X presents the labour growth rate in the Manufacturing sector between 2019-2021 (ILO).



When looking further into the detailed data, it is interesting to note that:

- The labour force growth of the petroleum, chemical, and non-metallic mineral products subsector is strongly driven by the growth in pharmaceutical products (32.74%) and rubber and plastics (38.5%). The manufacture of coke and refined petroleum products fell by -47.44% across the period;
- Within the electrical and machinery subsector, a steep labour force decline is also registered with -20%
- The labour force for the manufacturing of textiles fell dramatically (-20.12% between 2019-2021);
- Similarly, the subsector for repair and installation of machinery and equipment, a relatively small sector, experienced further decline across the period (-16.69%).
- The textile and wearing apparel sector also experienced decline (-9.06% over the period);
- The specific manufacture of wood and products of wood and cork (outside of furniture) grew by 17.48%;

Innovation

Moreover, the highest innovation expenditure is recorded for the Food and Beverages subsector. The textiles subsector has a very low innovation expenditure overall, suggesting this subsector is still employing traditional production methods. Other recent reports have pointed to Ukraine's declining innovation potential in the industrial sector as a whole, as well as its low added value.[67] Ukraine's industry produces and exports mainly low-tech intermediate products, which makes the country's economy still heavily resource-based.

CO2 emissions

In the country, the manufacturing sector is responsible for the most emissions and within the subsectors, the food sector produces the most emissions in total. Note that these are consumption based emissions, meaning that imported products with high emissions footprints will increase this figure. Overall, this suggests that **the manufacturing sector overall has chronic inefficiencies in resource utilisation and energy consumption**. The sector is still dependent on old processes and machinery as well as fossil fuels as the main source of energy to power industry. There could be opportunities to seek local or regional products to replace imports with high footprints. It is interesting to note that the CO2 efficiency performance of the Food sector has improved across the 2018-2022 period (dropping from 0.45 kilograms CO2e/USD in 2018 to 0.2 kilograms CO2e/USD in 2022. A similar pattern presents in Metals sector over the same period (a drop from 2.2 kilograms CO2e/USD in 2018 to 1.1 kilograms CO2e/USD[68]) suggesting that the sector overall may have increasingly integrated energy-efficient technologies and practices.

Resilience (R)

Imports

A look into import trading partners reveals the following: **The electrical and machinery subsector depends heavily on imports for its activities. Ukraine imports close to half of these goods from China (48.8%)**, followed by several EU countries: Germany (17.2%), Poland (15.8%), Hungary (9.6%) and Czech Republic (8.4%).

Table X gives an overview of Ukraine's main trading partners - imports of Electrical and Machinery (in 000 USD).

[67] United Nations Industrial Development Organization (UNIDO). (2023). *Ukraine: Rapid Industrial Diagnostic Study for Ukraine* (pp.1-55, Rep.). Retrieved from: UNIDO Website

[68] UNEP (2024). SCP-HAT database v3.0. UN Life Cycle Initiative, UN One Planet Network, UN International Resource Panel. Paris. http://scp-hat.lifecycleinitiative.org/methods

Country	Machinery and mechanical appliances, boilers, nuclear reactors; parts thereof	Electrical machinery and equipment and parts thereof; sound recorders and reproducers; television image and sound recorders and reproducers, parts and accessories of such articles	Grand Total
China	1,102,783	2,115,330	3,218,113
Germany	732,570	405,553	1,138,124
Poland	491,088	549,408	1,040,497
Hungary	7,9126	553,127	632,253
Czechia	160,232	396,078	556,311

Imports of Textiles

Interestingly, a significant share of the textile and apparel on the Ukrainian market is imported from abroad. The country has a huge import of used clothes and shoes - notably from the United Kingdom. As a result, the bulk of textile waste in Ukraine is generated due to imported second-hand products. The recent data available for 2020 shows that **a significant portion of the textile and wearing apparel industry waste is not being effectively utilised or recycled** (just 203.2 tons, or approximately 2%%, was utilised as secondary raw materials, and no material at all was recovered specifically in apparel manufacturing).[69]

Of all textiles products imported, almost 50% by value originate from three trading partners: China (20.6%), Poland (18.8%), and Türkiye (9.8%). Almost 50% of this (24% of the grand total of all textiles products imported), is made up of second hand clothing,materials and rags. Notably, 20% of textiles products *by volume* are imported from the United Kingdom, although this makes up only 5.6% of total value.

Exports

The main trading partners are investigated for product groups concerning Metal Products, Electrical & Machinery, and Food & Beverages, respectively.

Food and Beverages total export value is ~22.6 billion EUR, with 7 trading partners making up over 50% of this value: Poland (10.90%), Romania (10.69%), Türkiye (9.09%), China (7.82%), Spain (5.52%), Netherlands (4.87%), Italy (3.72%).

