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Exploratory Strategic Foresight for Circular Economy in Ukraine

FINAL REPORT

Towards the Circular Economy Ukraine

Action implemented by:

OECD BETTER POLICIES FOR BETTER LIVES | UNECE | UN environment programme | UNIDO | THE WORLD BANK IBRD • IDA | WORLD BANK GROUP

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List of abbreviations

AI/AGI	Artificial Intelligence/Artificial General Intelligence
B2B / B2C	Business to business / business to consumer trading
CBAM	Carbon Border Adjustment Mechanism of the EU
CE	Circular economy
CPC	Common Product Classification
CO_2	Carbon dioxide
CSR	Corporate Social Responsibility
EC / EU	European Commission / European Union
EPR / EPL	Extended product life / extended producer responsibility
ESG	Environmental and social governance
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross domestic product
HDI	Human Development Index
ICT	Information and communications technology
IOT	Internet of Things
IPCC	Intergovernmental Panel on Climate Change
ISIC	International Standard Industrial Classification
KIBS	Knowledge Intensive Business Services
KPVC	Key product value chain
LED	Local economic development
NGO	Non-governmental organization
OECD	Organisation for Economic Co-operation and Development
P2P	Peer-to-Peer trading
RFID	Radio frequency identification, of products or components
R&I / RTD	Research and Innovation / research and technology development
SDG	Sustainable Development Goals
SMAC	Smart, mobile, AI, cloud-based technology
STI / S&T	Science, technology, innovation systems / ‘science and technology’
‘STEEPCU’	Futures/foresight domains & systems (‘socio-technical-economic-ecological-political-cultural-urban’): with many variations
STEM	Science, technology, engineering, mathematics (in education and training)
WEEE	Waste electrical and electronic equipment
WEF	World Economic Forum
UN-DESA	United Nations Department of Economic and Social Affairs
UNIDO	United Nations Industrial Development Organization
UNEP	United Nations Environment Programme

Glossary of key terms

- **Circular Economy** –UNIDO defines circular economy as an industrial economy that routes materials, parts and products back into use several times and creates more value and less waste. It is an alternative, in which value is maintained for as long as possible, products are designed to last, and the generation of waste is minimized.
- **Context scenarios** – The addressee of a scenario analysis – for instance, a firm or a country – can never control the entire range of factors influencing future development. Context scenarios capture in a systematic way the space of possible combinations of factors that will shape the future but are beyond the influence of the addressee. In other words, context scenarios represent possible future environments that addressees may have to face and for which they have to prepare strategies.
- **Foresight** (as in 'Technology Foresight') - the process involved in systematically attempting to look into the longer-term future of science, technology, the economy and society, with the aim of identifying the areas of strategic research and the emerging generic technologies likely to yield the greatest economic and social benefits.[1]
- **Future vision** – 'Future vision' is the description of a desirable prospect with regard to a particular context scenario.
- **Key product value chain –** a connected series of production and products, from design, to raw materials, intermediate inputs, final production, marketing, distribution, and support to the final consumer.
- **Key technologies, and key technology innovation systems** – Key technologies is a concept to describe technological developments that could be of use for a wide range of economically important applications. The concept of key technology innovation systems combines the notion of key technologies with that of technological innovation systems in order to capture the institutional and other requirements necessary to realize key technologies *and* their economic impact.
- **Pathway mapping** – This is effective where risks, goals and resources are 'volatile, uncertain, conflicted and ambiguous'. The pathway-mapping method is based on the Pathways Toolkit, which works with a ***wider*** community of stakeholders, ***deeper*** layers of value and meaning, and ***further*** horizons of transformation.
- **Roadmap** – A sequence of steps or events necessary to realize a scenario. These steps can be technological, economic, social or political in nature. In its most simple form, a roadmap distinguishes present state, future state(s) and actions to be taken in between, but it can also take the form of series of actions ordered along a timeline.
- **Science, technology and innovation (STI) systems** – Developed as a concept between the late 1980s and early 1990s, the notion of "systems" to capture the nature of research and innovation has exerted a strong influence on research, technology and innovation policy during the past two decades. In most systems approaches to STI, emphasis is put on the importance of interactions between different types of actors, and of the institutions guiding and framing these interactions. Developed initially as a synthesis of previous actor-centred approaches, more recently the notion of functions of (research and) innovation systems has been introduced. Depending on the

[1] UNIDO 2005

respective emphasis put on different driving forces, authors speak of innovation systems, research and innovation systems, or science, technology and innovation systems.

- **Success scenario** – This is a desirable future that is challenging, but that must also be possible to achieve.
- **Triple helix** – A concept developed to understand the close relation of governance, innovation and production in a development process. The triple helix model of innovation refers to a set of interactions between academia (the university), business and government, to foster economic and social development, as described in concepts such as the knowledge-based economy and knowledge-based society. Depending on the availability of empirical evidence and data, the model could incorporate public or civil society as the fourth helix (quadruple helix model), the natural environment of society and ecological issues (quintuple helix model) or even extended algorithmically more generally to a multiple or n-tuple helix model.

Summary for policymakers

Circular economy

A 'circular economy' (CE) is an economy where products, parts and materials are 'cycled' back into the industrial system, creating additional value – economic, social and environmental. In a circular economy, (a) products are designed to last, (b) repair and recycling are standard and (c) raw material inputs and waste outputs are at a minimum.

The CE is now the focus of visions and transformations in progress in many countries around the world.

To look ahead at such visions and turn these into practical pathways and actions – this is the role of 'foresight' and strategic thinking.

This project, the '*Exploratory Strategic Foresight for Circular Economy in Ukraine'* is managed by the United Nations Industrial Development Organization (UNIDO), under the EU-funded EU4Environment Action programme, with co-financing from the German Federal Ministry of Economic Cooperation and Development (BMZ).

This Final Report brings together the results from each of the four stages of the project: scoping, scenarios, visions and pathways.

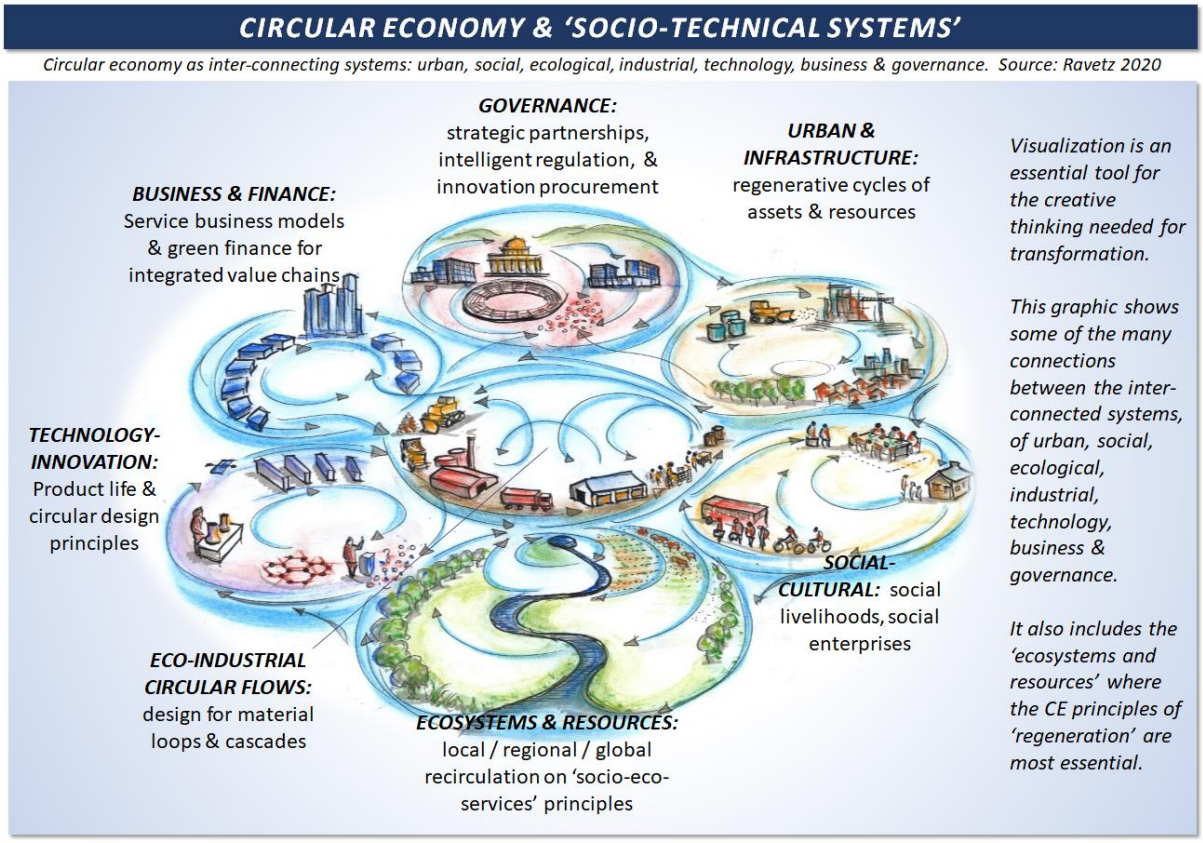
It presents an outline of the potential visions and opportunities for a CE-Ukraine, within the current uncertainties, with practical pathways to achieve them.

The foresight approach

The general foresight approach is to explore possible futures, and map practical ways to turn problems into opportunities. Beyond the scope of mainstream strategic planning, foresight works with a ***wider*** community of stakeholders: with ***deeper*** layers of value – social, ecological and political: and with a ***further*** horizon for longer-term transformation.

The method of this 'exploratory strategic foresight' works in four main stages (see annex, A.5, for details): scoping and systems mapping: scenarios for the future: visions and opportunities: pathways and strategies for action.

Through the stages, panel discussions and online surveys with several hundred participants, provided ideas and responses, and visual mapping tools helped to explore the bigger picture.



Circular economy – scoping and mapping

The CE principles focus on materials and resources, but the reality includes a much bigger picture. The scoping and mapping of such a bigger picture needs a highly structured approach, as demonstrated in the following sections:

- The 'Key product value chains' (KPVCs) are the central focus: these are connected chains of activity and value creation, from raw materials to manufacturing, distribution, consumption and post-consumer waste.
- The 'circularity' of each KPVC can work in many cycles: from re-use and repair to re-manufacturing and recycling, to energy recovery.
- For the trade agenda, these KPVCs are not only national but international and global systems, with imports and exports at every stage along the chain.
- 'Socio-technical systems' are the dynamic forces which shape the material flows: here defined as business, governance, community, technology, industry and infrastructure.

This scheme is the basic model for mapping in detail each of the KPVCs, as in Part II. The first implication is that the 'material CE' can work only if other things work: for example, the 'economic CE' for viability of firms and investors, the 'social CE' of motivation of consumers and workers, and the 'technology CE' of innovation systems.

The graphic in the figure is a non-technical illustration of these socio-technical systems in each KPVC, and some key synergies between them.

Key product value chains and pathways

This CE-Ukraine foresight explores five main priority KPVCs. These were first based on the EU Circular Economy Action Plan,[2] and then further developed through consultations. Some pathways are presented with non-technical titles for communication with a general readership.

'Constructions'

This KPVC ranges from primary materials to completed buildings, fittings, and components: and then includes for life-time operation, maintenance, conversion, renovation and end-of-life demolitions. The KPVC visions and pathways include:

(a) ***'Construction resources' pathway:*** this works on the supply side, for transformation of materials resource efficiency, waste minimization and recycling on construction sites: and for post-life buildings and components, re-use, and recycling. This depends on upskilling and co-production across the whole construction industry.

(b) ***'Construction innovation' pathway***: advanced technology and infrastructures: with full digitalization, product identity, alignment with EU research ecosystems. This promotes innovations such as bio-material structures, with design for re-use, dis-assembly and re-manufacturing of materials, components, fittings, and furnishings.

(c) ***'Construction procurement' pathway***: on the demand side, this sees government leading strategic partnerships of real estate clients, construction firms, RTD bodies, and civil society, to drive up standards and mobilize investment for the infrastructure needed.

Food products

This KPVC works from primary inputs to agriculture, to manufacturing and distribution, to consumption by households and catering, to post consumer bio-materials and packaging. The KPVC visions and pathways include:

(a) ***'Food efficiency' pathway:*** On the supply side, with innovation in crop production and technology, efficiency can be greatly increased, chemical inputs reduced, farm waste recycled into farm inputs. In manufacturing, there is huge potential for food and drink processing waste to achieve near 100% recycling and recovery.

(b) ***'Food health' pathway:*** On the demand side, there are multiple priorities: reducing food waste and packaging, increasing healthy food and drink, reducing food poverty, and strengthening the social and economic role of many kinds of food business in retail, catering and public services.

(c) ***'Food livelihood' pathway:*** On the community dimension, food is a livelihood issue, for rural village production, marginalized communities, and urban neighbourhoods.

[2] European Commission (2015).

Land reform, housing reconstruction and spatial planning policy can all help to promote food enterprises based on local social capital.

Electronics and ICT

This KPVC is a typical industrial chain, from primary raw materials (many of them 'critical'), to manufacture and distribution. Electronics and ICT is a particularly globalized value chain driven by very rapid innovation and obsolescence. The KPVC visions and pathways include:

(a) ***'Technology for life' pathway:*** On the production and market supply side: this combines trade regulation with market development for re-use and recycling. The hyper-rapid innovation cycle can be steered towards extended product life, producer responsibility, take-back policies, leasing models, reverse logistics, design for repair and dis-assembly, etc.

(b) ***'Device literacy' pathway:*** on the *consumer and demand side,* there is an agenda for social innovation and local skills / enterprises, in the repair, re-use, recycling and recovery of electronics / ICT devices and installations.

(c) ***'Industry 5.0' pathway:*** for the whole economy agenda, this starts with the aspiration for full digitalization, for a future 'smart-wise' whole economy and society.[3] It then includes the planned circularity of e-waste as an essential part of the transition towards 100% re-use and recycling.

Plastic and packaging:

This covers two closely connected product types. Plastics are used in every part of a modern economy: and especially in packaging, where plastics are essential to KPVCs such as food or electronics. The visions and pathways include:

(a) ***'What goes around comes around' pathway:*** this works on the packaging industry supply side. It starts with extended manufacturer's responsibility and new kinds of valuation of plastic recycling services: this depends on strategic partnerships in circular procurement between manufacturer and buyer, and 'B2B' firm exchange.

(b) ***'Packaging for life' pathway:*** this works on the social / demand side of re-use and recycling. It sets up programmes for public awareness and education, practical incentives, and local scale urban infrastructure, with a 100% shift from disposable packaging towards fully re-usable, repair-able, and recycle-able packaging.

[3] European Commission, 2021.

'Plastics for life' pathway: this works on the industrial materials supply side: with combinations of eco-industrial management, business-finance models, and advanced technology innovation systems. Overall, this points towards industrial symbiosis, where materials can be shared between different sectors, i.e. one firm's waste is another's raw material.'Wastes':

Wastes are defined as materials with zero or negative value: this KPVC covers a wide range of inter-connected systems and material flows, which are embedded in all KPVCs, To support a rapid transition from 'wastes' towards 'resource management', the visions and pathways include:

(a) ***'Waste not want not' pathway:*** this takes a household / municipal waste focus. It starts with the domestic economy of households and communities, where re-use repair and recycling can grow, in kitchens, gardens, local shops and local workplaces. It also creates infrastructure at the local level, both physical logistics and material exchanges, and local business activity and investment.

(b) ***'Resources for life' pathway:*** this focuses on with bio-materials, firstly from food and then from other sectors. Simple household composting of kitchen and garden waste can provide valuable inputs: for retail and catering operations, management of food product quality and sharing of surplus via food banks, are the practical starting points. For agricultural and forestry waste bio-methane technologies can be set up.

(c) ***'Symbiosis for growth' pathway:*** for all kinds of manufacturing and non-household waste, industrial symbiosis is the guiding principle for circularity in resources, primary materials, components, semi-finished and final products. Full digitalization is the key to logistics for resource management, with technologies such as robotic separation, component RFID tracking, smart AI-driven logistics and energy / materials platforms.

Socio-technical systems and transformations

The circular economy transformation in material flows, then depends on transformations in each of the main 'socio-technical systems'. These transformations are applied to the KPVC pathways in various combinations.

- ***Business-finance transformations – from 'product' to 'service': (***includes finance, investment, enterprise models and marketplaces). This transformation moves from a free-standing product 'on the shelf', towards a wider system and value constellation of technology, finance, leasing, maintenance, repair, etc.

- ***Policy-governance transformations – from 'regulation' to 'partnership': (***includes governance and regulation, public services, public procurement). This shifts from the former model of government as top-down law-makers, to a more pro-active partnership role which brings together government with business, civil society, academics and innovators.

- ***Social-community transformations – from 'consumers' to 'citizens': (***includes household economy, education and skills, local livelihoods). This broad transformation sees the potential for society to move beyond the narrow materialist role of

'consumers', towards a more integrated and inclusive role as citizens, based on full participation and co-production.

- ***Design-technology-innovation transformations – from 'products' to 'value chains': (***includes digital economy, innovation systems and design systems). This paradigm shift reflects the above bigger picture, where product design is one part of a wider and deeper 'systems innovation' for whole value chains / constellations.

- ***Environment-industry transformations – from 'efficiency' to 'circularity': (***includes production lines, materials handling, environmental assessment and management). Looking beyond current programmes for resource efficiency and cleaner production, this is about very practical changes in industrial processes, materials management, and logistics.

- ***Urban infrastructure transformations – from 'waste' to 'resources': (***includes material logistics, local economies, spaces, land, and buildings). This transformation starts with spaces and buildings at the local level, and over time creates capacity for 'reverse logistics', exchange hubs and storage zones, all the way to urban / regional scale facilities.