[69] Державна служба статистики України . (2020). Поводження з побутовими та подібними відходами за 2011-2020 роки. Retrieved from: UkrStat Website

Electrical and Machinery total export value is ~3.8 billion EUR, with 4 trading partners making up a little over 50% of this value: Hungary (20.82%), Germany (14.64%), Poland (12.35%), and Czechia (5.87%).

Metal Products total export value is ~6.3 billion EUR, with Poland as the main trading partner accounting for 22.81% of this, primarily driven by the export of Iron and Steel. Other metal product trading partners are the US, Puerto Rico and US Virgin Islands (8.18%), Bulgaria (7.20%), Türkiye (6.61%), Italy (6.23%), which are also predominantly driven by exports of Iron and Steel.

Circular economy (CE)

Material footprint

The material footprint of the food and beverage subsector is very high, highlighting the subsector's reliance on virgin raw material use. It is particularly high for certain subsectors in the food sector, namely alcoholic products, beef meat and cereals, dairy, but also in the petroleum sector. Similarly the footprint is high for the electrical and machinery subsector as well as textiles. It is, however, largely underestimated for metal products, which does not report any data for this indicator.

Waste footprint

The reported industrial waste data is largely underreported across these different subsectors. Only the food and beverages, petroleum, chemical and non-metallic minerals, and metal products report on their waste data. The metal products subsector generates large and varied quantities of by-products. More than 60% of the waste is released during the blast furnace production stage, which underscores the opportunities to explore strategies for utilising these by-products in a circular way. Conversely, no data is available for electrical and machinery, of which electronics is a part; the waste management for WEEE encompasses a combination of formal and informal collection channels. There are currently no voluntary back schemes and collection initiatives, and much of WEEE, like the textiles products, is disposed of with municipal waste.

Agriculture, forestry and fishing

Overall, the agriculture sector has a heavy raw material footprint, is one of the highest employing sectors and represents significant economic output for the country. Indicators relating to the innovation expenditure for the sector was unreported, as was the waste

footprint. The CO2 efficiency is relatively poor although not as critical as that of manufacturing or construction.

For an analysis at the subsector level, only two indicators were available, relating to CO2 efficiency (ID_1) and material footprint (CE_1). This prioritisation should therefore be treated with caution and crossed with other findings, as is described below. The priority Agriculture subsectors are:

- Growing cereals, with a low CO2 efficiency and high material footprint;
- Raising of cattle, with a low CO2 efficiency and a moderately high material footprint.;
- Growing vegetables, with a low CO2 efficiency.

Table X provides an overview of the performance of agricultural subsectors against two indicators (CO2 efficiency and material footprint).

Agriculture	ID_1	CE_1	Final Score
Crustaceans and molluscs	0.0%	0.00	0.00%
Fishing	7.6%	0.00	1.57%
Forestry and logging	0.3%	0.00	0.10%
Growing beverage crops (coffee, tea etc)	17.3%	0.00	3.56%
Growing cereals n.e.c.	81.3%	1.00	38.76%
Growing crops n.e.c.	0.0%	0.00	0.00%
Growing fibre crops	0.3%	0.00	0.06%
Growing fruits and nuts	29.1%	0.02	6.31%
Growing grapes	2.4%	0.00	0.54%
Growing leguminous crops and oil seeds	8.9%	0.02	2.28%
Growing maize	4.6%	0.02	1.29%
Growing rice	2.4%	0.00	0.49%
Growing spices, aromatic, drug and pharmaceutical crops	4.8%	0.00	1.02%
Growing sugar beet and cane	0.7%	0.01	0.38%
Growing tobacco	0.5%	0.00	0.10%
Growing vegetables, roots, tubers	55.8%	0.21	15.89%
Growing wheat	17.0%	0.04	4.28%

Raising of animals n.e.c.; services to agriculture	4.4%	0.00	0.92%
Raising of cattle	100.0%	0.43	29.71%
Raising of poultry	14.8%	0.04	3.88%
Raising of sheep and goats	0.3%	0.00	0.08%
Raising of swine/pigs	20.6%	0.00	4.12%
Seeds and plant propagation	3.1%	0.00	0.63%

Sectoral Development (ID)

The agriculture sector is still heavily reliant on oil and natural gas to operate. In 2022, In Agriculture, over 70% of all energy is derived from Oil and natural gas. Furthermore, 70% of consumption of this oil and gas comes from the four sectors: cereals n.e.c., vegetables, roots, tubers, Raising of cattle and Growing fruits and nuts.[70] Reports in the past have also flagged that agricultural businesses still rely on outdated equipment that wastes energy. Nevertheless, Ukraine's vast fields have a huge capacity for extensive biomass usage. Several organisations have called for an increase in the use of biomass for the production of alternative energy.[71]

Resilience (R)

Ukraine ships its wheat, cereals and oil seeds all over the world. Its agricultural exports are overwhelmingly dominated by the export of cereals, followed by various oil seeds. Its key markets include China, Türkiye, various EU Member States as well as countries in the Middle East.

Table X lists main export markets for Ukrainian wheat, oil seeds and cereals (BACI CEPII, 2022).

[70]UNEP (2024). SCP-HAT database v3.0. UN Life Cycle Initiative, UN One Planet Network, UN International Resource Panel. Paris. Retrieved from Website
[71] Hill. E. (2018). Ukrainian agriculture: a farewell to fossil fuels?. Retrieved from: UNIDO Website

Country	Products of the milling industry; malt, starches, inulin, wheat gluten	Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruit, industrial or medicinal plants; straw and fodder	Cereals	Grand Total (000 USD)
Romania	8,382	706,396	1,277,032	1,991,811
China	4,503	16,978	1,106,907	1,128,388
Spain	1,111	64,819	983,907	1,049,838
Türkiye	5,511	512,932	871,147	1,389,589
Egypt	866	34,953	731,074	766,893
Poland	22,007	483,181	646,393	1,151,581
Italy	738	86,466	407,479	494,683
Hungary	1,518	272,252	401,572	675,342
Netherlands	4,029	106,263	338,924	449,216
Lebanon	519	13,481	303,455	317,455
Grand Total	145,530	3,836,329	9,805,250	13,787,109

Note: This data is from 2022. Previously in 2021, Russia dominated most export markets across different sectors.

The sector is also reliant on several imports, namely **fertiliser**, fish, fruit and nuts as well as beverages. The import of fertiliser is mainly coming from Poland and Belarus, and the fish imports from Norway. Many soils have been lost due or become acidic, saline, or alkaline due to unsustainable agricultural practices, such as excessive use of mineral fertilisers and outdated technologies.[72] There is hence a wide opportunity for Ukraine to develop local, sustainable organic fertiliser through circular approaches - by utilising local waste to create compost, for instance.

Circular Economy (CE)

Waste data was not available for these subsectors, which does not allow us to gather further insights on the different agricultural waste categories (for example, organic, solid,

[72] Food and Agriculture Organization of the United Nations (FAO). (2020). *OVERVIEW OF LAND DEGRADATION NEUTRALITY (LDN) IN EUROPE AND CENTRAL ASIA* (pp. 1-2, Rep.). Retrieved from: FAO Website

liquid, gaseous) that can be repurposed for environmentally purposes. Data is also missing on the significant amounts of manure generated from poultry and ruminant animal farming.

Wholesale and retail

The wholesale and retail sector was the biggest employing sector in Ukraine before the war. In 2021, over 3 million people were employed in the sector.

Detailed subsectoral breakdown for our selected indicators is not available for the sector. Instead, we observe indicators related to **primary energy use** and **raw material use** normalised per final demand, to get a sense of circular opportunities in the sector. Interestingly, both indicators have shown significant improvement over the period of 2018-2022, outperforming both Poland and the EU average. In 2018, the ratio of raw material use over final demand for the sector was far higher than the EU average and Poland. Similarly, Ukraine used a larger amount of primary energy relative to final demand that the EU average and Poland.[73] More recent data shows a dramatically different situation, with Ukraine performing better than Poland and EU countries. **Due to the ongoing war situation and limited timeframe, it's probable that the issue lies within the model itself, meaning that this data is unreliable and requires further investigation**.

Construction

The construction sector records low C02 efficiency levels, a high material footprint as well as a strong dependency on imported materials. It employed approximately 690,000 workers in 2021,[74] which is likely to be underestimated given the prevalence of informal workers in the sector. The waste data is largely underreported for the sector. Other sources indicate that a small proportion of construction and demolition waste is being utilised as secondary raw material but that the majority is landfilled, with a small proportion also being mixed up with municipal solid waste.

Detailed subsectoral breakdown for our selected indicators, except for employment, was not available for the sector. Instead, we look into three indicators related to primary energy