Recommendations and next steps

The single most important agenda for the CE-Ukraine is for EU alignment, with the EU CE Action Plan as the starting point. Following this, many CE-related applications such as EU Taxonomy, EU Characterization, EU Carbon Border Adjustment mechanism and similar schemes, cover a wide range of trade agreements, product standards, material classifications, corporate compliance, credit-worthiness, consumer standards, environmental objectives and others.[4]

In practical terms this can build on the UNIDO Ukraine Industrial Diagnostic Report,[5] with a 'wider-deeper-further' approach:

(a) Set up a ***wider*** 'CE ecosystem' of actors / stakeholders, for co-innovation and co-production. For Ukraine this suggests a connected set of networks, hubs, forums, skills sharing, technology transfer and knowledge exchange.

(b) Build capacity for a ***deeper*** 'CE value-system': the CE is not only a functional-material agenda, but one which integrates technologies and markets with other social, cultural, and ecological values, such as in cooperative enterprise, regenerative farming, civil society renewal, and active citizenship.

(c) Explore the ***further*** 'CE transformation' which connects short-term problems with longer term horizon 3 agendas. For Ukraine, this may start with the most 'mission critical' and urgent issues, for instance:

[4] European Commission, 2015 and 2020.

[5] UNIDO, 2023.

- How to increase Ukraine's energy security in times of disruption and shortage?
- How to ensure a viable future for Ukrainian farming in times of water crisis?
- How to turn the problem of Ukraine's waste into a new business opportunity?

Ukraine in its current context and uncertainties, has great challenges and potentials. The potential is not only the agenda of 'catching up' with the EU and others – it sees the opportunity for Ukraine as a leader and forerunner in the circular economy transformations ahead.

PART I

Overview and context

The following sections provide an introduction and context to this project: an overview of the baseline conditions and alternative futures: and an overview of the selected ‘key product value chains’ and socio-technical transformations

1. Introduction

A 'circular economy' (CE) is an economic system where the value of products, components and packaging is maintained for as long as possible. This brings many benefits – social, economic and environmental.

The CE is now a transformation in progress in many countries around the world. Ukraine has great potential to be a forerunner in the field.

To explore such potential and turn it into action – this is the role of 'Foresight'. This project, the *Exploratory Strategic Foresight for Circular Economy in Ukraine*, has worked with stakeholders on future visions for the CE-Ukraine, and the 'transformation pathways' to turn them into action.

The project was managed by the United Nations Industrial Development Organization (UNIDO), under the EU-funded EU4Environment Action, with co-financing from the German Federal Ministry of Economic Cooperation and Development (BMZ).

This Final Report brings together the results from the four stages of the project: scoping, scenarios, visions and pathways.

1.1. Overview of the circular economy

A circular economy is an economic system where the value of all material products, components and packaging is maintained for as long as possible. To ensure this outcome, these are all designed to last, maintained and repaired, reused and shared, and at the end of the useful lives their components and materials are circled back into the agricultural and industrial systems to create additional value. In addition, in a circular economy renewable energy is used as much as possible. All these actions mean that the extraction of virgin raw materials from the environment and leakage of materials back into the environment, in the form of waste, emissions, and pollution, are minimized. [6]

The CE transformation is now in progress in many countries around the world. Such transformation is not only about materials: it depends on synergies between many 'social systems' of business, government, and civil society: and many 'technical systems' of design, innovation, environmental management, and infrastructure.

The general scope is shown in Figure 1. Here, a typical KPVC ('key product value chain') starts with raw materials on the left, which come through manufacture, distribution, purchase, usage, and out as surplus material on the right-hand side. As far as possible the materials can be segregated for re-use, recycling and other 're'- loops from repair to recovery.

[6]UNIDO, 2019 & 2020: Circle Economy Foundation (2023a & 2023b): OECD 2020

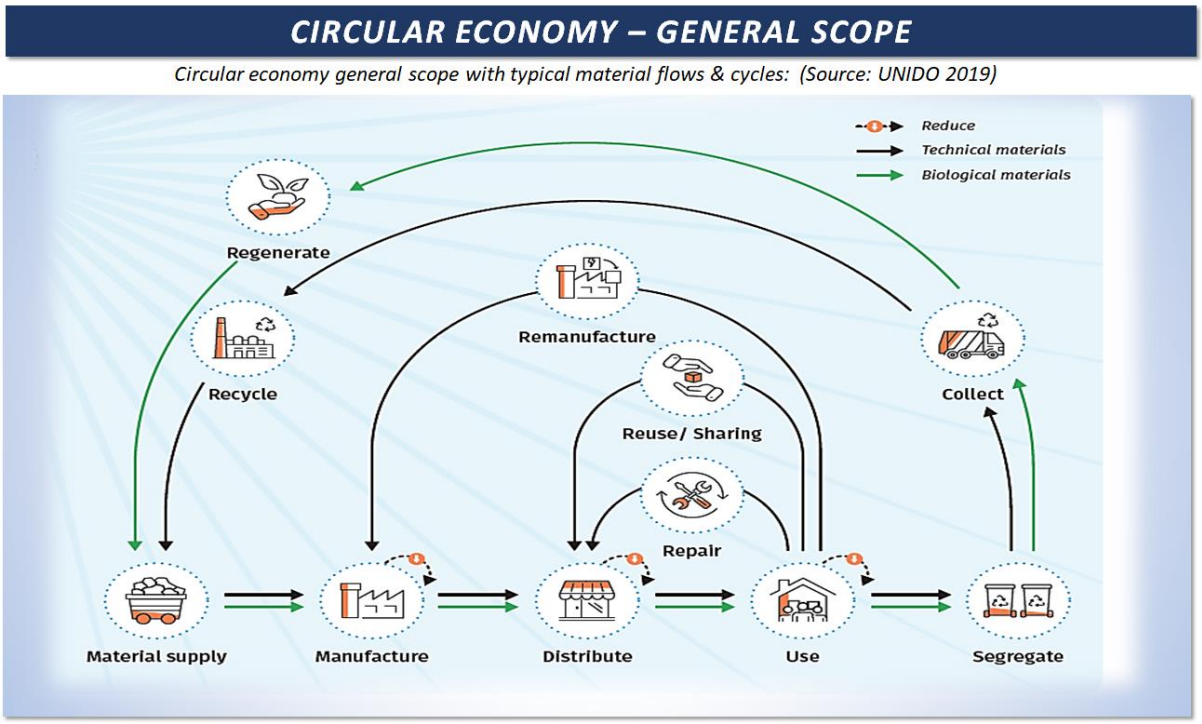


Figure 1. Circular economy – general scope

For Ukraine, as with other countries, there are many potential benefits:

- Increased income for business and the wider economy
- Reduced dependence on external resources
- Minimized waste and pollution
- Reduced environmental footprint.

In addition, for Ukraine the CE transformation will be essential at a strategic level:

- Modernize the economy and increase productivity
- Enhance investment, trade flows, incomes and skills
- Strengthen cooperation with the EU and internationally.

Such transformation can be far-reaching, with many sectors of business and society, many material streams, and many locations being involved. While there are some costs and some risks, the potential benefits are huge and of national importance.

1.2. Circular economy transformations

The CE is not only about materials and resources: it represents a transformation towards new systems of production and consumption. This means firstly a transformation in economic systems across the board, with new synergies between many sectors of business and finance, and many material streams, in many locations.

It is also a governance transformation, calling for a more active role by the Government in setting up partnerships and strategic programmes of innovation and procurement. Similar thinking applies in each of the main 'socio-technical systems', here defined as 'business-finance', 'governance-policy', 'social-community', 'design-technology', 'eco-industrial', and 'urban-infrastructure'.

These new synergies will require new thinking on the new opportunities which will be generated, and pathways to achieve them. A summary of the transformations includes, in each of these socio-technical systems:

- Business-finance – from 'product' to 'service';
- Governance-policy – from 'regulation' to 'partnership';
- Social-community – from 'consumers' to 'citizens';
- Design-technology – from 'gadgets' to 'value chains';
- Eco-industrial – from 'efficiency' to 'circularity';
- Urban infrastructure – from 'waste' to 'resources'.

Following through, this 'exploratory foresight' has mapped the wider landscape of CE transformation in Ukraine. The diagram in Figure 2 shows this bigger picture:

- A typical 'Key Product Value Chain' is shown in the centre (this includes various infrastructures, which support the main value chain);.
- The material 'circularity' can be seen above in various loops and layers, from repair to recycling to recovery;
- This involves imports and exports, and global trade at every stage, in different patterns in each KPVC, as shown below;.
- Socio-technical systems are shown on the left side – business, governance, community, technology, industry and infrastructure. For each system there is a short list of 'enablers', i.e. common practical actions or ways forward.
- The basic CE material flow principles are shown on the right side – 'regenerate – cycle – slow – narrow'. [7]

This diagram is the basic templates for each of the KPVC mappings in Part II.

[7] Circle Economy Foundation, 2024 and 2023.

The implication is that the material flow CE can work only if other things work: the economic viability of firms and investors, the social motivation of consumers and workers, the technology innovation 'eco-systems', and so on.

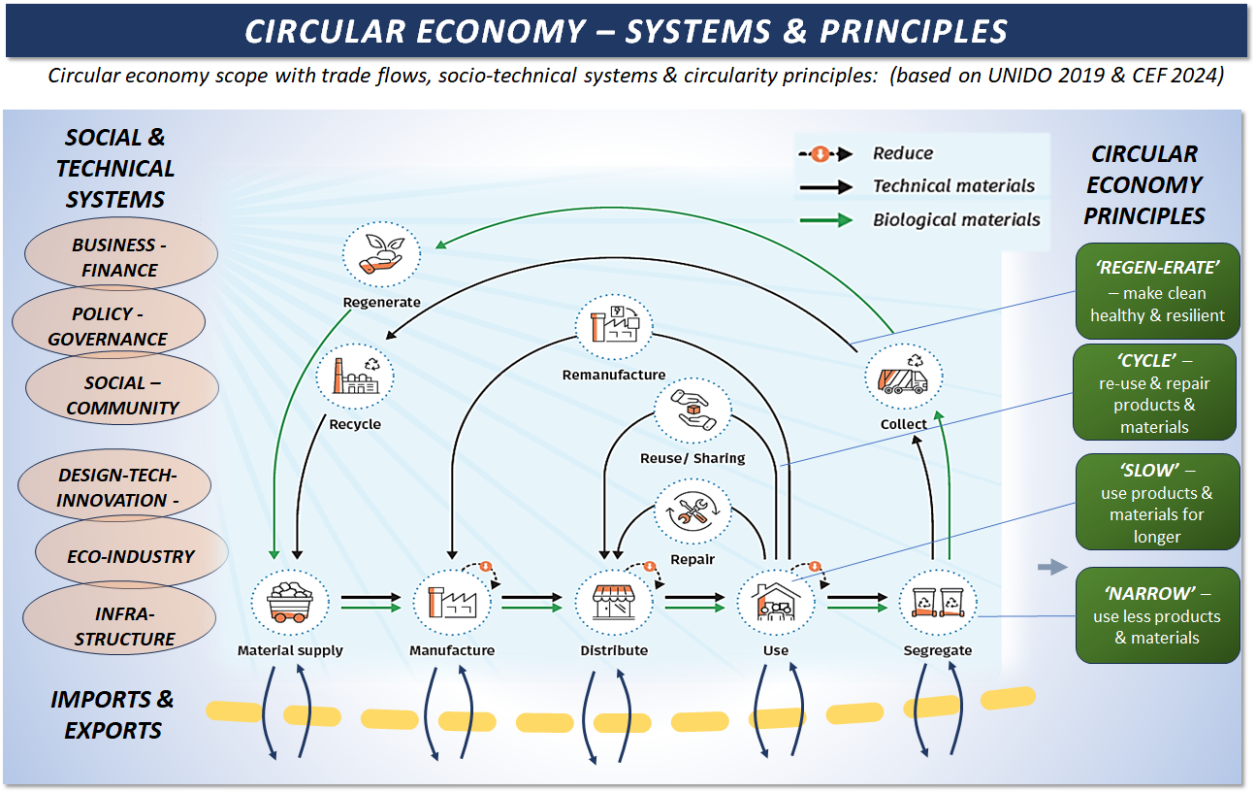


Figure 2: Circular economy: systems and principles

1.3. Transformation in practice

For Ukraine as for any other country, there is no fixed model for what the CE will look like, in 5, 10, or 20 years from now. Fortunately, Ukraine can benefit from the research and innovation and policy development, around the EU and beyond, and learn from the experience so far. Some strategic innovation agendas are crucial to success:

- CE-Ukraine will involve economic innovation: in business models, value chains, financial models, market and logistics models.
- CE-Ukraine will depend on social enterprise, so that consumers, citizens and workers have awareness and motivation to re-purpose, re-use and recycle.
- The CE-Ukraine also depends on policy and governance innovation, beyond the conventional 'policy versus business divide'. This calls for new models of policy and governance: supply chain partnerships, strategic innovation / procurement, industrial standards forums, regulatory collaborations, etc.

- The over-arching agenda is for EU alignment, as the largest and most advanced trading bloc in the region. The EU-CE action plan, EU Taxonomy, EU Characterization, EU Carbon Border Adjustment mechanism, and many other schemes, serve the CE agenda for trade movements, product standards, material classifications, corporate compliance, credit-worthiness and others.[8]

Overall, many national governments, cities and regions, firms and enterprises, institutes and associations, NGOs and universities are promoting the circular economy. There are countless reports, policies, manuals, best practice examples and platforms. All these are inspiring examples of positive thinking.

However, in reality there are many hidden barriers, gaps and challenges – some of which are shown in the baseline profiles below, and in the KPVC chapters. Feedback from the project participants (as in the Annex) suggests that new business models are seen as risky to enterprises. New product designs or service models need to find new markets, which can take time, and new systems for re-use or recycling need to be 'learned' together, by producers, retailers, and consumers.

On the demand side, many households may not have interest or opportunity for recycling and other lifestyle changes. In public procurement the principle of lowest cost generally comes before any other goals, environmental or otherwise. And then, barriers exist in the deeper layers of the system.

The political power of most large firms is based on conventional business models of 'take-make-dump', and many investors steer away from the perceived risk of 'green new deal' businesses. The 'old networks' of industrial production may not work in a new business environment, and so there may be resistance, economic and political.

In summary, the transformations to CE are not always simple or easy, and this will be true for CE-Ukraine as elsewhere. For instance, the EU has been promoting the circular economy for nearly 10 years, with large inputs of funds, but so far it seems that progress so far is a long way behind expectations.[9]

Ukraine being a very special case – at present the disruption and destruction of the war, has increased risks, displaced large populations, taken out vital infrastructure, destroyed local markets, and increased risk for investors – the question to be explored is, what is to be done for the future?

1.4. The foresight approach

The foresight approach works to explore and mobilize such transformations.[10] It looks not only for idealistic visions, but for practical opportunities, which are also 'game-changers'. It looks beyond the short term 'problem-fix' ('horizon 1'), towards systems change in the longer term ('horizon 3'). It looks for synergies between stakeholders, right across the innovation ecosystem, and along the value chains from supply to demand sides. It explores not only the

[8] European Commission (2020 & 2023).

[9] European Court of Auditors, 2018.

[10] UNIDO 2005: Miles et al 2016: Saritas 2020: Ravetz & Miles 2016

positives but also the negatives – the many gaps and barriers which keep the industrial 'take-make-dump' system resistant to change – and then looks for the catalysts, enablers and opportunities for transformation.

The overall goal of this 'exploratory foresight' project is to help mobilize Ukraine's shift towards the policies and practices of the EU CE action plan. The result is a set of ***'transformation pathways'***, which connect the future visions to practical actions.

In that context, the special role and contribution of this project can be seen with an extended scope – 'further, wider, and deeper':

- Looking ***further*** beyond the short term, to whole transformation: with a 'horizon 1' of 1-5 years: 'horizon 2' of 5-10 years: and a 'horizon 3' of 10-25 years.[11]
- Looking ***wider*** to all stakeholders and communities, from business leaders to the poor and displaced: the CE depends not only on economic 'winners', but in the motivation for change of all citizens and communities and cultures.
- Looking ***deeper*** for the synergies of CE material flows with other systems – economic, social, technological, governance and cultural.

These foresight methods are well suited to situations of high uncertainty and rapid change. As Ukraine's current situation is one of very high uncertainty and rapid change, the foresight approach can be very relevant. As shown in the diagram below:

(a) In the short term on the left, the main agenda is for management of the war situation: with huge costs, risks, and uncertainties.

(b) The post-war recovery plan is highly dependent on (a): this is already in detailed planning, but surrounded by major uncertainties on the future of aid, investment, demographic change etc.

(c) For horizon 2, the 'green agenda' is not always seen as a priority in post-war recovery amongst other urgent priorities – but the direction is clear, towards EU alignment, along with other bilateral and multilateral frameworks.

(d) For horizon 3, systemic 'transformation pathways' point towards future visions and new opportunities, and this is the first creative contribution of the foresight approach. These longer-term pathways can also help to address and resolve the medium-term challenges and barriers of the 'green post-war recovery' plan.

[11] Sharpe and Williams, 2013.