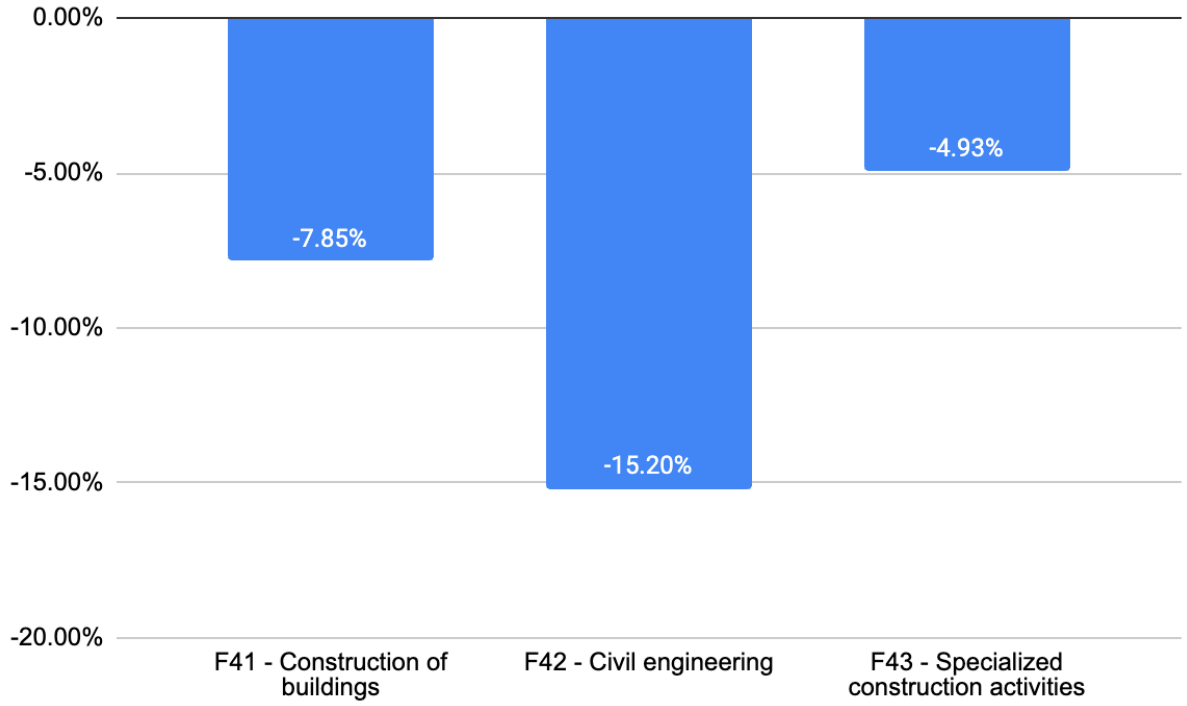
[73] UNEP (2024). SCP-HAT database v3.0. UN Life Cycle Initiative, UN One Planet Network, UN International Resource Panel. Paris. Retrieved from Website
[74] ILO. (2023). Prospects for achieving Ukraine's GDP targets for 2032 in the context of the labour market. Retrieved from ILO Website

use, raw material use as well as the origin of demand in the sector to get a sense of circular opportunities in the sector.

Labour

The labour statistics for the sector indicate a notable decline in various sectors of the industry between 2019 and 2021, most notably for civil engineering. This suggests a significant downturn in infrastructure development activities. The ILO report on predicted labour growth rate to meet GDP growth expectations by 2030 predicts an 8% labour growth rate for the section between 2022 and 2032.[75]

Figure depicts labour force evolution in the construction sector between 2019 and 2021 (ILO).



[75] ILO. (2023). Prospects for achieving Ukraine's GDP targets for 2032 in the context of the labour market. Retrieved from ILO Website

Energy use

From the reported primary[76] energy consumption in the sector for the construction of buildings, roads and railways, the **principal energy input going into the sector is mainly coal and natural gas**. In 2022, approximately 60% of energy inputs going into the construction sector came from oil and natural gas. The second highest source of energy was nuclear energy (approximately 24%), followed by coal and peat (10%).[77]

Looking at the raw material use, the **sector predominantly relies on the use of non metallic minerals**, such as concrete, cement, sand and asphalt (92% of all material use in 2022). There is virtually no use of biomass (around 2%) which points to strong opportunities for developing alternative, local building materials (for example, timber).[78]

Waste

It is noteworthy that before the war started, Ukraine's legislation contained very few special norms or requirements regarding the treatment and reuse of construction waste. Enterprises and municipalities dealt with the situation by their own efforts and mostly by dumping in landfills/dumps designed for solid household waste. This situation became unmanageable as the sheer scale of damaged or destroyed buildings across Ukraine exploded. The approximate amount of construction waste formed in March 2023 was 2,155 cubic metres[79] and is ever growing.

Trade

According to pre-war statistics, Russia was the main trading partner on both imports and exports in the construction sector according to figures from the EORA database in 2021. In 2022, the trade relationship was altered, and the main trading partners for Ukraine as an importer became Poland, Türkiye and China.

Table X lists construction trade statistics, Ukraine as importer (thousands USD, CEPII BACI 2022).

[76] Primary energy is the energy found in nature that has not been subjected to any human engineered conversion process. Primary energy can be non-renewable or renewable.
[77] UNEP (2024). SCP-HAT database v3.0. UN Life Cycle Initiative, UN One Planet Network, UN International Resource Panel. Paris. Retrieved from Website
[78] UNEP (2024). SCP-HAT database v3.0. UN Life Cycle Initiative, UN One Planet Network, UN International Resource Panel. Paris. Retrieved from Website
[79] Property Forum. (2023). Construction waste in Ukraine: What's the solution?. Retrieved from: Property Forum Website

	product description			
country	Stone, plaster, cement, asbestos, mica or similar materials; articles thereof	Salt; sulphur; earths, stone; plastering materials, lime and cement	Grand Total	Percentage
Poland	35,800	40,398	76,198	35.4%
Türkiye	4,267	44,909	49,176	22.9%
China	25,983	3,930	29,912	13.9%
Romania	1,158	21,240	22,398	10.4%
Germany	12,952	6,815	19,767	9.2%
Egypt	98	17,751	17,849	8.3%

As an exporter, Ukraine's main trading partners were Poland, Spain and Romania in 2022.