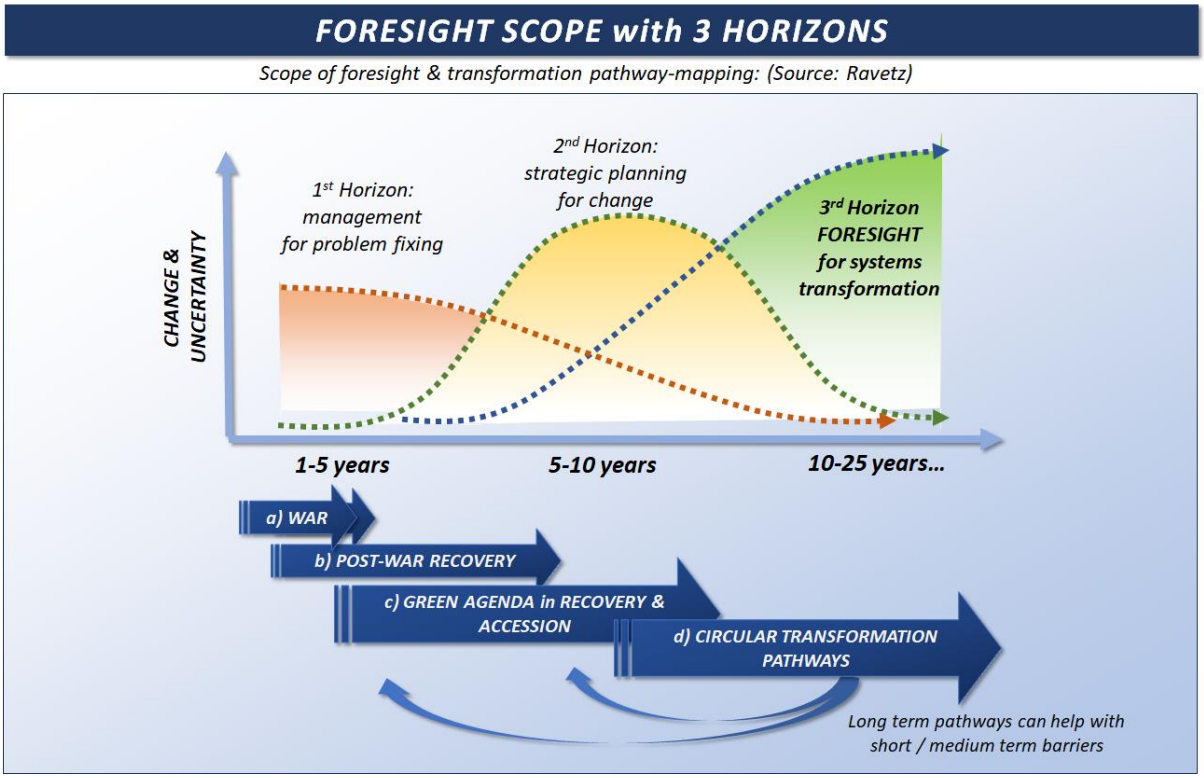


Figure 3: Foresight scope with 3 horizons

This *'further-wider-deeper'* scope has been explored through many programmes on CE and related agendas – net-zero, sustainable food, adaptive governance and so on.[12]. It can be framed as a *'collective circularity intelligence'* – the capacity for shared learning, innovation and collaboration – with *further* horizons of transformation, *wider* communities of interest, and *deeper* layers of value.

In summary, Ukraine is a very special case: currently on the front line of war – but also with a unique potential for post-war transformation. Project participants have discussed how Ukraine could provide leadership for the whole EU and beyond. This project with its '*further-wider-deeper'* scope aims to contribute to that agenda.

1.5. About the project

The project 'Exploratory Strategic Foresight for Circular Economy in Ukraine' was managed by UNIDO, under the Component 2 'Circular Economy and New Growth Opportunities' of the EU-funded EU4Environment Action, with additional funding from the German Federal Ministry of Economic Cooperation and Development (BMZ).

[12] Ravetz 2020

This Final Report is a synthesis of the working papers from each stage of the project: Scoping, Scenarios, Visions and Pathways, together with the side-reports on panels and surveys.

The primary evidence comes from three main panel meetings held online, with representatives of ministries, academia, business and civil society (108 experts in total). A preliminary in-person meeting was held in Warsaw, together with a series of stakeholder interviews and technical consultations. Two online surveys were conducted for the visions and pathway mapping stages (155 participants). The realization of all those events counted on the support of the RECP Centre. The list of representatives of Ministries, academia, business and civil society who contributed to the Exercise is available on http://www.recpc.org/circular-economy/.

The foresight project also reviews the desk study evidence so far coming from Ukraine, the European Union, the Organisation for Economic Co-operation & Development (OECD) and UNIDO. It fits this with international developments in CE thinking, from organizations such as the Circle Economy Foundation and the Ellen McArthur Foundation. It provides a novel synthesis of CE thinking, not only for the mainstream CE definition and application to Ukraine, but for a bigger picture of systems change and transformation.

The report is set out in three parts:

- Part I: General context and method: introduction, baseline, and context
- Part II: Outline of key product value chains
- Part III: Annex with supporting material.

Overall, this synthesis report aims to contribute to the larger 'Circular Economy Ukraine' programme, as on http://www.recpc.org/circular-economy/. This programme includes baseline assessment of the situation in the country, online training program for decision-makers, compilation of business cases of available circular practices as well as a set of project proposals to further advancing the Circular Economy practices and principles in the country.

2. Baselines and futures

The starting point for the CE-Ukraine transformation is challenging – and yet brings many opportunities. This section gives a brief review of the national context and baseline: an outline of the framework for alternative future scenarios: and the formation of a national vision statement.

2.1. Context and baseline

Ukraine is a large country with many regions and landscapes: an emerging economy with around 50% of the EU average of GDP per person (as of 2023).

The Russian invasion of 2022 has caused massive damage and disruption, both physical and socioeconomic, and the outcome is still very uncertain. This catastrophe has given rise to around 6 million refugees, veterans and internally displaced persons, with widespread disruption of labour and skills, infrastructure, and consumer markets.[13]

The economy has up to now centred on primary resource-based production of minerals, metals, agriculture and forestry. Ukraine's international food exports account for 41% of export value (now returning to pre-war levels).[14]

For the environment and sustainability agenda, this general assessment from the UNIDO Industrial Diagnostic Study is pertinent:[15]

> … Ukraine still lags the EU and other comparators in terms of CO_2 emissions, with total emissions intensity still significantly higher than those of many comparator countries.
>
> Ukraine's material efficiency is currently low, and policymakers should therefore prioritize measures to enhance material efficiency and promote recirculation into the economy to promote reuse. As part of the country's sustainable industrial development agenda, the improvement of material efficiency may result in triple dividends: (i) reducing dependence on the supply of raw materials; (ii) lowering environmental pressure, and (iii) improving industry's competitiveness.
>
> The absence of State-supported mechanisms to transition to a circular economy, including availability of funding, capital investments in environmental protection, acquisitions for collaborative business projects with the EU, green lending, and preferential loans for SMEs is a major obstacle. Additionally, many enterprises lack the financial resources to restructure and modernize their production facilities. Lastly, there is a notable lack of information and consulting activities in the field of circular economy.

Focusing more on waste management and the CE agenda, this assessment from the Circle Economy Foundation includes the following considerations:[16]

[13] National Recovery Council, 2022.
[14] USDA, 2014.
[15] With reference to Landell Mills et al., 2023.
[16] Circle Economy Foundation, 2024.

… Since 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, conditioning Ukraine-EU integration. The earlier Association Agreement of 2014 between the European Union and Ukraine already supported the adaptation of Ukraine's regulatory body to the EU models.

The most relevant piece of legislation for the circular economy is the adopted June 2022 Law of Ukraine on "National waste management", regulating the relations in connection with 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 2030, adopted in 2019, identifies tasks and practical measures designed to enable Ukraine by 2030 to switch to a new model of waste management existing in the European Union. Now that the June 2022 law on a national waste management architecture has been voted, regional administrations are in the process of developing regional plans for waste management, up to 2025, as demonstrated by the Zaporizhzhia oblast and the regulation for regional waste management as well as local waste management plans.

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 non-existent sectoral circularity objectives or regulation, particularly for the construction sector
- Fragmented inter-ministerial/agency/municipal communication
- Lack of a coordinated approach for monitoring waste statistics.

2.2. Feasibility and capacity of CE-Ukraine

The CE transition depends very much on the presence of 'enablers' – practical combinations of policy, business, technology, and others. A preliminary list of enablers was compiled from international experience, expert consultation and literature (details in Section 3). This was supplied to the panel participants and survey respondents (Survey A of this project), who selected the most critical and relevant priorities and enablers for Ukraine, in the short, medium, and long term horizons. The chart in Figure 4 illustrates the list of the enablers for successful CE transition in Ukraine, ranked by the priorities of survey participants.

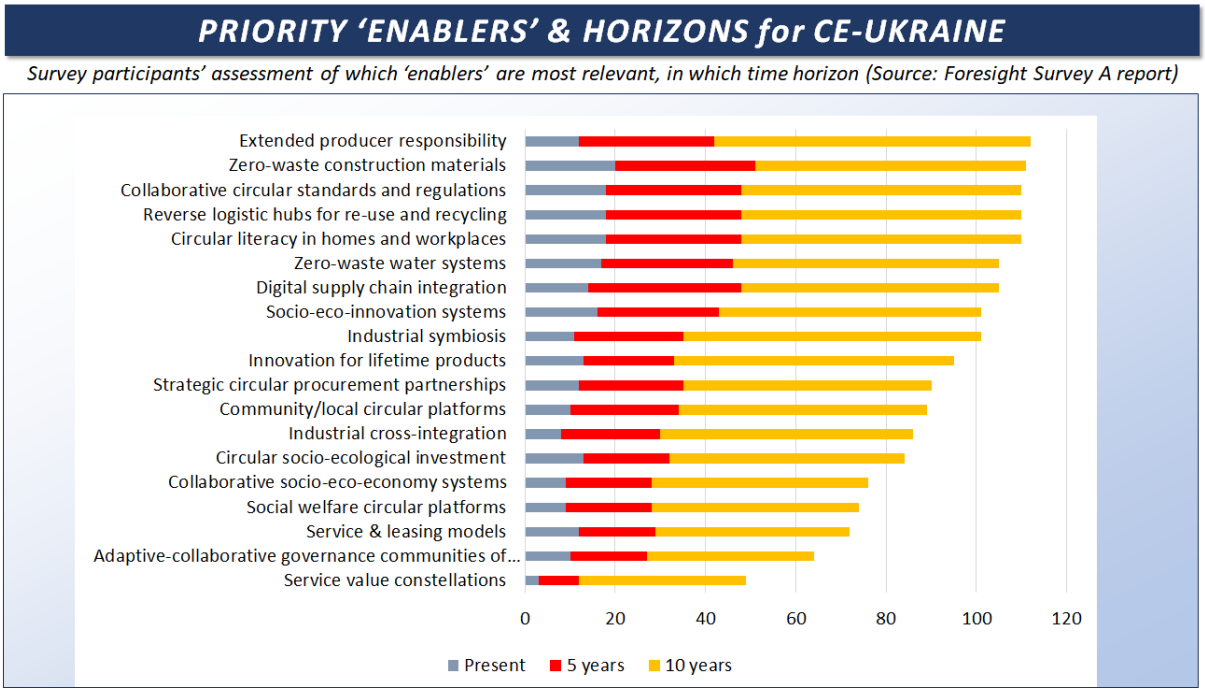


Figure 4: Priority 'enablers' and horizons for CE-Ukraine

In the short-term horizon, zero-waste emerges as an important concept: zero-waste construction materials and zero-wastewater systems are among the top five enablers within five years. Collaborative circular standards and regulations, reverse logistic hubs for re-use and recycling, and circular literacy in homes and workplaces are other top critical enablers. In the medium-term horizon, the critical enablers in the short-term remain as high priority. In addition, extended producer responsibility becomes one of the top critical enablers, along with digital supply chain integration, and socio-eco-innovation systems. In the long-term horizon, extended producer responsibility becomes the top critical enabler for CE in Ukraine. Industrial symbiosis and innovation for lifetime products are also mentioned as the critical enablers for the long run.

Ukraine's current position for successful CE transformation was analysed through the Survey A of this project (conducted at the end of 2023) in four areas of capacity: Science and Technology (S&T), innovation, industrial and service delivery, and exploitation / implementation. Figure 5 shows the results.

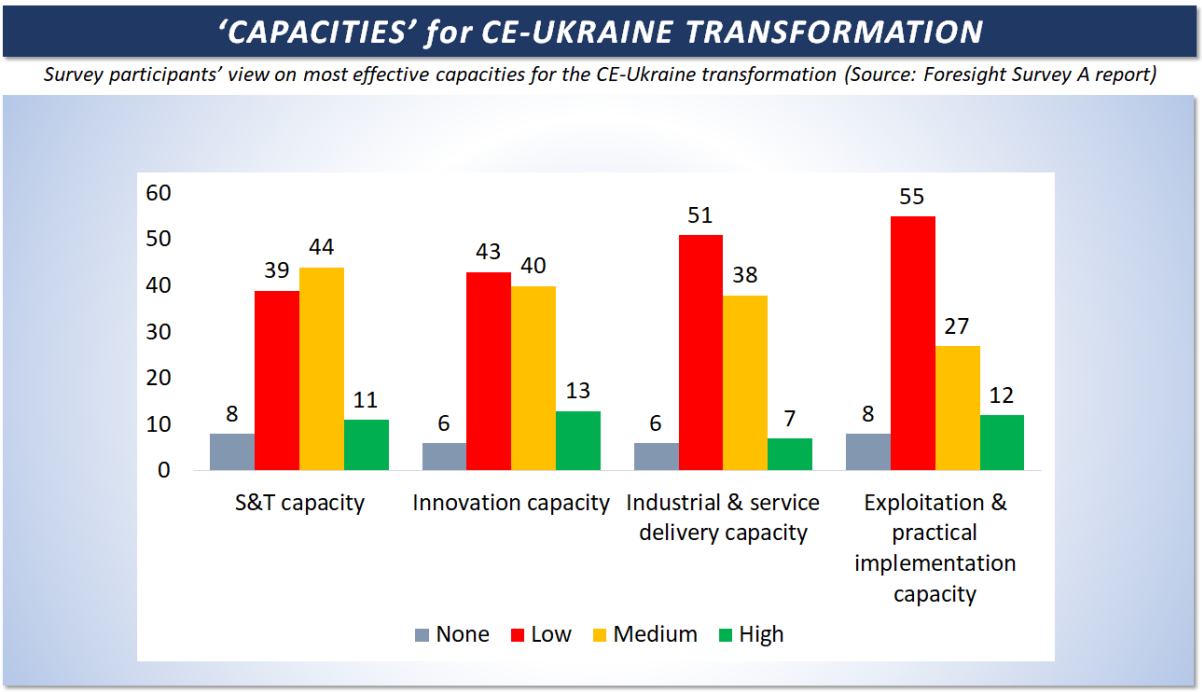


Figure 5: 'Capacities' for transformation for CE-Ukraine

Most of the respondents consider Ukraine's current capacity for CE transformation in all four areas to be low or medium. Current S&T capacity of the country is medium according to the largest number of respondents. This is promising, considering that Ukraine has historically a well-established S&T system. However, when the innovation capacity is considered, it is relatively low. Moving to industrial and service delivery the respondents highlight more the lack of capacity in the country. Finally, more than half of the respondents considered the country's exploitation and practical implementation capacity low. There is a clear need to extend the S&T capacity into other domains to achieve successful CE transformation in the country.

2.3. Alternative futures: a scenario framework

The CE-Ukraine forward agenda depends on what kind of future context may exist in 5, 10 or 25 years. There are profound uncertainties – will the war end, and if so, on what terms? Will the migrants and internally displaced persons return? Can Ukraine align with or join the EU, and what other options are relevant? Will government partners and international investors return and help to fund the reconstruction?

And while such national-level questions are being examined, what is the context for the CE-Ukraine? Will the CE work with friendly or hostile partners and neighbours? Will the changes be 'pushed' by industrial supply sides, or 'pulled' by consumer demand?

The scenario planning approach is central to the foresight approach: and so the second state of this project created and explored alternative futures for the CE-Ukraine transition. These are framed as 'context', being conditions and forces beyond the immediate control.

In this way the CE-Ukraine scenario framework created a two-by-two matrix, with main axes as follows (Figure 6):

X axis: Circular Economy scope and application:

- Whole society CE value chain and demand side focus - versus -
- Narrow CE production focus and industrial change.

Y axis: National development path:

- Ukraine is globally integrated, economically and politically: full resources are available for CE, with focus on full reconstruction - versus -
- Ukraine CE is isolated economically and politically: limited CE resources, and only for some regions, with focus on partial reconstruction.

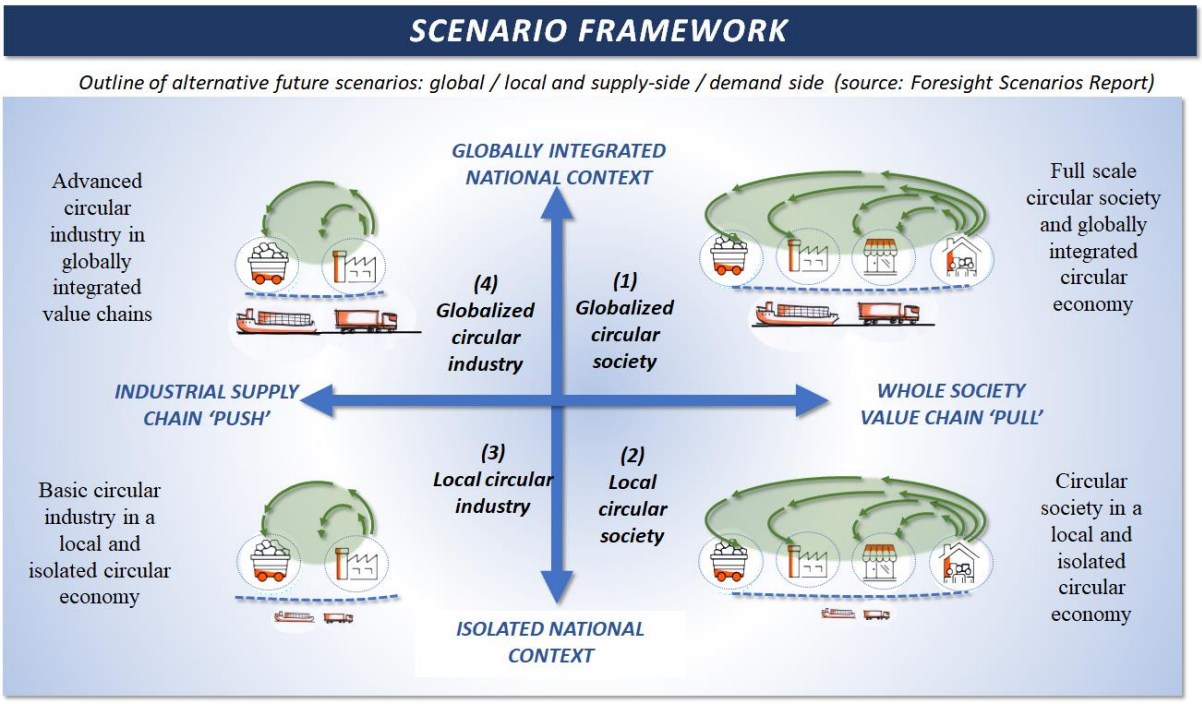


Figure 6: Scenario framework

The x-axis of the scenario framework focuses on the scope of the circular economy and its application. On the right hand side the CE strategy will have a whole society focus: on the left, the CE has a narrower focus just on production and industrial change.

The y-axis considers the national CE development path. On the upper side of the axis Ukraine restores its economy fully, and develops strategies for the adoption of the EU CE framework and integration into global value chains. General economic prosperity allows the country to dedicate a substantial amount of resources to a CE transition. On the lower side of the axis there is a partial recovery of the economy, where an isolated and defensive country concentrates a substantial amount of its resources to maintain basic infrastructures and services. This leaves limited resources available for a CE transition with partial recovery of the industrial base and infrastructure.

The combination of x and y axes yields four scenarios, focusing on the broad context for the development of a CE in Ukraine:

- Scenario 1: Full scale circular society and globally integrated circular economy (Global Circular Society - GSC)
- Scenario 2: Circular society in a local and isolated circular economy (Local Circular Society - LCS)
- Scenario 3: Basic circular industry in a local and isolated circular economy (Local Circular Industry - LCI)
- Scenario 4: Advanced circular industry in globally integrated value chains (Global Circular Industry - GCI).

These scenarios offer alternative perspectives on the CE-Ukraine and its path toward green industrial recovery over a 10- to 25-year timeframe. These scenarios outline a range of favourable and unfavourable conditions that may emerge, based on the uncertainties in the broader context. The implications of the scenarios for each of the KPVCs are summarized in Part II of this report.

2.4. Towards a CE-Ukraine 'vision statement'

The exploration of alternative future scenarios then led stakeholders to the formation of a national 'vision statement' for CE-Ukraine, in the third horizon of 10-25 years. This can be summarized as follows:

TOWARDS A NATIONAL CIRCULAR ECONOMY VISION STATEMENT

"Ukraine fully embraces a full circular economy approach, on both the production and consumption sides. The country successfully transitions to a prosperous state with a restored high-value economy. The Government provides all resources needed to support the circular economy transformation in business and civil society, moving towards full alignment with the EU framework and integration with global value chains. The full circular economy approach helps Ukraine to follow the principles of using fewer materials, extending the lifespan of products, regenerating resources, and maximizing material reuse."

3. Key product value chains and socio-technical systems

This section provides an overview of the selected KPCVs ('key product value chains', and the socio-technical systems, in scope and definition, and in application through the enablers.

3.1. Value chains: selection

This CE-Ukraine foresight explores a range of KPVCs. These were based on the EU circular economy action plan, with some recent developments. In principle, each KPVC is defined as a complete value chain, from raw materials to finished consumer products and post-consumer waste. However, the reality is not so simple:

- 'Constructions': from primary materials to completed buildings, fittings and components: and then maintenance, conversion, renovation and end-of-life demolitions: the circularity is a question where the 'product' has a very long life.
- Food products: from primary inputs to agriculture, to manufacturing and distribution, to consumption by households and catering activities.
- Electronics and ICT: from primary critical raw materials, to manufacture and distribution: this is mainly a globalized value chain with very rapid innovation.
- Plastic and packaging: two inter-connected material systems, which are embedded in all the KPVCs, with potential for re-use and recycling.
- 'Wastes': a variety of inter-connected material systems, which are embedded in all KPVCs, with potential for transition towards 'resource management'.

The last two on this list are not full value chains, in the sense of raw materials leading to finished products: each is more of a material-intensive component and infrastructure system. Also, other KPVCs were covered in outline at various points in the project, and some interim results are shown in the other project reports.

- Textiles articles, and a highly globalized production-consumption chain.
- Domestic appliances: design for repair, re-use, and resource efficiency.
- Motor vehicles, batteries: design for repair, re-use, and resource efficiency.
- Energy systems: low-impact zero-waste infrastructure, from supply to demand to 'energy services'.

3.2. Value chains: scope and definition

There are many definitions of value chains: some are more focused on the production process:[17] *"…the full life cycle of a product or process, including material sourcing, production, consumption and disposal/recycling processes*.". Others look at the bigger picture:[18] *"… 'value chain' also encompasses thinking about the value created by the chain for end-use customers… and a range of other stakeholders, including communities and governments"*

[17] World Business Council for Sustainable Development, 2011.
[18] SustainAbility, UNEP and the Global Compact (2008)

The 'food products' KPVC, for instance, includes primary inputs of energy, water etc: a supply chain of production and distribution: a global chain of imports and exports: and the 'demand chain' of households and catering. Each of these sectors and products then has its own wider network of inputs and outputs: it also has deeper layers of value - economic, social, political and ecological.[19]

Based on the United Nations official classification of 'products' and 'sectors', Table A.1. in the Annex summarizes each of the KPVCs, as a starting point for more detailed analysis.[20]
The service sectors may have less direct material flow or CO_2 emissions in their activities, however as drivers of the demand side, they may be equally or more significant in the circularity of the whole value chain. In the food products KPVC for example, each of the service sectors of catering / accommodation, education, health, and public administration are important drivers of change, all the way from primary inputs to finished products, together with the many inter-connected services as above.

Each of the KPVCs can be analysed in this way: from primary sectors to secondary, tertiary, government, households and post-consumer waste. Table 1 outlines the five selected KPVCs with key points in each sector group, as a starting point for more detailed analysis.

Table 2: Sector group analysis of priority KPVCs

	PRIMARY	SECONDARY	TERTIARY	GOVERN-MENT	CONSUMER	WASTE / MATERIALS
	Resource sectors	**Industrial sectors**	**Service sectors**	**'Public user' sectors**	**'End-user' sectors**	**'Post-user' sectors**
'Constructions'	Sand, aggregates etc	Building components manufacture	Design, maintenance, rental, sale	Public building procurement	Accommoda-tion in use and maintenance	Construction and demolition waste
Food products	Agriculture, forestry, farm inputs	Food and drink processing and packaging	Food retail and catering	Public service catering	household diet, cooking	Food and packaging waste
Electronics and ICT	(Many global trade flows)	Advanced manufacture for recycling and disassembly	Service innovation as driver of change	Public procurement	Consumer awareness and infrastructure	Infrastructure for reuse, recycling
Plastics and packaging	New bio-degradable materials	Production model for recycling and recovery	Service model for recycling and recovery	Public procurement	Consumer awareness and infrastructure	Infrastructure for recycling and recovery
'Wastes'	Waste recovery as raw material	Industrial design for re-cycling and disassembly	Service models for EPR etc	infrastructure for recycling and recovery	Household reuse and waste sorting	Sustainable waste management

[19] Allee, 2003

[20] United Nations Department of Economic and Social Affairs, 2015.

3.3. Socio-technical systems and transformations

The CE transformation aims at circular material flows: but this depends on innovations and transformations in each of the main 'socio-technical' systems – business-finance, policy-governance, etc. These transformations are not fixed items to be achieved with a 'policy lever': they are more like directions of travel, with many uncertainties and complexities.[21] So, a list such as below is just the starting point for exploration and dialogue, to be applied to the KPVC pathways in various combinations.

(a) ***Business-finance – from 'product' to 'service':*** (includes finance, investment, enterprise models and marketplaces). This transformation moves from a free-standing product 'on the shelf', towards a wider system and value constellation of technology, finance, leasing, maintenance, repair, etc.

(b) ***Policy-governance – from 'regulation' to 'partnership':*** (includes governance and regulation, public services, public procurement). This shifts from the former model of government as a top-down law-maker / regulator, to a more pro-active partnership role which brings together government with business, civil society, academics and innovators.

(c) ***Social-community – from 'consumers' to 'citizens':*** (includes household economy, education and skills, local livelihoods). This broad transformation sees the potential for society to move beyond the narrow materialist role of 'consumers', towards a more integrated and inclusive role as citizens, based on full participation and co-production.

(d) ***Design-technology-innovation – from 'products' to 'value chains':*** (includes digital economy, innovation systems and design systems). This paradigm shift reflects the above bigger picture, where product design is one part of a wider and deeper 'systems innovation' for whole value chains.

(e) ***Eco-industry – from 'efficiency' to 'circularity':*** (includes production lines, materials handling, environmental assessment and management). Looking beyond current programmes for resource efficiency and cleaner production, this is about very practical changes in industrial processes, materials management and logistics.

(f) ***Urban infrastructure – from 'waste' to 'resources':*** (includes material logistics, local economies, spaces, land and buildings). This transformation starts with spaces and buildings at the local level, and over time creates capacity for 'reverse logistics', exchange hubs and storage zones, all the way from the household level to urban / regional scale facilities.

These transformation principles provide a visionary agenda for the CE in terms of material flows. However, the positive combinations of material systems with these other 'socio-technical' systems –economic, environmental, technology, social, urban and governance – is not a simple task.

The following sections explore each of the six systems, with an outline of typical challenges in Ukraine, drawn from the baseline reports and survey participants. There follows an outline of potential transformations, and a menu of the most likely 'enablers', to help mobilize them.

[21] Potting et al, 2017

These were developed from international literature and expert advice, and then explored by stakeholders in the project panel meetings and surveys.

3.4. Business-finance enablers

Corporates and investment vehicles are understandably risk averse in the Ukraine situation, and supply chains are heavily disrupted. Most businesses follow conventional models for volume production, and the shift to service-based models is challenging, especially for SMEs with few assets. Where CE activity is making progress, 'green-washing' type PR is difficult to call out.

The transformation agenda involves not only better resource efficiency (see below), but also a rethinking of how supply or value chains work, new forms of business and finance models, and new forms of economic synergy. Possible enablers are:

- ***Use of service and leasing models:*** manufacturers do not sell products but instead rent / lease them, together with ancillary parts, on long services contracts, with payments being based on services delivered. (*Example: a complete lighting package is provided by Signify (ex-Philips Lighting) on an annual contract basis, with payment being based on the amount of lighting provided (the service)).*
- ***Adoption of extended producer responsibility ('EPR') policies:*** producers (and/or importers) of certain products are made responsible for the management of those products once they become waste. As part of this, manufacturers may aim for an Extended Product Life (EPL) for their products, by providing longer warranties, designing to avoid obsolescence, and designing for diss-assembly and recycling. *(Example: some mobile phone producers, such as Fairphone, design for longer life and retrofit).*
- ***Circular socio-ecological investment:*** banking and venture funds are designed to support whole supply-demand-value chains, not only individual products / markets. *(Example: waste management which supports reverse logistics, such as 'take-back' bottles or plastic containers).*
- ***Service value constellations:*** a whole economy approach, looking beyond individual value chains towards whole circles, where most of the value added is in services *(Example: the UK 'Market Transformation' programme worked with the 'constellation' of household appliance manufacturers, distributors, managers and consumers, for a major increase in efficiency and circularity).*

3.5. Policy-governance enablers

Challenges in CE governance start with the division of competencies into 'economy', 'environment', 'digitalization' etc. CE principles call for integration of whole supply-demand-value chains, but this is difficult within current structures. The EU's attempts to promote the circular economy with large funding programmes have so far not been very successful.[22] Much of the government machinery is separated from business, and connecting them is not easy.

[22] European Court of Auditors, 2021.

In response, the circular economy calls for a 'circular governance' transformation, with new ways of working which are collaborative, adaptive, strategic and synergistic. This can be summed as a *'collective governance intelligence'*, based on a ***wider*** community of stakeholders, ***deeper*** layers of value, and ***further*** horizons of change.[23]

- ***Collaborative circular standards and regulations:*** government has a vital partnership role in setting standards, targeting 'smart' regulation, and leading a strategic approach to sector transformation. *(Example: single-use plastic shopping bags are taxed in many EU countries, and both usage and wastage has dropped rapidly).*
- ***Strategic circular procurement partnerships:*** government as manager of public services also has a major role as buyer and consumer of CE-compatible products and services. *(Example: the municipality of Milan set up a local sustainable food procurement programme for all education and health services, which helped to transform the food system in that region).*
- ***Adaptive-collaborative governance communities of interest:*** a forward-looking government works with a whole industrial community or sector in a co-learning and capacity-building process. *(Example: the UK National Industrial Symbiosis Programme (NISP) set up a platform for exchange of waste materials: along with a public-private partnership for industrial skills and capacity-building (Lombardi and Laybourn 2012).*

3.6. Sociocultural enablers

The challenges and barriers in Ukraine have been analysed, as a reluctance for behaviour change, eco-scepticism, blame and displacement, illegal dumping of pollution and waste, added to the disruption and trauma of war. While inequality in Ukraine is less than the EU average, there are inbuilt barriers and exclusions which block the ideal of collaborative efforts. Meanwhile the desire for economic growth comes with a culture of consumption and affluence is very powerful, as in any typical capitalist economy.

In response, there are forward pathways which aim at resonance with everyday lifestyles, and capacity-building for positive change.

- ***Circular literacy in homes and workplaces:*** this may start with public services in education, health, social care, and cultural activities. *(Example: the UK 'carbon literacy' programme / platform is very successful for public education and awareness: similar ventures are in discussion for 'circular literacy').*
- ***Social welfare circular platforms:*** many areas encourage creation of business and formal employment opportunities to collect dumped material for recycling, and this can be extended into different material streams such as construction. *(Example: the growing number of recycling plants for waste separation, now working in partnership with food banks, furniture and bathroom banks).*
- ***Community / local circular platforms:*** some local areas now have social networks for sharing of needs and surplus items, which can be extended and mobilized for other areas with less cohesion and more transient populations. *(Example: many sharing / re-use platforms such as Freecycle, with great scope to scale up and go mainstream).*

[23] Ravetz, 2020.

- ***Collaborative socio-eco-economy systems:*** the move from 'take-make-sell-dump' systems to a more integrated model can bring environmental benefits if firms can adapt rapidly. *(Example: the rise of the 'pre-loved' fashion business, enabled by online platforms, can greatly reduce the material impact of clothing value chains, if social and cultural conditions are right).*

3.7. Design-technology-innovation enablers

Ukraine has immense resources in science and technology, but the challenges for innovation systems, R&D programmes, and industrial design are many. Generally, innovation ecosystems are still geared to individual products rather than to whole value chains and the CE principles. New technologies or designs for 'partial circularity' may not be quickly profitable, especially where the infrastructure is lacking. The EU experience so far shows major gaps between science-technology-innovation (STI) policies, and market deployment at scale.

The transformation agenda here is about deploying enablers, which turn around the conventional model of 'technology innovation' for new products, towards a 'socio-eco-innovation' for whole circular systems.[24]

- ***Innovation for 'Extended Product Life' (EPL):*** this aims towards the transformation of products in use, and the 'socio-technical interface' in households or workplaces. *(Example: IT equipment can be standardized with modular design and production to avoid waste and obsolescence).*
- ***Digital supply chain integration:*** the use of IOT for supply chain management is well known, but the potential of AI is just taking off. *(Example: following the smart meter systems for electricity or water, smart kitchens, or catering aims to reduce food waste and increase positive reuse of surplus).*
- ***Socio-ecological-innovation systems:*** this turns around the innovation frame, from the benefit-cost ratios of individual products or producers to a more integrated assessment of social and ecological value. *(Example: automotive design to support low maintenance shared use facilities.)*

3.8. Environment-industry enablers

In Ukraine, as elsewhere, the mainstream industrial firm and business model is focused on 'quantity' and production of volume: environmental management, resource efficiency and cleaner production generally work to improve rather than to transform the supply chain. A re-focusing on 'quality' means not only new monitoring but new systems, and a transformation from 'product' to 'service' value added. In primary materials, chemicals, heavy or light engineering, advanced manufacture, etc, similar principles apply. In the crucial defence and military sectors, the needs are especially urgent, but similar principles apply, for high value products as part of high value systems.

- ***Resource efficiency and cleaner production:*** this agenda has a long history but is still urgent in many industries. With some notable exceptions, indicators and diagnostics on Ukraine show generally low levels of 'RECP' across many industries.
- ***Industrial symbiosis***: technically, it is the use of the wastes of one factory as raw material input by another factory. In a wider sense, the principle that every product is part of a

[24] Burmaoglu et al., 2021.

circle, not only of material / energy, but of value added, not only economic but social and ecological. *(Example: the UK National Industrial Symbiosis Project, enabled packaging producers to be integrated to a social economy of reverse logistics)*[25]

- ***Industrial cross-integration***: this looks for new ways to integrate material and energy flows between different industrial sectors. *(Example: new electrostatic technologies enable circularity across sectors – shrimp-farming, hydrogen generation, rare earth extraction, wastewater treatment and wetland remediation.*

3.9. Urban infrastructure enablers

The Ukraine urban environment could be a barrier in the circularity transformation: if space is lacking in the household or workplace for recycling / re-use, or if systems for returning packaging are too costly, then such actions will be more difficult. Ukraine has a special opportunity here in the post-war reconstruction programme, and urgently needs practical designs, logistics systems and resource infrastructure at every level.[26]

- ***Reverse logistic hubs for re-use and recycling***: common products such as containers and packaging can be standardized with 'reverse supply chains' back to manufacturers, and space / facilities to support that. *(Example: food or cleaning product containers returned to suppliers).*
- ***Zero-waste construction materials***: buildings can be designed for diss-assembly, with modular construction for low/zero-waste in the material chain. *(Example: engineered timber frame, insulated panel construction).*
- ***Zero-wastewater systems:*** as climate change impacts grow, intelligent water management will be essential. *(Example: water harvesting, storage, separation of grey / drinking and surface / sanitation systems).*

3.10. Summary of KPVCs and socio-technical transformations

The following tables summarize the CE transformation agenda in the social and technical systems of Ukraine for each selected KPVC:

Table 3: KPVC transformations in 'social systems'

	BUSINESS-FINANCE	POLICY- GOVERNANCE	SOCIAL-COMMUNITY
KPVCs			
'Constructions'	System-wide green credit and finance in construction and real estate	Circular construction strategic procurement programmes	Skills training for whole community - designers, installers, building managers and residents
Food products	Whole industry cooperation for farmers / agri-business, food / beverage producers, distributors / retailers.	Coordination of regulation and standards, industrial partnerships, procurement programmes, innovation clusters	Local economic development, food health awareness, and cultural value of local food systems

[25] Lombardi and Laybourn, 2012.