Table X lists construction trade statistics, Ukraine as exporter (thousands USD, CEPII BACI 2022).

	Product description			
country	Stone, plaster, cement, asbestos, mica or similar materials; articles thereof	Salt; sulphur; earths, stone; plastering materials, lime and cement	Grand Total	Percentage
Poland	15,951	42,933	58,884	26.2%
Spain	458	41,989	42,447	18.9%
Romania	6,485	34,881	41,365	18.4%
Italy	1,769	37,940	39,709	17.7%
Türkiye	1,441	21,003	22,444	10.0%
Republic of Moldova	10,146	9,430	19,577	8.7%

Annex III Priority circular strategies for Ukraine

Table X gives an overview of key opportunities for the circular economy in Ukraine based on the Key Elements Framework.

Eight Key Elements	Strategy group	Strategy Group Description	Targeted sector(s)[80]	Circular strategy	Baseline need being met
Core - Prioritise regenerative resources	Regenerative materials	Utilise bio-based, reusable, non-toxic and non-critical materials for products	C	Using alternative, bio-based materials and inputs Using materials that are not toxic or hazardous	Ukraine's construction sector is import-dependent Various local materials are available locally, such as rye, timber and hemp
			C	Using materials that can be easily reused or recycled after use	Ukraine can rely on vast quantities of concrete panels, steel and bricks for reuse from damaged buildings and infrastructure
			C	Using materials that are not defined as critical[81]	Ukraine's construction sector predominantly relies on the use of non metallic minerals, such as concrete, cement, sand and asphalt (86% of all material use).
	Regenerative energy	More efficiently using energy that is ideally renewable and electric	All sectors	Use renewable energy or renewable fuels like biomass	Ukraine's energy mix is over reliant on fossil fuels Ukraine has underutilised biomass capacity (less than 2% in the energy mix for fueling the construction sector, for

[80] The sectors include Agriculture and forestry (A), Construction © and Manufacturing (M).
[81] The list of materials defined as critical are included in the EU's Critical Raw Material Act.

					instance)
			All sectors	Optimise energy use	Ukraine's industry is material and energy intensive There is potential across all sectors to improve energy efficiency
Core- Preserve and extend what's already been made	Maximise lifetime of products in-use and after use	Upgrade, repair and maintenance of products while they ares still in-use	M	Provide repair services or maintenance services for products or parts	Available statistics across different sectors, notably textiles and electronics, indicate a very low re-use rate
		Product take back and giving products another life after their end-of use	M	Marketplaces or services that enable the second hand sale of products	Ukraine is flooded with second-hand, used textiles of which less than 2% is currently reused
			M	Activities that restore products back to their original state or working conditions	Available statistics across different sectors, notably textiles and electronics, indicate a very low reuse/refurbishment rate
			M	Extraction and reuse of parts from end-of-life products for use in new products	WEEE is poorly separated and treated and refurbished in Ukraine. It is currently mixed with household waste with very little information on refurbishing activities.
	Maximise lifetime of biological resources	Ensure that biological resources are properly managed and preserved	A	Managing and enriching biological resources such as soil, land, etc.	Many soils have been lost due or become acidic, saline, or alkaline due to unsustainable agricultural practices, such as excessive use of mineral fertilisers and outdated technologies.
			A	Preserving and conserving biological	Ukraine is home to diverse ecosystems and species and has extensive forest

				resources such as food, forests, etc.	resources. Current practices do not prioritise soil health or sustainable forestry practices
Core - Use waste as a resource	Valorise waste streams-closed loop	Reuse, repurpose and recycle waste streams within the same industry	C, M	Transforming waste products, materials for reuse within the same industry	Waste coming from the construction and metal products sectors are still not effectively repurposed (for example, for mining: mine tailing, mine water; for construction: recycling of bricks, asphalt and steel into secondary materials)
			M	Using a mechanical or chemical process, to regenerate textile waste streams into new textile materials, sufficiently preserving the quality of the fibre/material in order for it to be used in high value textile applications such as yarns, fabrics and garments.	Ukraine is flooded with second-hand, used textiles of which a very minor portion is effectively recycled
	Valorise waste streams-open loop	Reuse, repurpose, and recycle waste streams within other industries	M, C	Transforming waste products, materials for reuse within other industries	Waste coming from the construction and mining sectors are still not effectively repurposed (for example, reusing discarded asphalt for road construction, mine tailings can be used in construction materials, scrap metal can be used in manufacturing industries, etc)
			M	Using a mechanical process, to transform non textile waste streams/ by-products into new textile	Ukraine is flooded with second-hand, used textiles of which a very minor portion is effectively recycled