[26] OECD, (2020b).

Electronics and ICT	Electronics supply chain transparency, product passports, and design for reuse / re-engineering	Coordination of standards, compatibility, regulation, with forward finance for EPR and service models.	Wider social motivation for reuse / re-engineering, sharing platforms
Plastics and packaging	Transformation in business models and logistic systems for packaging reduction / re-use / recycling	Plastic packaging tax / subsidy / regulation: capacity-building for alternative logistics	Social innovation and community enterprise for packaging reduction, re-use, re-distribution, recycling
'Wastes'	New investment channels for integrated supply chain business models	Overall coordination and promotion of integrated zero-waste supply-demand chain partnerships	Coordination of social enterprise, price incentives, product innovation and urban infrastructures

Table 4: KPVC transformations in 'technical systems'

	DESIGN and TECHNOLOGY	ECO-INDUSTRY	URBAN and INFRASTRUCTURE
KPVCs			
'Constructions'	Construction design for dis-assembly, modular fabrication, resource efficient innovation	Construction symbiosis – collective innovation hubs for exchange of materials and processes	Urban re-engineering with strategic hubs and transfer stations, for re-use of materials and components
Food products	Product design and innovation shifts from individual 'items' to integrated 'food chain' models	Agri-food environmental management can follow the industrial symbiosis model for recycling and exchange	Systems for reverse logistics and bio-material management, from household level to regional hubs
Electronics and ICT	Standardized design for reuse / re-engineering	Coordination of UA minerals sector with EU critical materials platform	Product and component re-use / re-engineering / recycling – hub locations and exchange platforms
Plastics and packaging	Product design and supply chain innovation, for dis-assembly, re-use of plastics, reduce and recycling of packaging	Technical standardization and industrial symbiosis for packaging re-use, recycling and recovery	Infrastructure hubs and resource exchange platforms for symbiosis and materials management
'Wastes'	Integrated supply chain design, innovation programmes, materials management systems, import / export rules	Re-thinking industrial processes and components for waste minimization, re-use, recycling	Retrofit of housing and workplaces for sharing, re-use and recycling of common materials and products

PART II

Key product value chains

The following sections provide an overview of the foresight results for the selected KPVCs in Ukraine: ‘constructions’; food products; electronics and ICT; plastics and packaging; and wastes. Each is described in six main subsections:

- What is the problem? Scope and baseline (with key diagram)
- What if? Alternative future scenarios
- What is possible? Future visions
- How to achieve? Pathways for transformation (with key diagram)
- Who can do this? Key stakeholders and enablers
- When? - 3 horizons and next steps

4. 'Constructions'

At present Ukraine has a massive challenge in war damage, with over 10 million tonnes of construction / demolition waste generated since 2022. With this as the starting point, this value chain foresight explores the potential for transformation in construction and buildings, sets out visions, and provides a mapping of pathways to achieve them.

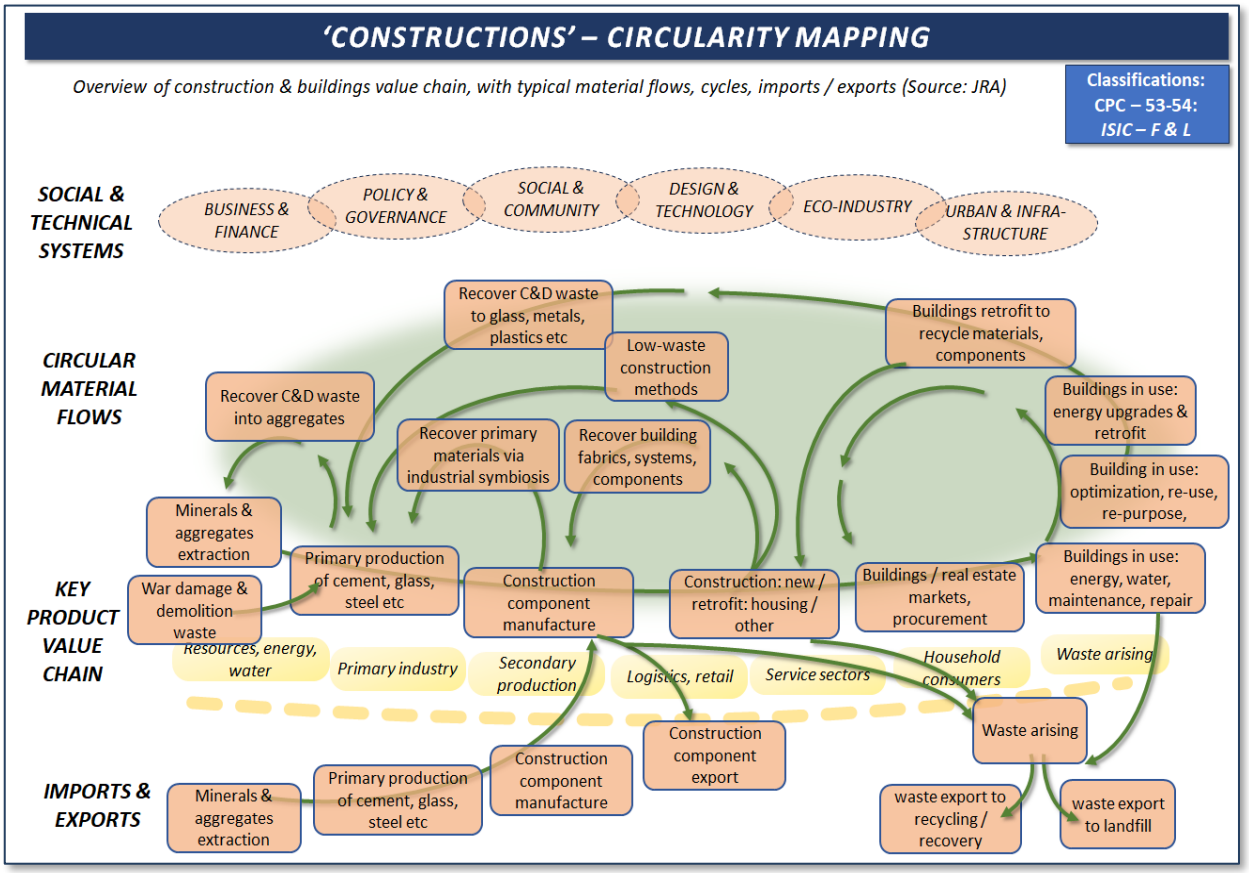


Figure 7: 'Constructions': circularity mapping

Most constructions are designed for a very long period of useful life: and so questions come up - what is 'circular' about construction'? Three principles can help to guide the changes needed for the very large impacts and footprint of construction:[27]

- Resource ***recirculation***: re-use, recycling, recovery etc. of the materials used in existing construction.
- Resource ***efficiencies***: design for optimum performance of a construction's materials and components.

[27] World Economic Forum, 2023.

- Resource ***utilization***: building / accommodation re-use and extended product life.

4.1. What is the problem? Scoping the 'constructions' system

The 'constructions' KPVC as in the figure above, includes many types and markets: housing new / retrofit, commercial and public buildings new / retrofit, landscape / external works, infrastructure / civil engineering. In each of these there is an extended life cycle: initial construction, maintenance and rehabilitation, energy management and servicing during the building life, demolition and management of the end-of-life remains.

Key 'upstream' activities include minerals, agriculture, forestry, energy and water, manufacturing, transport etc. Key 'downstream' activities include transport, real estate, professional, public administration, education and health, and the use of housing / other buildings by the population.

(*Classification notes: key sectors are defined in the ISIC as 'Construction' – F, and 'Real estate activities – L. Key products are defined in the CPC as 'Constructions' - 53.*)

Summary of baseline conditions and challenges: construction and buildings

(*Source*: CE Foundation 2024, UNIDO 2023)

Supply side

- Over 10 million tonnes of post-conflict construction waste
- Need for international investors to rebuild real estate
- Heavy damage to basic infrastructure

Demand side

- Major renewal of housing and building stock needed, with modern standards
- Market disruption, with over 6 million persons displaced / migrated / veterans
- Public organizations lack access to capital funding

Barriers and gaps

- Fragmentation of industry, skills, technologies, etc.
- Building design is complex, risky, and not aligned with circularity
- Low-cost materials versus high-cost labour
- Lowest cost / short term profit business models

Circular economy issues:

'The **construction sector** has 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 CO_2 efficiency is also very low, suggesting that production methods are outdated and inefficient. The sector reports no waste data which is also problematic. Accurate monitoring of waste, prevention strategies and the proper management of flows for toxic and non-toxic waste should be a priority.

4.2. What if? - scenarios for 'constructions'

Much depends on the future of the national economy, its relation with the EU and others, the level of technology innovation and development, and the level of population change, urbanization and reconstruction.

The scenario framework described in section 2.1 provides an overview of alternative future possibilities:

Alternative future scenarios for 'constructions'

- ***'Globalized Circular Society':*** The post-war construction waste of over 10 million tonnes presents an opportunity for resource recovery. Reuse and recycling of construction materials, will be prioritized in the rebuilding. "Lifetime design for disassembly" will see nearly all components reused or recycled at the end of their life cycles, both within Ukraine and internationally.
- ***'Local Circular Society':*** Socio-eco-innovation in construction components, such as modular and sustainable building materials, will be more concentrated in the demonstration regions.
- ***'Local Circular Industry'***: Utilizing the 10 million tonnes of post-conflict construction waste may struggle with resource limitations. The combined public procurement programme will focus on essential infrastructure repair, with limited capacity for socio-eco-innovation and lifetime design for disassembly.
- ***'Global Circular Industry':*** The combined public procurement programme may become a catalyst for socio-eco-innovation in construction components, with a focus on designing products for disassembly and recycling to promote a strategic sector transformation.

4.3. What is possible? - future visions for 'constructions'

The following three 'visions for transformation' were developed in the panel workshop. Each panel started with a general goal, responded to challenges, and then formed the direction of travel to the three broad visions. The general timescale is a 'Horizon 3' of 10-25 years.

(a) Innovation for materials, designs, building management, re-use and recycling: for both short term functionality, and for long term transformation.

(b) Procurement: circular hubs, demonstrators and strategic partnerships: with value chain partnerships, circular hubs and demonstrators, strategic procurement programmes.

(c) Materials and markets: the construction sector will set up strategic markets and infrastructures for material sorting and processing for re-use, recycling and recovery.

4.4. How to achieve? – pathways for 'constructions'

The diagram below shows an outline of three systems-level pathways to meet the KPVC 'visions'. At this stage these are directions for exploration and development, which need to respond to future challenges and opportunities.

4.4.1. ***Construction resources pathway***

(Supply-side focus: mobilized by combinations of eco-industrial-technology-infrastructure systems)

The huge volumes of materials and components in construction are a challenge but also an opportunity for the adoption of CE principles. Also, in practice there are difficult trade-offs, e.g. between more efficient new-build or material saving retrofit.

For bulk materials such as cement or glass there are new technologies for resource efficiency and low-waste production. For engineering systems and fittings, one can look towards design for disassembly, extended producer responsibility, and service/leasing models. With partnerships of designers, producers, installers and building managers, these value chain models can apply to a wide range of items, such as light fittings, bathrooms, security, carpets, and furnishings.

For post-demolition waste the way forward would be in setting up coordinated markets, logistics and infrastructures, for re-use, recycling, and recovery. This is a key opportunity for the Government to work in partnership with design, construction, technology innovation bodies.

4.4.2. ***Construction innovation pathway***

(Whole value chain focus: mobilized by combinations of business-technology-infrastructure systems)

This pathway is about advanced products, materials, technologies and building systems. It follows a general development of 'innovation culture' and best practice, across whole chains of supply-demand, from raw materials to building users. It tests and develops 'reverse logistics' infrastructure, laboratories for construction materials, market development for used / recovered materials.

Such innovation programmes would address not only the hard technology and materials, but also the human side – users, installers, designers and building managers. There is a range of options for government to lead in partnership with industry, such as experimental 'beacons', 'lighthouses', innovation hubs and best practice learning. This combines with public awareness and information support, on household energy efficiency, and circularity management.

4.4.3. ***Construction procurement pathway***

(Demand-side focus: mobilized by a combination of government-industry-infrastructure systems)

For building users and managers responsible for procurement and investment, this pathway focuses on performance of materials, components, and whole buildings. This can be led firstly by government, with a combination of regulations, advice, incentives, skills development, and partnership building for circular construction.

Procurement of buildings, by government, private / public clients and by real estate developers, is the key to the transition. Financial models can be accelerated by the public sector, with

combinations of subsidies, levies, and preferential loans for projects with re-use and recycling of construction waste. These can work in combination with the development of national CE terminology, capacity-building, data platforms, and innovation hubs.

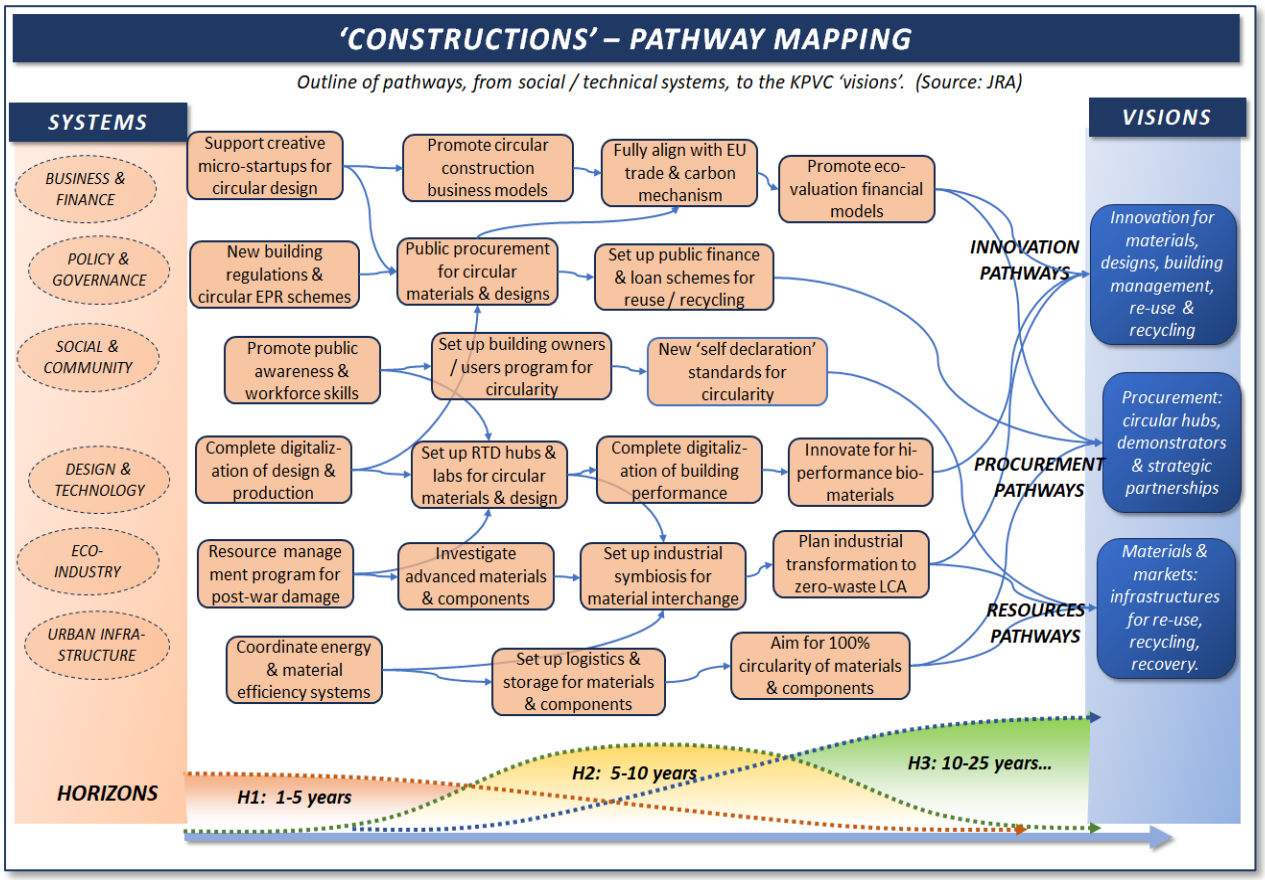


Figure 8: 'Constructions': pathway mapping

4.5. Who can do this? Key stakeholders and enablers

For ***business and finance***, common service and leasing models, combined with EPR (extended producer responsibility) and EPL (extended product life), can cover a large proportion of construction fittings and services. This can be aligned with EU frameworks for corporate reporting and investment appraisal. Circular building finance models aim to overcome the barriers of short-term cost / profit calculation and mobilize investment in longer term circular solutions.

For ***government and policy***, the key role is to support and mobilize the above by legislation / regulation, by promotion of innovation culture and advanced products / materials, and especially by setting up integrated value chain partnerships, with material producers, manufacturers, designers, construction, and a wide range of building users. There may be a special role for a governmental finance initiative for leverage on private sector investment. The

government role covers both national and regional / local administrations, and for these there may be added potential for collaboration on the ground.

For ***social-community*** issues, there is a priority for job creation and local economic development, especially for primary sectors such as minerals and aggregates, which may need to transition rapidly towards material re-use, recycling and recovery. Similar points apply to vulnerable and marginalized communities, where the urgent need for accommodation can be integral to circular construction and building partnerships.

Design, technology and innovation systems can be mobilized to transition from 'product' design / innovation, to 'whole supply chain' models. This then applies to ***eco-industrial*** management systems, where the principle of industrial symbiosis can be applied to materials recovery and exchange.

Urban infrastructure is also needed at various scales, from local hubs / exchanges for re-used materials and fittings, to national resources for material energy recovery, centred on the post-war demolition waste volume.

4.6. When? – 3 horizons for 'constructions'

This then fits into the longer view with the 3-horizon perspective:

- Horizon 1 (2030): post-war materials management: sector and supply chain innovation
- Horizon 2 (2035): strategic steps for industrial change
- Horizon 3 (2050): full transformation to near-zero-waste and energy material production: zero-waste site operations: mainstreaming of dis-assembly and circular flows of construction waste.

For the next steps, an example project proposal is under discussion:

Example project idea: construction and buildings

(*Source*: CE Foundation)

"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 the dangerous and toxic materials, such as asbestos, that risk trickling into the environment and damaging both human and environmental health.

The objectives of this proposal are to design and implement comprehensive policies to streamline construction waste management, including effective sorting and recycling methods, and provide mentoring and training programmes to stakeholders involved in construction waste management, enhancing their skills and knowledge to improve recycling processes and mitigate environmental risks. This would be led by local municipalities, construction companies, and waste companies.

5. Food products

As the primary land-based product type, food is the most exposed to events, natural disasters, climate change, and human catastrophes such as war. It is also highly dependent on the policies and institutions of landowning, markets, and subsidies.

On the production side, Ukraine is one of the largest food exporters in the world, and this export market raises the question *'what is circular?'*

On the demand side, food and diet is the most embedded in the human side - communities, cultures, and lifestyles – and perhaps the most difficult to change.

The foresight approach here explores the potential for transformation in the system of food and farming, sets out visions, and proposes outline pathways to achieve them.

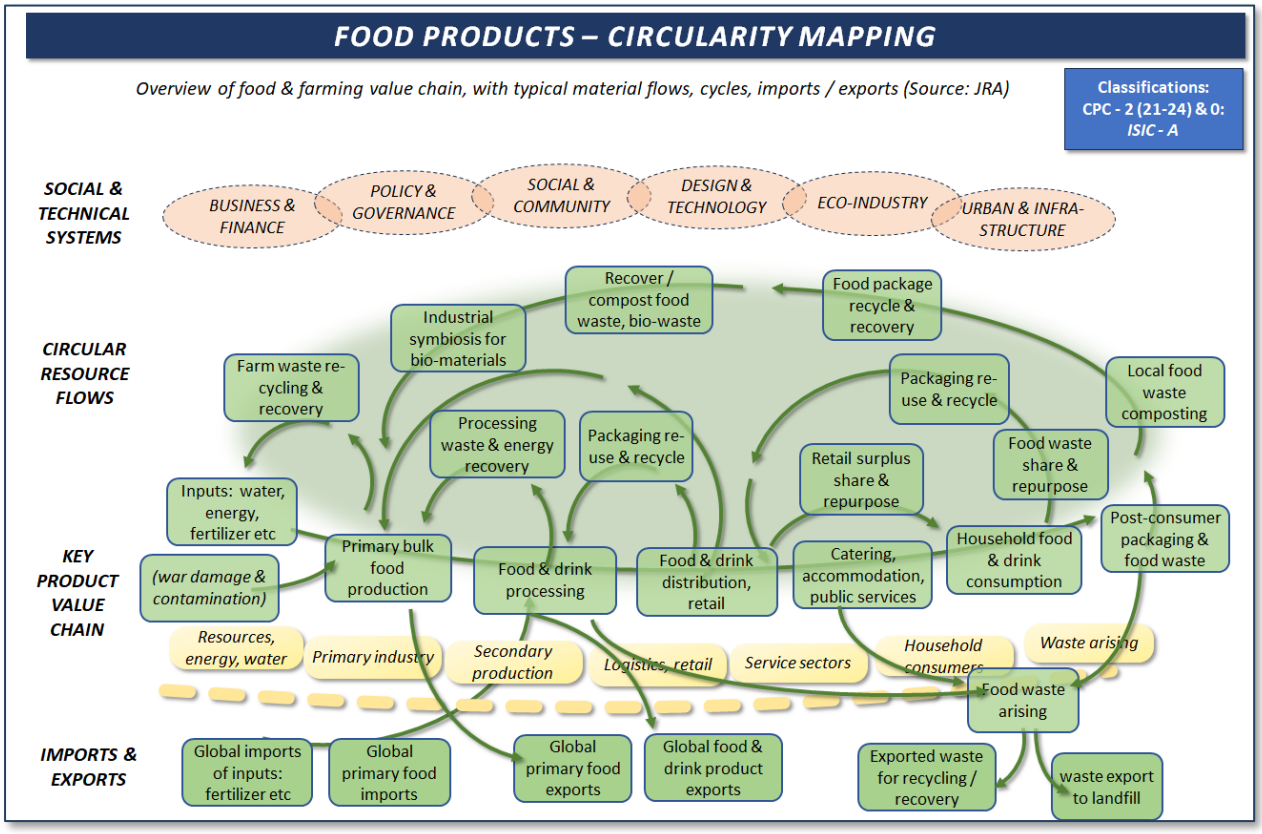


Figure 9: Food products: circularity mapping

5.1. What is the problem? Scoping the food products system

The 'Food products' KPVC, as in the mapping, includes many types and sectors: inputs of energy, water, fertilizer and pesticide and machinery: the supply chain of production, processing, distribution and retail: with large volumes of imports and exports, and consumption by households, catering and public services. There is a wide range between centralized / industrialized systems, and small-scale local production.

Key 'upstream' activities include minerals, agriculture, forestry, energy and water, manufacturing ('food and beverages' sub-sector), transport etc. Key 'downstream' activities include retail, accommodation / catering, education, health, and entertainment sub-sectors in the service sector.
(Classifications: key sectors are defined in the ISIC as Agriculture, forestry, and fishing – A, and 'Accommodation and food service activities' - I. Key products are defined in the CPC as 'Agriculture, forestry and fishery products - 0 (01-04): Food products and beverages 2 (21-24).

Each part of this picture applies in various ways to the key issues and challenges, on both supply and demand sides:

(a) Supply / production / export system

- Ukraine is one of the world's top agricultural producers and exporters and plays a critical role in supplying oilseeds and grains to the global market. More than 55 percent of the country is arable land and agriculture provides employment for 14 percent of Ukraine's population.[28]
- Agricultural products are Ukraine's most important exports. In 2021 they totaled $27.8 billion, accounting for 41 percent of the country's $68 billion in overall exports.
- The invasion of 2022 caused a sudden reduction in production / exports, but as of early 2024, the pre-war levels have returned.
- Regeneration of soil, water, eco-systems, following EU policy at some distance
- Circularity of bio-materials and phase shift towards organic / regenerative
- UA land reform – potential foreign investment and elite capture
- Policy context – gradual alignment to EU markets, CAP, climate / nature goals etc
- Growth of large corporate food retailers along with unregistered food imports
- Financial conditions and loan rates are difficult for new enterprises, technologies etc.
- Innovation clusters and techno-parks in agri-food are expanding

(b) Demand / consumption / import system

- General gradual shift towards food quality, local food and healthy diet
- However, sustainable food demand is yet a small part of total
- Policy priority is generally for lowest cost and lowest prices
- Markets are unstable, with exodus of 5 million refugees, many internally displaced persons
- Conditions unstable in occupied territories, for producers and consumers
- Food health and security: food waste reduction programmes, consumer protection labelling, school food improvements, and food bank draft laws, are each in progress

Summary of food products issues
(*Source*: Based on interviews and CE Foundation 2024)

Circular food issues
- ongoing changes to crop patterns: war damage e.g. the Kakhovka dam destruction: climate change and water shortage in southern Ukraine: some production already going to bio-methane: but lack of skills and labour is a problem

[28] USDA 2024

- alternative energy sources are increasing due to national infrastructure problems
- 1/3 farm production is by small-holder households with plots of 2-7 hectares, generally with less inputs and waste, but labour intensive methods
- organic production is already developed, with 450,00 hectares in production, not so much national demand, 90% is exported – mainly to EU, UK and Japan
- EU integration: EUBRD moving towards ESG and CBAM regulations, but progress slow.

Circular economy profile
(*Source*: CE Foundation)

"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, maize as well as ruminants. The sector boasts a large number of workers and has a particularly heavy material footprint as it imports such an important part of its raw materials.

The sector is still far too dependent on unsustainable, outdated and inefficient production methods. It needs to boost alternative energy sources, notably by tapping into its huge biomass potential, but also turn to developing local, organic fertiliser to reduce its dependence on imports.

5.2. What if? - scenarios for food products

Much depends on the future of the national economy, its relation with the EU and others, the level of technology innovation and development, and the level of population change, urbanization and reconstruction. The scenario framework described in section 2.1 provides an overview of alternative future possibilities:

Alternative future scenarios for food products

- ***'Globalized Circular Society':*** farm production in Ukraine is mainly for export markets, with high standards of resource efficiency and circularity. The food Ukrainians consume is largely imported from the global system, with post-consumer circularity of unused and waste food.
- ***'Local Circular Society'***: the country's production is mainly consumed within national borders: but with similar high standards for production and circularity of resources.
- ***'Local Circular Industry':*** national production is more resource efficient and circular, but consumption is wasteful of food and food-related packaging.
- ***'Global Circular Industry':*** the agri-export market is booming with growing efficiency and circularity: but the consumption side is left with the worst type of imports from the global food system (unhealthy, over-packaged, ecologically damaging etc).

5.3. What is possible? - future visions for food products

The following three 'visions for transformation' were developed in the expert panel and commented in the survey. The panel started with a general goal, responded to challenges, and then formed the direction of travel to the three broad visions. The general timescale is a 'Horizon 3' of 10-25 years.

(a) ***Food efficiency pathway:*** (supply-side focus): farming with advanced methods for regenerative circular production, not only precision production but also the maintenance of the health of soil, water, and ecosystems.

(b) ***Food livelihood pathway***: (community focus): local livelihoods with urban-rural integration of food systems, to maintain both rural economies and communities, and urban lifestyles.

(c) ***Food health pathway***: (demand side focus): all households / consumers can access healthy, sustainable, low-packaging, affordable food, with optimum redistribution and recycling of bio-waste.

Many participants in the survey and panel contributed valuable comments and feedback:

Comments and feedback on the visions for food products

(*Source*: Survey respondents)

- Restoration of the earth after the war: encourage the development of organic farming.
- New alternative food sources are being created based on innovative technologies that combine waste-free food production and health benefits.
- When developing supply chains and introducing local crops, the long-term impact of climate change is modelled and adaptive and mitigation measures are implemented to counteract these negative consequences.
- Before the war, Ukraine had a strong potential to ensure food security, so focusing on this direction on the principles of this in the future will give an impetus to economic recovery and to the growth of national competitiveness.
- Change household approaches to diet and food preferences.
- Production enterprises have a clear strategy and plan for its implementation on the ground.
- Local human resources have been formed, which makes it possible to implement the existing plan efficiently.
- At the household level, there are opportunities to reduce the environmental impact, implement sustainable farming practices and waste management technologies.
- At the infrastructure level, there is a rapid development of sustainable agricultural infrastructure; modernization of financial infrastructure ensures an influx of investment in sustainable technologies and innovations, contributes to improving the investment climate.

- International integration and cooperation, cooperation with the EU and various international structures for the exchange of experience and resources are deepening at the international level.
- It is necessary to strengthen control over the use of agricultural land and water.

5.4. How to achieve? – pathways for food products

The diagram below shows an outline of three systems-level pathways to meet the KPVC 'visions'. At this stage these are directions for exploration and development, which can respond to future challenges and opportunities.

5.4.1. *'Food efficiency' pathway*

(Supply-side focus; with a combination of business-technology-industrial systems)

This pathway focuses on the production side, where Ukraine is one of the largest exporters, producing enough basics for 400 million people. With new techniques, farm inputs and management technology, the efficiency can be greatly increased, chemical inputs reduced, farm waste and food / drink processing waste can be recycled / recovered. Overall, this fits with the longer-term EU agenda for greening and modernization of farming and food / drink processing: this will also contribute to resilience to energy / water problems, and climate change.

Generally, the 'circularity' principle is yet to be applied in export-driven production: a more domestic 'circularity' agenda looks at material cycles such as bio-gas vs composting.

Precision agriculture has huge potential, with technologies such as Synthetic Aperture Radar, or AI-based crop management systems. However, there are challenges in bringing new technology to market, and mediating the imbalance between global agro-industrial producers and local enterprises.

Overarching these are institutional issues of land-owning, farm size, and farm subsidy / support systems for regenerative farming, now very controversial in the EU. Ukraine may refer to the experience of other countries, but also may contribute some unique opportunities and insights. EU alignment can proceed strategically, via European Bank for Reconstruction and Development investment, corporate environmental, social and governance (ESG) schemes and Carbon Border Adjustment Mechanism (CBAM) systems for imports and exports.

5.4.2. *'Food health' pathway*

(Demand side focus: with a combination of design-technology-social-governance systems)

On the consumption side, there are multiple priorities for reducing food waste and packaging and increasing healthy food and drink. This also includes reducing food poverty and strengthening the social and economic role of many kinds of food business in retail, catering and public services. In the short term, social marketing and policy incentives can be set up. In

the longer term, fully circular food systems can be developed in the hierarchy of re-distribution / re-use / re-cycle / recovery: healthy food then combines with low-impact regenerative farming and low-packaging food / drink processing. However, in practical terms, different priorities may require trade-offs, for instance between food shelf life and packaging / logistics systems.

In the wider view, food systems are very much in the human domain of psychology, community, and culture, for the crucial issue of diet choice, food waste, packaging and other impacts. The sustainable / circular combination of low-input, low-meat diets may take time to emerge, calling for a strategic partnership approach with government, business, local providers, civil society organizations.

5.4.3. ***'Food livelihood' pathway***

(Community focus: with a combination of urban-social-governance systems)

Food is also a livelihood issue, where for example the older generations with family links in rural villages bring surplus to urban centres. Such localized systems can focus on food quality, public health, social enterprise, inclusive of veterans and internally displaced persons, young persons and students. This is then a territorial or bio-regional focus, on green belt and peri-urban areas around the cities and towns, together with urban spaces and infrastructure for growing / exchange / distribution of local food. Land reform, housing reconstruction and spatial planning policy can all help to promote food enterprises based on local social capital.

Food processing, distribution, catering and export, can then become a focus for local and regional economic development, along with bio-energy and other non-food farm products. This also contributes to food security and equality / justice, with the growth of food banks, food sharing etc, targeted on internally displaced persons, veterans and the unemployed.

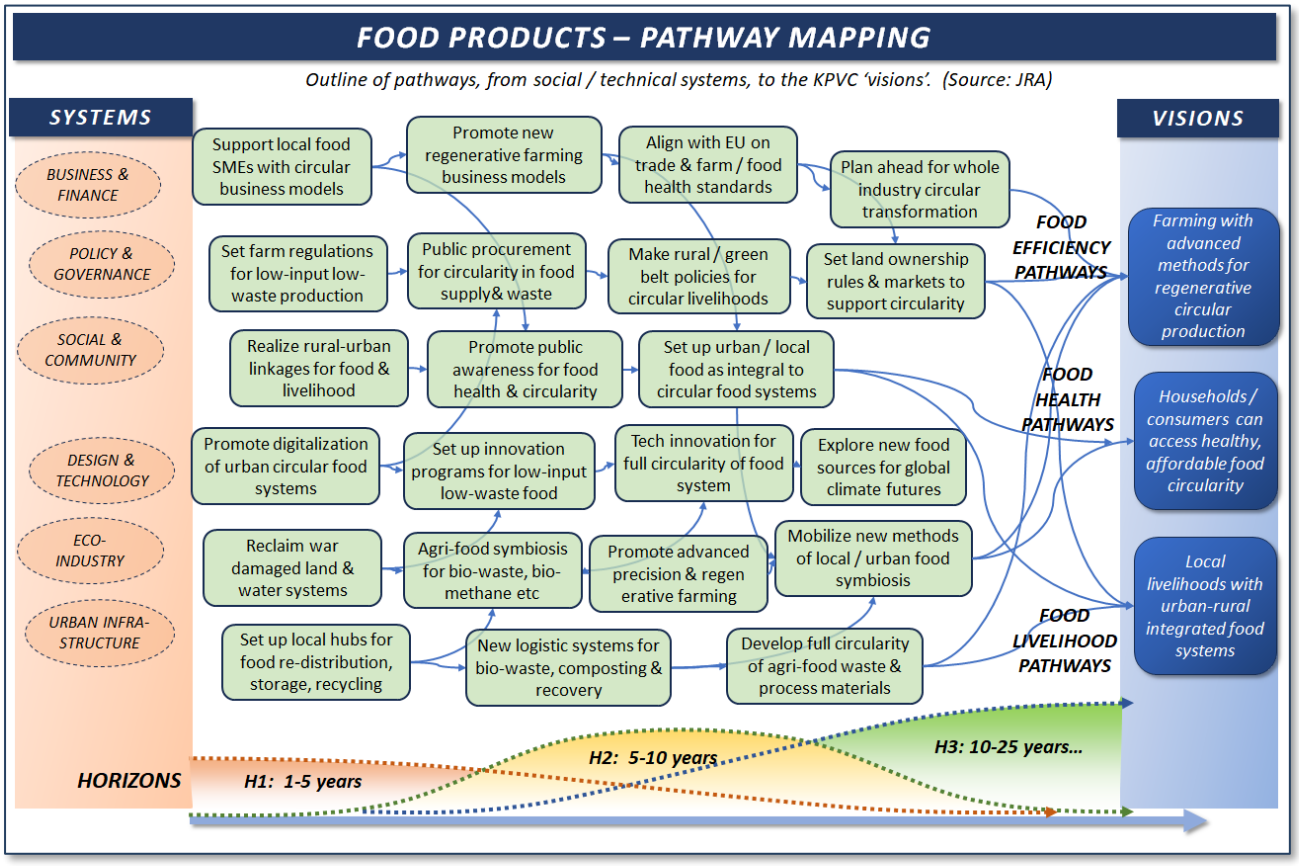


Figure10: Food products: pathway mapping

5.5. Who can do this? Key stakeholders and enablers

For ***business and finance***, the integrated value chain approach can mobilize the crucial cooperation between farmers / agri-business, food / beverage producers, and food distributors / retailers. This can help to unlock whole 'farm to fork' chains, and rapid transition towards low-input, low-waste, low packaging food systems.