				materials, or turn textile waste streams into non-textile products. In this process the quality / integrity of the fibre or material is sufficiently preserved in order for it to be used in high value applications (for textiles: yarns, fabrics and garments).	
	Energy recovery from waste	Recover waste energy or generate fuels and energy from waste streams	All sectors	Recovering and reusing waste heat, gas, etc. for energy	The metal products sector has relatively poor CO2 efficiency performance. The sector has insufficiently explored waste heat and gas recovery methods
			A	Generating energy from waste through processes such as anaerobic digestion, gasification, incineration, etc.	The agricultural sector relies heavily on fossil fuels The biomass in the sector is underutilised There are missed opportunities for repurposing of organic waste in the sector
Enabling - Rethink the business model	Product business models	Deliver products to customers through business models that ensure maximum value / service business models	M	Selling high quality, long-lasting products	The structure of the Ukrainian economy remains concentrated in sectors with low added value.[82]
			M	Providing products through leasing, rental, or pay-per-use models instead of sales	The business of product as a service and other servitisation models are poorly developed in Ukraine Ukraine is a material intensive economy

[82] European Commission. (2023). *Ukraine 2023 report* (pp.1-152, Rep.). Retrieved from: European Commission Website

					which still relies on imports for a number of consumer goods (for example, textiles)
Enabling - Design for the future	Design out waste	Designing products to reduce waste during production and use	M, C	Designing products of multiple parts that can be easily exchanged	The construction sector in Ukraine still lacks circular approaches to building materials Similarly, products are not designed for reuse or recycling, such as the plastics industry in the manufacturing sector
Enabling - Collaborate to create joint value	Industry collaboration	Engage with industry peers to create joint value and identify synergies	All sectors	Putting in place purchasing guidelines for procurement departments and evaluating suppliers on circular economy principles	There is limited evidence of green and circular criteria inside public procurement tenders in Ukraine
			All sectors	Working together with industry peers to engage in business activities or exploratory projects that advance the circular economy	There is limited collaboration between different industry stakeholders to promote circular approaches, due to a lack of knowledge and expertise
		Engage with the government on circular policies and programmes	All sectors	Engaging in discussions with government bodies and policymakers to push for regulations that support the circular economy	There has been developments in introducing circular regulations and requirements but there are still important gaps and implementation is slow
			All sectors	Financial incentives to promote a circular economy	The current fiscal system is still largely linear (for example, the landfill tax is too low and does not incentivise businesses to resort to circular approaches, EPR schemes are not established, no subsidies

					for organic or sustainable produce, etc)
	Internal collaboration	Engage internally to guide and facilitate greater knowledge sharing between internal divisions	All sectors	Provide guidance or professional training to educate civil servants/employees to use circular economy principles	There is a lack of awareness and understanding of circular economy principles among public service and within companies
Enabling - Incorporate digital technology	Data and insights	Employ technologies to gather and analyse data to provide insights on resource use	All sectors	Utilising data and models to to identify, enable and/or implement circular strategies (eg. effective resource use & logistics planning, circular business models & design)	There is a lack of data and adequate monitoring systems to effectively trace resource use across sectors

Annex IV Recycling capacities, relevant infrastructure and relevant industry considerations

As explored in Chapter four of this report, before the war started, Ukraine lacked vital regulation on waste prevention and management, dated infrastructure and limited coordination between different relevant actors. Landfill fees are very low for by European standards and the recycling system is underinvested. All these deficits have made the situation all the more complicated with by the war and subsequent war debris that has inundated certain parts of Ukraine and left local stakeholders with very little capacity to process the waste.

The mining sector produces the highest proportion of waste, comprising up to 85% of the total generated waste in the country according to the State Statistics Service of Ukraine. Following closely is manufacturing, contributing 11%. Although municipal waste constitutes only 1.3% of total waste generation, its management poses challenges due to its diverse composition. **The primary focus of this chapter lies in examining recycling capacity for industrial waste**, therefore, domestic and household waste capacity will not be addressed in detail.

In passing, it is nevertheless important to state that **municipal solid waste management in Ukraine remains at a rudimentary stage, primarily involving the collection of mixed waste (including textiles and WEEE) and its disposal in landfills**. According to data from Ukrstat, the vast majority of household waste was landfilled in 2020.[83] Secondary recovery/recycling rates were very low (below 1%), and it should be noted that statistics do not always distinguish between energy recovery use and other recovery methods, such as recycling. The composting rate was unavailable. According to the official data on 5. 487 landfills and dumps in Ukraine, in 2016 almost 6% of them were overloaded and 30% did not meet national environmental safety standards. Due to the insufficient level of control and lack of a proper MSW management system, over 27 thousand unauthorised dumps are formed each year.

[83] Державна служба статистики України . (2020). Поводження з побутовими та подібними відходами за 2011-2020 роки. Retrieved from: UkrStat Website

While data availability regarding waste, particularly within the construction sector, remains a challenge in Ukraine and is likely underreported, considering these limitations underscores the critical need for prioritising urgent action. **Immediate attention is required for addressing the pressing issues of debris from war and mining waste and debris from war**. **It**'s **recognised that addressing waste management in the industrial and municipal sectors will necessitate more time, as well as the implementation of effective policies and significant investments**.