For ***government and policy***, there is a key balance of pushes and pulls: between regulation and common standards in the agri-food sector, and opportunity building via industrial partnerships, procurement programmes, and innovation cluster building. On the demand side, education and health programmes can help to move towards circular food systems, with incentives for sharing of surplus. For local and regional economic development, the circular food economy can be a counterpart to the conventional capital-intensive agri-business.

For ***social-community*** issues, the livelihood pathway can be linked to local economic development, food health awareness, and the cultural value of local food systems. For vulnerable and marginalized communities, there are basic principles of food access and quality, which can mobilize more systematic food sharing of the surpluses of retail / catering activities. The social-cooperative enterprise model has potential for enabling stronger links between producers, retailers, consumers in the wider community.

Design, technology and innovation is already rapid in the food and beverage sector, and can be steered from individual ‘products’ to whole integrated 'food chain’ models. For processing of farm and food industry waste, the ***eco-industrial*** management systems can follow the industrial symbiosis model for recovery and exchange, both for food and non-food products. To enable scaling up, new forms of ***urban infrastructure*** can scale up from kitchen waste containers to street or neighbourhood composting, to urban / regional recovery facilities.

5.6. When? - 3 horizons for food products

The pathways above then fit into the longer view, with the 3-horizon perspective:

- Horizon 1 (2030): Post-war restoration, de-contamination of land and water: first steps in production / supply chain efficiency and circularity

- Horizon 2 (2035): Strategic steps for supply-side production innovation: and demand side shift in food markets, logistics, infrastructures

- Horizon 3 (2050): Transformation to near zero-waste and low-energy food production, processing, distribution and packaging: combined with shift to healthy affordable food livelihoods in households and communities.

Next steps for horizon 1: to be discussed as the foresight process moves towards action planning.

6. Electronics and ICT

Ukraine's electronics and ICT system is dependent on a highly globalized network of production and trade. However, this system is rather different to the previous broad scope value chains: here the main value added is more in the very rapid innovation (IP and related values), than in material hardware. Meanwhile in practical terms, many product types are reducing in size, while increasing in complexity, with built in obsolescence. However, most products are dependent on 'critical raw materials', a topic of high international concern: and the combined impact of central ICT infrastructure (server farms, etc) is growing exponentially.

The foresight approach focuses here on the potential for positive transformation, i.e. towards circularity. It reviews possible scenarios, sets out visions, and proposes some outline pathways to achieve them.

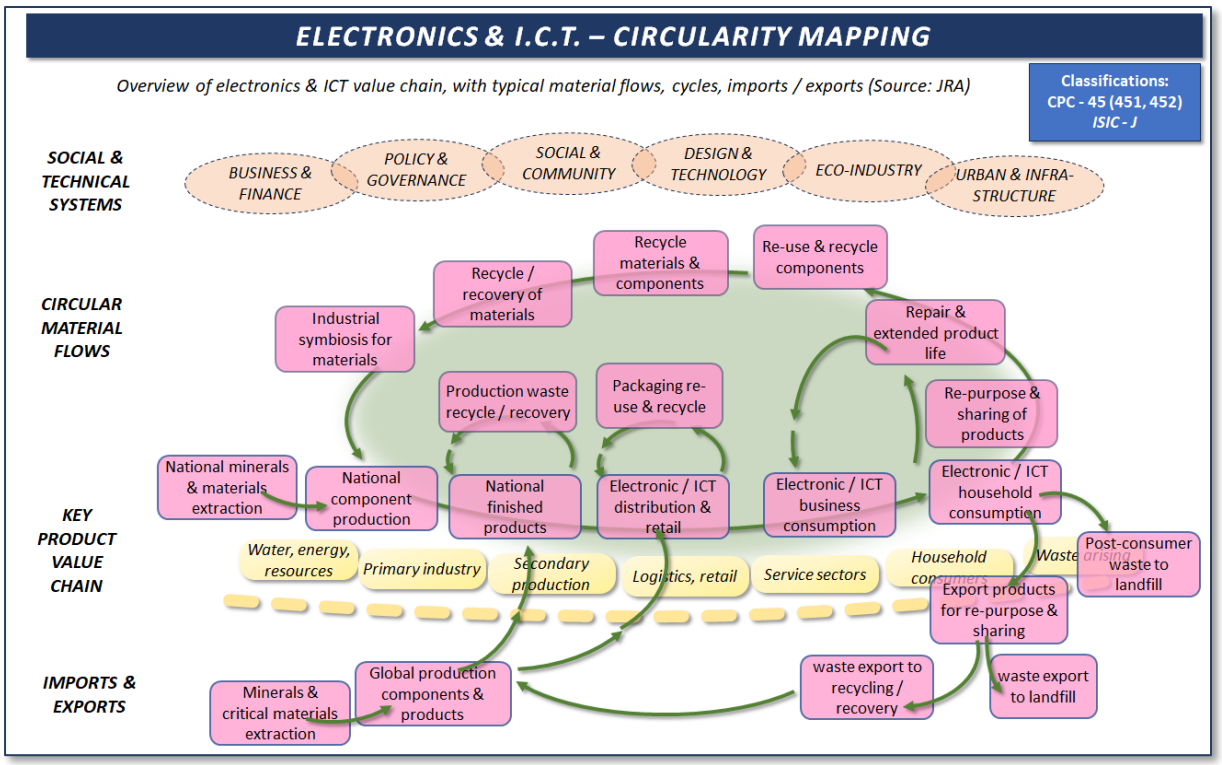


Figure 11: Electronics and ICT: circularity mapping

6.1. What is the problem? Scoping electronics and ICT

The electronics and ICT KPVC shows a huge range of products, markets, supply chains, trade patterns, consumer behaviours, and rapid pace of change. It includes household small electronics (TVs, phones, etc), commercial / industrial electronics, ICT hardware (computers, monitors etc), and many kinds of systems and peripherals (batteries, leads, drives, etc). The whole KPVC creates most of its value by informational services, more than the physical products, which are then easily discarded.

Key ‘upstream’ activities include: raw materials, manufacturing, distribution, etc. Key ‘downstream’ activities include retail and almost all other service activities.

(Classifications: key sectors are defined in the ISIC as Manufacturing (26, computer, electronic and optical products), and ‘Information and communication’ – J. Key products are defined in the CPC as ‘office, accounting and computing machinery’ - 45 (451, 452).

This applies to the key issues on supply and demand sides, and on waste management in particular:

Summary of baseline issues

(*Source*: Based on survey and panel results, UNIDO 2023, CE Foundation 2024)

Supply side and market conditions

- Many goods are unregistered / illegal imports, very difficult to regulate
- Critical raw materials are key to ICT production, but shortages are likely to increase.
- Ukraine needs to grow its domestic production, subject to global value chains.

Demand and post-consumer side

- Consumers struggle to keep up with latest models
- Packaging is a major issue with most product types
- Many devices come with many short life ancillaries (cables, power packs etc)
- Re-use and sharing markets (i.e. second hand) are already established
- Many product types are difficult to recycle or recover high value materials from

Waste management and CE issues

“The volume of electronic waste (e-waste) is significant in Ukraine, estimated at 300-350 thousand tons annually. 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 (‘waste electrical and electronic equipment’)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”.

6.2. What if? Scenario mapping for electronics and ICT

The future here seems highly open to uncertainty. This includes the future level of technology innovation and digitalization: the penetration of global brands: the balance of international trade / domestic production: and the commitment (public / private / civic) to turning e-waste into valuable resources through re-use and recycling. The scenario framework described in section 2.1 provides an overview of alternative future possibilities:

Alternative future scenarios for electronics and ICT

- ***'Globalized Circular Society'***: large global brand markets, with advanced resource efficiency, and national production / distribution: wide public / consumer awareness and commitment to circularity:
- ***'Local Circular Society'***: less global and more national production with rapid tech innovation and sector development: wide public / consumer awareness and commitment to circularity:
- ***'Local Circular Industry'***: less global and more national production with rapid tech innovation and sector development; however, the public / consumers are not engaged and e-waste grows rapidly with no clear destination:
- ***Global Circular Industry***: large global brand markets, with advanced resource efficiency, and national production / distribution; however the public / consumers are not engaged and e-waste grows rapidly with no clear destination.

6.3. What is possible? - visions for Electronics and ICT

The following three 'visions for transformation' were developed in the expert panel. The panel started with a general goal, responded to challenges, and then formed the direction of travel to the three broad visions. The general timescale is a 'Horizon 3' of 10-25 years.

(a) ***Integrated chain management:*** The electronics / ICT sector will work towards integration of policy, production, retailing and demand side, on the principles of 'Industry 5.0'.[29]

(b) ***Coordinated producer responsibility:*** Electronics / ICT product enterprises, markets and supply chains will be coordinated by public-private-technical partnerships.

(c) ***Production / innovation systems:*** The electronics / ICT sector will work towards diversity in production and distribution: with a coordinated package of SME support, technical training, logistics and infrastructure.

[29] European Commission, 2021.

6.4. How to achieve? – pathways for Electronics and ICT

The diagram below shows an outline of three systems-level pathways to meet the KPVC 'visions'. At this stage these are directions for exploration and development, which need to respond to future challenges and opportunities.

6.4.1. *'Technology for life' pathway*

(Production and market supply side: with combinations of innovation-eco-industrial-business systems)

This pathway focuses on the supply chain, both international and national: it combines trade and import regulation with market development for re-use and recycling. The hyper-rapid product innovation cycle can over time be steered towards the familiar menu for circularity: extended product life, producer responsibility, take-back policies, leasing models, reverse logistics, design for repair and dis-assembly, etc.

The full digitalization of the wider economy is also involved, where in a short time, almost all businesses will be SMAC (smart, mobile, AI, cloud-based), with large hard-wired installations becoming obsolete. However, the growth of centralized infrastructures such as server farms then changes the focus: while these are currently located in a very few countries this is likely to change, with implications for energy and water resources.

6.4.2. *'Device literacy' pathway*

(Consumer and demand side: with combinations of social-governance-technology-infrastructure systems)

On the demand side there is an equal agenda for social innovation and local enterprise in the circularity of electronics and ICT devices and installations.

A coordinated programme of public infrastructure will include reverse logistics hubs, local repair / re-purpose shops, and skills training, which then fits with the hardware recycling and recovery industry.

The implications of such a shift could be problematic if this involves large numbers of workers transferring from hi-tech production, to a relatively labour-intensive local repair shop economy, as already is the case in less developed countries.

6.4.3. *'Industry 5.0' pathway*

(Whole economy agenda: with combinations of governance and all other systems)

This pathway takes an alternative approach, starting with the aspiration for full digitalization, for a future 'smart-wise' whole economy and society (as seen for example in the Baltic states). This rapidly moving picture can start with systems of governance and public services, and then cover all branches of economic activity, inter-connection with social systems according to

public demand. It then includes the circularity of e-waste as an essential transition towards 100% re-use and recycling.

The added contribution here is for government to take the lead role in defining a future society with near 100% digitalization: to then set up strategic programmes for procurement and national industrial development: and to build in the circularity agenda from the very beginning.

Note the '5.0' refers to the EU programme 'Industry 5.0' which aims to integrate a fully digital industrial economy with social and ecological values.[30]

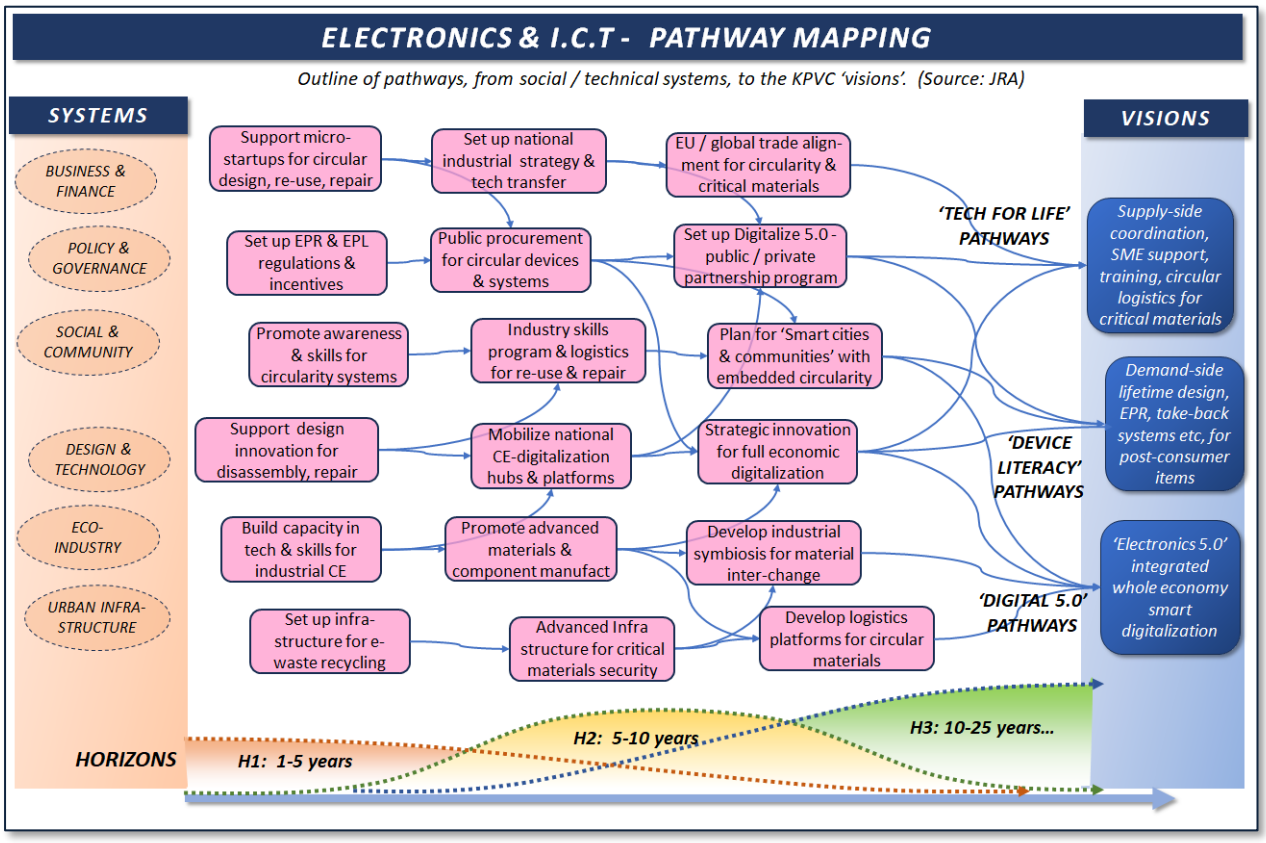


Figure 12: Electronics and ICT: pathway mapping

6.5. Who can do this? Key stakeholders and enablers

For ***business-finance***: new models can emerge for electronics supply chain transparency, product passports, and business / finance models to promote product re-use, repair and re-engineering. A fundamental issue is how far Ukraine can set up national production systems, to overcome import dependency.

[30] European Commission, 2021.

For ***policy-governance***: the ministries of economic development and digitalization could further collaborate for joint coordination of standards, compatibility, regulation, with forward finance for EPR and service models. The national agenda for full digitalization needs to include CE principles from the beginning, and use the national agenda to drive them.

For ***social-community*** networks, there is urgent need to promote social motivation for product repair, re-engineering, and sharing platforms. For ***design-technology***: some ICT innovation systems are beginning to look at standardized product design for reuse / re-engineering; there is increased attention on the energy consumption of central servers, and the LCA impact of material inputs.

For ***eco-industry,*** there is an agenda for coordination of the Ukraine minerals sector with EU critical materials platforms and policies.

For ***urban-infrastructure***, a new system for reverse logistics can be set up for product and component re-use / re-engineering / recycling. Coordination is needed on locations for hubs and exchange platforms.

6.6. When? - 3 horizons for electronics and ICT

The pathways above then fit into the longer view, with the 3-horizon perspective:

- Horizon 1 (2030): Service and Leasing models: Extended producer responsibility: Collaborative circular standards and regulations
- Horizon 2 (2035): Circular literacy at home and workplace: Innovation for “Extended Product Life”: Industrial cross-integration
- Horizon 3 (2050): Social welfare circular platforms: Digital supply chain integration: Reverse logistic hubs for re-use and recycling

Next steps for horizon 1: to be discussed as the foresight process moves towards action planning.

7. Plastics and packaging

The global plastics challenge – with waste and pollution found in every part of the natural world and the human body – has yet to go mainstream in Ukraine, but this may change shortly.

Plastics and packaging is not so much a single value chain but a cross-cutting set of activities, which provides inputs to all other value chains. In some it appears to be indispensable, for instance the modern food products KPVC as known, could not function without plastic packaging.