The immediate urgency for Ukraine lies in addressing the repurposing and recycling of war debris, stemming from both damaged buildings and military materials. As the subsequent section delves into, the industrial sector also contributes to waste generation, much of which is presently landfilled and underutilised. The waste management sector overall still relies on low-level technologies and landfills, and there are important financial and technical limitations. Notably, the metals subsector exhibits an important scrap activity that warrants continued support and endorsement. However, overall, there exists a deficiency in appropriate and modern infrastructure within the waste sector, hindering effective management and recycling efforts.

For all the main product categories in the manufacturing sector, - organic waste, plastic waste, metal scrap, glass waste, paper and cardboard and e-waste, - repurposing methods in Ukraine are extremely limited.

Several recycling plants exist in Ukraine. There are several for plastics, with various capacities, as well as for metal recovery. One source reports that there are 17 waste paper recycling enterprises, 39 polymer processing enterprises, 19 plastic bottle processing enterprises, 16 glass scrap processing enterprises, and 44 metal processing enterprises. Ukraine is one of the few countries in Europe with no policy of extended producer responsibility in place.

Metals

Ukraine has been playing a crucial role in the European steel scrap market, supplying scrap materials to various countries. Although this trade has been significantly affected by the war, there is evidence that the export of scrap metal increased in 2023 compared to the previous year. According to one source, Ukraine exported 182,000 tonnes of metal scrap,[84] marking a substantial increase of 3.4 times compared to the figures recorded in 2022. The majority of

[84] Kolisnichenko, V. (2024). Scrap export from Ukraine increased by 3.4 times y/y in 2023. Retrieved from: GMK Center

these exports were directed towards the European Union, driven by favourable taxation conditions. However, it's worth noting that a significant portion of these exports were subsequently re-routed to Turkey or India through re-export channels.

Multiple companies contribute to this market, and the collection and processing of scrap metal is expected to continue growing in the future. This market presents substantial growth opportunities for Ukraine in its relationship with the EU, with Ukrainian scrap primarily exported to EU countries such as Poland, Greece, and Bulgaria. Alongside the trade in scrap steel, the decarbonisation of Ukraine's steel industry also depends on the industry shifting to smelting scrap steel rather than making virgin steel.

In the context of post-war recovery, the importance of scrap for the Ukrainian steel industry is expected to increase, with a rising potential for selling repurposed military scrap resulting from military operations. However, several challenges lie ahead:

- **The infrastructure is dated and many sites have been badly damaged by the war**. The restoration and modernisation of industry enterprises will involve the adoption of new technologies, such as steel smelting in electric arc furnaces (EAF) using scrap and Direct Reduced Iron (DRI).
- Adapting to new regulations, necessitating a restructuring of the ferrous metal scrap market post-enforcement of the law on waste management (No. 2320-IX).[85]

Plastics

The potential for plastic waste recycling remains largely untapped in Ukraine. Currently, Ukrainian enterprises have the capacity to recycle all types of plastics at a rate exceeding 300,000 tonnes per year, yet only 180,000 tonnes of polymer waste are actually recycled in both closed and open loop recycling.[86] Approximately 20 enterprises across Ukraine are engaged in the recycling of polyethylene terephthalate (PET) containers into secondary materials. This reliance underscores the importance of local plastic waste recycling to mitigate import dependency and enhance the resilience of the domestic plastic industry, as highlighted in Chapter six on seeking alternative, local, circular inputs to lower imports.

[85] Kolisnichenko, V. (2024). Scrap export from Ukraine increased by 3.4 times y/y in 2023. Retrieved from: GMK Center

[86] Державна служба статистики України . (2020). Поводження з побутовими та подібними відходами за 2011-2020 роки. Retrieved from: UkrStat Website

Limited information is available regarding the use of innovative plastic sorting techniques, particularly whether they are predominantly mechanical or also incorporate chemical methods. There is potential for chemical or feedstock recycling, representing another innovative technological avenue to effectively reuse the resource stream of plastics. Generally, chemical recycling is gaining traction but is not yet widely adopted compared to traditional mechanical recycling methods.

It is noteworthy that the Law On Plastic Packaging does not unfortunately set targets for reuse which could help to boost the recycling sector for plastics.[87] The law focuses on the prohibition of several types of plastics.

Electrical and machinery[88]

The volume of electronic waste (e-waste) is significant in Ukraine, although estimates on e-waste coming from the State Statistical Service are considered unreliable. There are no available statistics on the repurposing of this waste, either through refurbishment or the recycling of parts.

The waste management system for WEEE in Ukraine consists of a combination of formal and informal collection channels. Formal collection channels operate within a legal framework, often regulated by licensing systems for hazardous waste operations. In contrast, informal collectors operate outside the legal system, and uncollected WEEE is frequently disposed of in municipal waste. Additionally, there are voluntary take-back schemes and collection initiatives carried out by the private sector.

Approximately 100 organisations are licensed for e-waste management, including collection, transportation, and processing, in Ukraine but there is little available information on the appropriate management and repurposing of this waste.

Textiles

Trade data flows indicate that a significant amount of post-consumer used textiles are exported to Ukraine. The government does not currently regulate and organise the process for separating and appropriately treating this waste, and neither does it manage a separate

[87] Orlyk, M., & Radchenko, V. (2024). Plastics and packaging laws in Ukraine. Retrieved from: CMS Website

[88] The focus of this section is specifically on electronic products and WEE waste, not other electrical products and general machinery.

collection of textile waste from its population. The system is operated by private companies as well as various charitable organisations and foundations that are involved in collecting clothes for reuse.

There is little available information on the availability of appropriate infrastructure for recycling this textile waste appropriately, either through mechanical or chemical recycling methods. Little information is also available on whether any of this waste is recovered as energy through incineration.

Construction waste and war debris

According to sources, the amount of construction waste reached 450,000 tonnes in 2023[89] and is ever growing. As was underlined in Chapter five, the waste data for the construction sector is likely underreported and constantly increasing with the impacts of the war.

The lack of a streamlined method to sort and separate concrete and repurpose war debris has further complicated the process of recycling, as well as increasing the risk that the dangerous and toxic construction materials, such as asbestos, will risk trickling into the environment and damaging both human and environmental health. According to estimates by the Ministry of Environmental Protection and Natural Resources, the estimated environmental damage caused by land contamination exceeds UAH 900 billion. **Because circular practices in the construction sector are little developed, and also because the vast volume makes a circular practice limited, war debris waste is filling up legal and illegal landfills**. Temporary storage sites have also been set up but are likely to be too limited. A new regulation for the "Procedure for Waste Management Generated by Damage (Destruction) of Buildings and Structures as a result of hostilities" should help to structure this sector in the future.

This critical situation has been called to the attention of various donors, who have responded with various mapping and damage assessments, as well as technical assistance projects, notably from UNDP. Circular economy initiatives in the built environment sector have called for greater cooperation between the Ukrainian building sector and construction companies, with construction companies using recycled concrete to minimise costs and transportation ways, for instance, or resorting to recycled concrete rather than natural

[89] Bern University of Applied Sciences Architecture, & Berner Fachhochschule. (n.d.). Decentralised recycling of war debris. Retrieved from: Berner Fachhochschule Website

gravel.[90] In the Kyiv region, 50 centralised collection sites were formed to sort and process demolition waste. Some debris has been put to use in rebuilding roads or creating temporary crossings.

[90] Bern University of Applied Sciences Architecture, & Berner Fachhochschule. (n.d.). Decentralised recycling of war debris. Retrieved from: Berner Fachhochschule Website

Annex V Data sources

Data used

The report relied on various sources coming from SCP HAT, State Statistics Service of Ukraine, and EORA. The most reliable and widely available data was used whenever possible.

Table X gives an overview of different sources of data used for the index.

Topic	Indicator	Source(s)	Year
Industrial development (ID)	CO2 efficiency [ID_1]	UNEP 2024 SCP HAT	2022
	Innovation Expenditure [ID_2]	State Statistics Service of Ukraine	2020
	Labour Force [ID_3]	State Statistics Service of Ukraine	2021
	Total Economic Output [ID_4]	EORA	2021
Resilience (R)	Import Dependency [R_1]	EORA	2021
	Export Dependency [R_2]	EORA	2021
Circular Economy (CE)	Raw material use [CE_1]	UNEP 2024 SCP HAT	2022
	Waste generation [CE_2]	State Statistics Service of Ukraine	2020

Data limitations

- The data used to construct these indices rely on a mix of pre and post war data. The UNEP 2024 data focused on two indicators, CO2 efficiency and material footprint, took the war into account, modelling based on the 2022 figures.

- Each data source presented its own sector mapping, these were harmonised where possible, and as such the indices were constructed at “NACE level 1”. However, as different data sources presented different levels of granularity, it is not possible to construct the full set of indices for all subsectors. Deep Dives are presented for indices that are available per deepdive. Otherwise, we extract other indicators to interpret the performance of sub sectors relative to each other (for instance material or energy use).
- Each data source was available for different years, ranging from 2020-2022. For trade insights at the product level, data from 2022 was used.
- To construct the import and export dependencies indices, multiregional input output database EORA was used. This database is constructed from national tables but nevertheless has its own limitations from being a multi region database. As the tables need to be harmonised at a global level, and represent trade flows between every country at a global level, it can be the case that these tables don’t fully match local tables as balancing is required between nations.
- Although the State Statistics Service of Ukraine does present more recent emissions accounts, we were unable to find these at the adequate level of granularity and as related to relevant economic output accounts to produce the CO2 efficiency measure (ID_1), therefore an alternative global source was used which presented the result directly.
- A variety of indicators exist to study innovation at the sector level, a more comprehensive study would ideally be required to combine these into one representative indicator.
- Due to limitations in scope, these indices could not be constructed over time and checked for statistical correlation, or compared to other countries. This is recommended for further research.