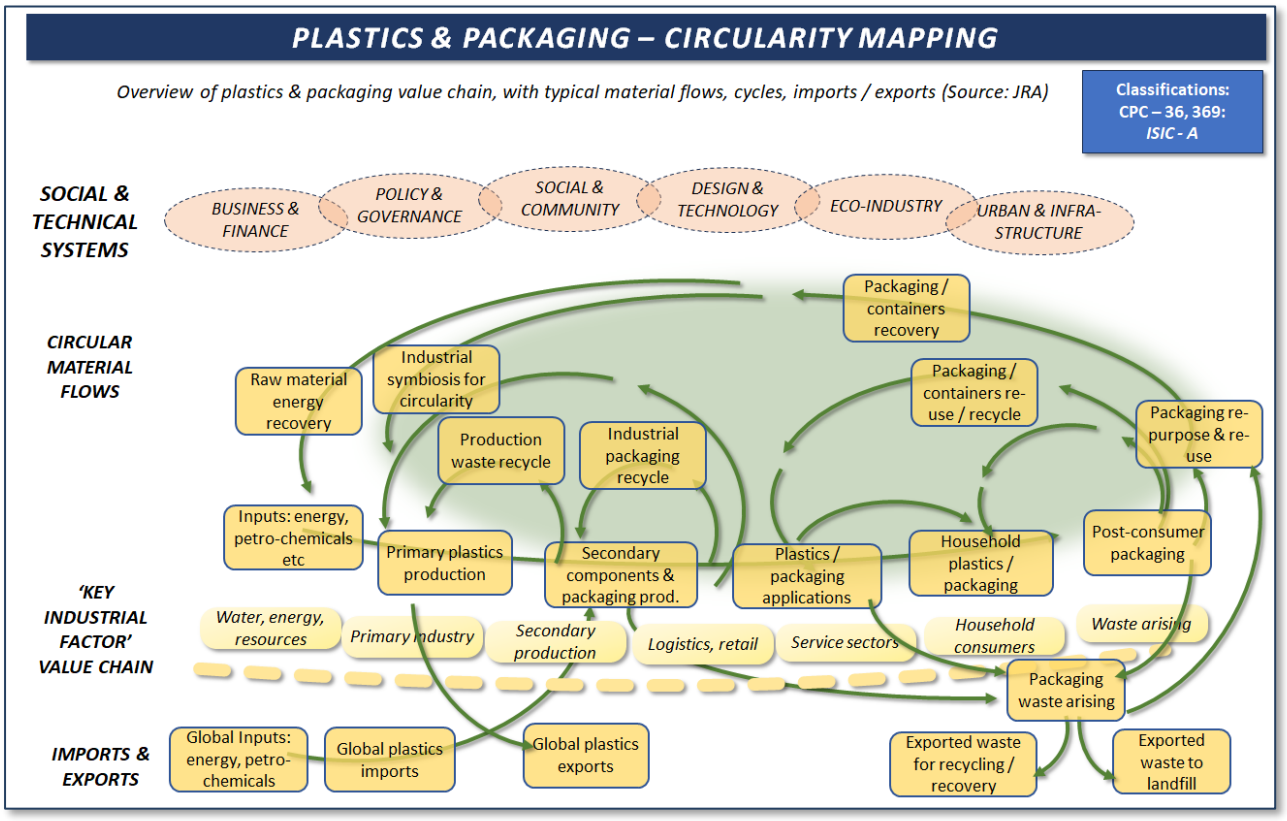


Figure 13: Plastics and packaging: circularity mapping

7.1. What is the problem? Scoping the plastics and packaging system

'Plastics and packaging' is the combination of two distinct agendas, which overlap where a growing proportion of packaging is plastic-based:

- Industrial plastics, including a very wide range of compounds, industrial products and applications; general plastics, synthetic materials, specialized polymers, with an increasing proportion used in containers and packaging.
- Packaging may also include a wide variety of materials and forms, for a specific purpose, such as food and drink, construction materials, household goods etc: material including plastic, paper, organic, glass, metal and other.

Key ‘upstream’ activities include: minerals, energy and water, agriculture, manufacturing, distribution. Key ‘downstream’ activities include: wholesale and retail trade, transportation and storage, and all other types of services.

(Classifications: key sectors are defined in the ISIC as Manufacturing – C (20- chemicals and chemical products, and 22- rubber and plastics products): and ‘Transporting and storage’ – J. Key product types are defined in the CPC as ‘Rubber and plastics products’ – 36, and ‘packaging products of plastics’ – 369.

Generally, the endemic problem of plastics in packaging of every variety calls for new levels of synergy between manufacturers, distributors, retailers, consumers, waste managers and governments. Many countries, regions and cities now have policies against single-use plastic bags or drinks containers, but this problem can go much further into value chains such as food, where packaging is integral to the whole production and material-management system. One way forward may be from the household side, with a spread of ‘materials literacy’ which enable much greater degrees of waste sorting and recycling, while on the retail side, it could be selling produce in bulk to consumers using reusable packaging. EPR too can be used to internalize the externalized costs of managing plastic waste.

An overview of the baseline issues includes the following:

Summary of baseline issues

(*Source*: Based on survey and panel result, UNIDO 2023, CE Foundation 2024)

Supply / production side

- Increasing automation, platform economics, long distance logistics, etc. requires a growing proportion of packaging with increasing complexity.
- Increasing performance of industrial components requires continuous innovation in plastics and a growing catalogue of substances, most being unregulated.
- Urgent global concerns on environmental pollution from plastic components, micro-plastics, and nanoparticles, which are found everywhere including in human bodies.

Demand / consumption side

- Consumers and retailers by default prefer to rely on large amounts of packaging to ensure food safety, logistic services, product quality, general convenience etc.
- The trend towards plastic packaging and away from glass, paper-based, metal or other materials.

General challenges, gaps and barriers:

- Current lack of investment, legislation, methods and practices
- Shortage of recycling facilities
- Lack of business interest, to encourage enterprises to cooperate on re-use and recycling.

Circular economy issues

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 tons per year,

yet only 180,000 tons of polymer waste are actually recycled. Approximately 20 enterprises across Ukraine are engaged in recycling 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.

7.2. What if? - scenarios for plastics and packaging

Much depends on the future of the national economy, its relation with the EU and others, the level of industrial innovation, and the level of population change, urbanization and reconstruction. The practical logistics in food and drink, household goods and many kinds of industrial systems are critical factors.

Alongside this, social and community issues are crucial, with consumer and citizen commitment to sorting, re-use and recycling.

Alternative future scenarios for plastics and packaging

- ***'Globalized Circular Society'***: with a more open economy, many goods and products travel further with more packaging: everything is carefully re-used and recycled: plastics production includes for global best practice in advanced recyclable and bio-degradable materials.
- ***'Local Circular Society':*** a more closed economy looks for whole cycles in containers and packaging with zero-waste. Plastics production focuses on basic production of recyclable and bio-degradable materials.
- ***'Local Circular Industry'***: industrial symbiosis on the production chain helps in the inter-connection of multiple processes, packaging components, plastic materials - so the public can continue to consume, discard and pollute their home environment
- ***'Global Circular Industry':*** imports of plastics and packaging are feedstock for the new national industries of recycling and recovery of plastics and packaging.

The scenario framework described in section 2.3 provides an overview of alternative future possibilities:

7.3. What is possible? - future visions for plastics and packaging

The following three 'visions for transformation' were developed in the panel workshop and following discussions. Each panel started with a general goal, responded to challenges, and then formed a direction of travel to the three broad visions. The general timescale is a 'Horizon 3' of 10-25 years.

(a) Rethinking packaging: The plastics and packaging industries will set up a systems innovation programme, which combines strategic regulation, price incentives, and advance procurement programmes.

(b) Social resource management: a 'Packaging-Industry 5.0' model will emerge from a social innovation programme of with awareness raising, price incentives, logistics and infrastructure.

(c) Circular plastics systems: a 'Plastics-Industry 5.0' programme will aim for a coordinated shift of industrial plastic materials towards bio-degradable, re-useable, re-cyclable materials.

7.4. How to achieve? – pathways for plastics and packaging

The diagram in Figure 14 shows an outline of three systems-level pathways to meet the KPVC 'visions'. At this stage these are directions for exploration and development, which need to respond to future challenges and opportunities.

7.4.1. *'What goes around comes around' pathway*

(re-use, upcycling, recycling, recovery: with eco-industrial, government, business-finance and infrastructure combinations)

This pathway starts with extended manufacturer's responsibility and new kinds of valuation of plastic recycling services, to overcome the current *lack of investment and legislation.* Creating value in the production and consumption of recyclable packaging depends on strategic partnerships in circular procurement between manufacturer and buyer, and 'B2B' manufacturer and manufacturer.

An adaptive and participatory management approach will help to build communities of interest, for the large scale circular social and environmental investments. With financial institutions, government/ ministries and international organizations, a new regime of common circular standards and regulations can be developed and rolled out.

7.4.2. *'Packaging for life' pathway*

(social / demand side re-use and recycling: with a combination of sociocultural-governance-infrastructure systems)

This pathway starts with 'circular literacy' combinations of education / skills at home and at work, to address the general lack of social responsibility and environmental education. It supports this with circular platforms and 'resource hubs' for socially responsible use of the final product in recyclable packaging containers. This then points towards a transformed pattern of logistical infrastructure, with a 100 per cent shift from disposable packaging towards fully re-usable, repairable and recyclable packaging. Retail and distribution activities will be at the front of this transition, with food shops as the first focal point.

7.4.3. *'Plastics for life' pathway*

(Industrial supply side: with combinations of eco-industrial, business-finance, tech-design-innovation systems)

This starts with ecological design for plastic composition and performance, with the aim of full recycling of suitable plastic. This will depend on a system of 'resource management hubs', smart platforms at the sub-sector level, and community 'kiosks' at the local level. Overall, this points towards the principles of industrial symbiosis, where materials can be shared between different sectors, i.e. one firm's waste is another's raw material: which raises questions on how

integrated supply chains can be organized, going beyond the barriers of conventional market competition.

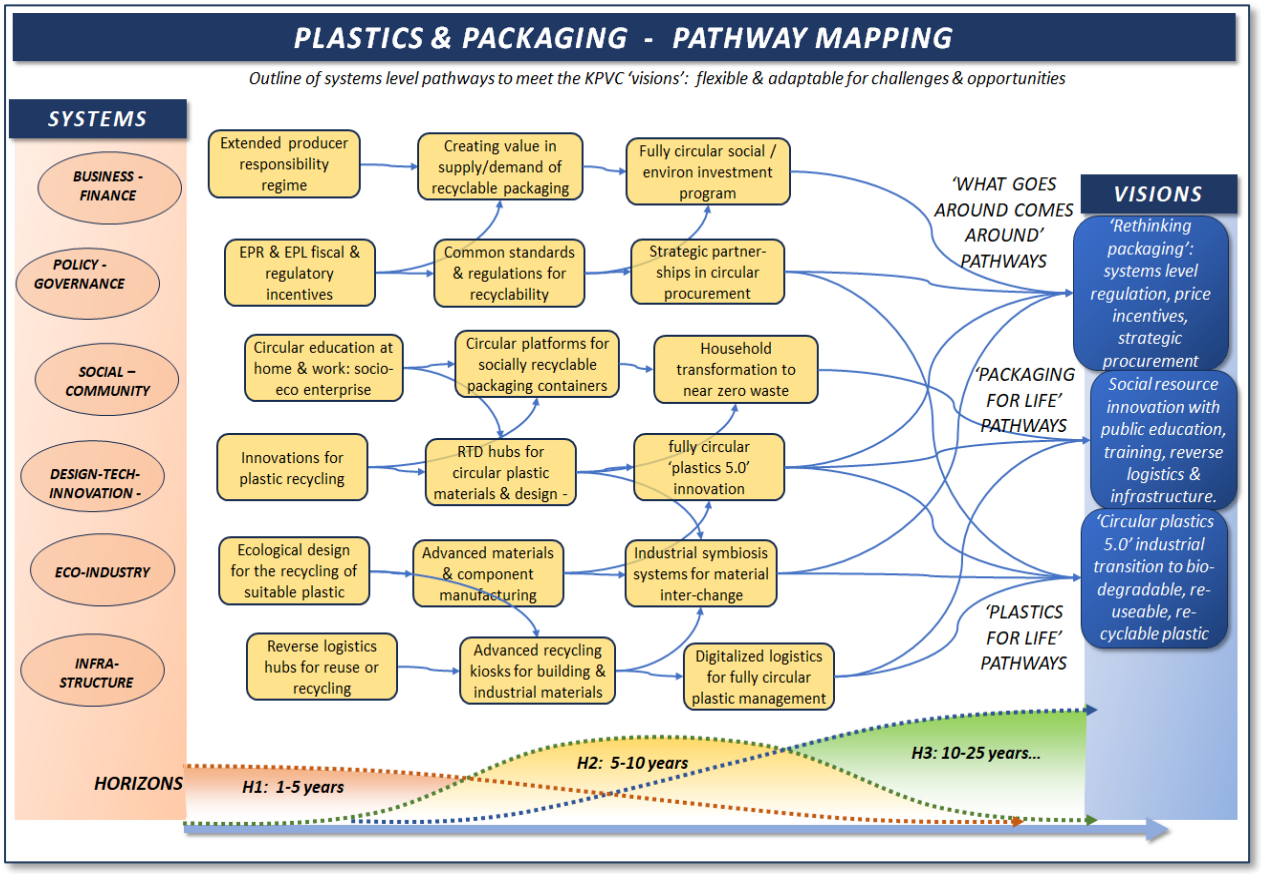


Figure 14: Plastics and packaging: pathway mapping

7.5. Who can do this? Key stakeholders and enablers

For ***business and finance***, the agenda focuses on new business models and logistic systems for packaging reduction / re-use / recycling. Alternatives to plastic may take time to establish along the value chains and need greater cooperation between firms and tech providers. For ***government and policy***, the public sector can lead the way, with coordinated systems of packaging transformation, via tax / subsidy / regulation / standards and procurement. Public private partnerships are needed for the capacity-building and value chain coordination for alternative logistics systems.

For ***social-community*** issues, there is rapid innovation on social awareness, and many forms of socio-eco-community enterprise for packaging reduction, re-use, re-distribution, recycling. The agenda then is how to scale up from the niche to the mainstream.

Design, technology and innovation systems are already moving fast on product design and supply chain innovation, for dis-assembly, re-use of plastics, reduce and recycling of packaging. Ukraine can aim for alignment with the global search for alternatives to plastic, and environmentally friendly forms of plastic.

The ***eco-industrial*** systems management and design need to focus on the longer agenda of re-thinking industrial processes and components for waste minimization, re-use, recycling: with low-zero packaging for common products and components. Product passports, RFID monitoring systems, and automatic segregation can all gain from the coming full digitalization. Meanwhile new forms of ***urban infrastructure*** are needed for the retrofit of housing, workplaces and industrial areas for sharing, re-use and recycling of common materials and products in packaging.

7.6. When? - 3 horizons for plastics and packaging

The longer view can be summarized with the 3-horizon perspective:

- Horizon 1 (2030): Service and leasing models: Extended producer responsibility: Collaborative circular standards and regulations
- Horizon 2 (2035): Circular literacy at home and workplace: Innovation for “Extended Product Life”: Industrial cross-integration
- Horizon 3 (2050): Social welfare circular platforms: Digital supply chain integration: Reverse logistic hubs for re-use and recycling.

Next steps for horizon 1: to be discussed as the foresight process moves towards action planning.

8. ‘Wastes’

While the EU has set a target of 50% household waste recycling by 2030, Ukraine is less than 10% currently. There is large scale disruption to waste management infrastructure in or near the war zones, and a lack of investment for modernization.

The transformation vision, from ‘waste disposal’ to ‘resource management’ involves a strategic shift in business practice, industrial systems, household / consumer practices and more.

This KPVC starts with the practical implementation in Ukraine of the new Law on Waste Management: then it looks for connections with more strategic and transformative visions for a full industrial symbiosis.

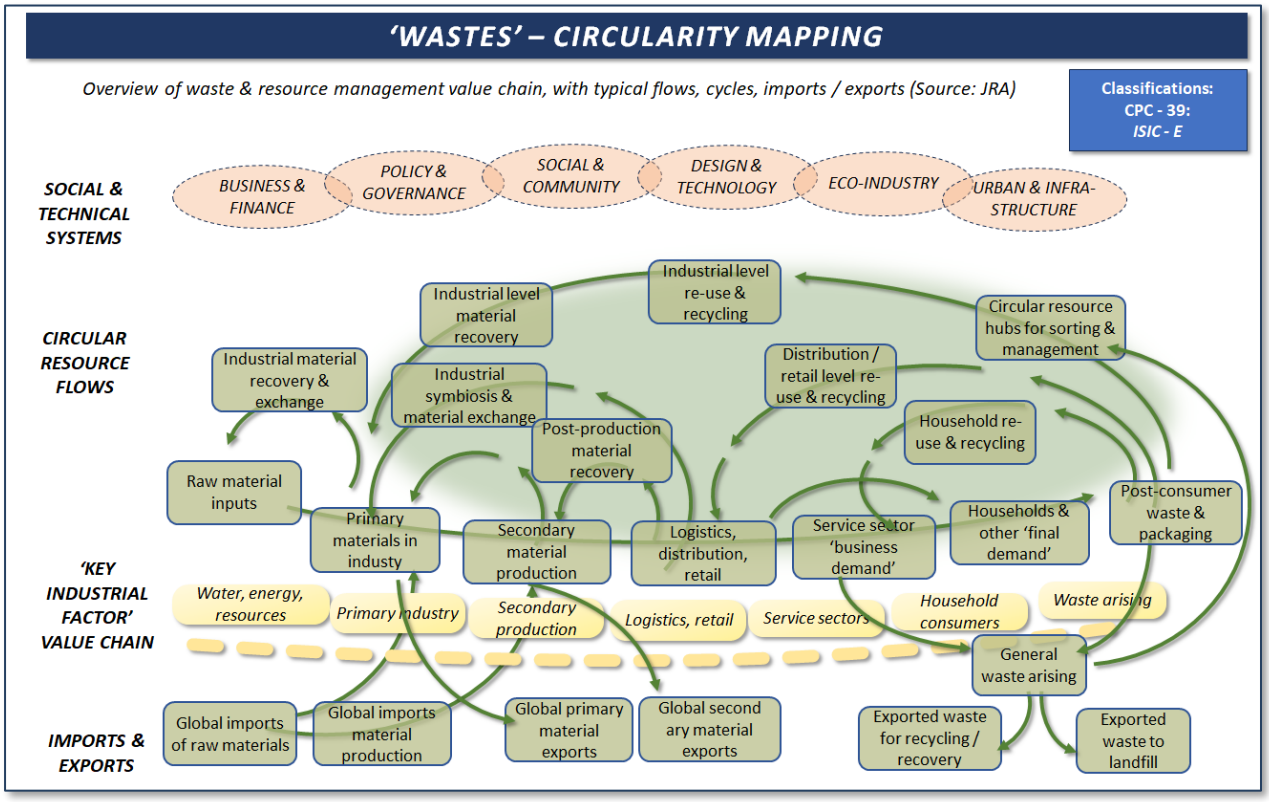


Figure 15: ‘Wastes’: circularity mapping

8.1. What is the problem? Scoping ‘wastes’ and waste management

‘Wastes’ covers basically the material flow of all other sectors, with a focus at the downstream or ‘end-fate’ part of the chain. Waste types and sub-sectors include a wide range: industrial and commercial wastes, consumer / municipal wastes, special wastes such as clinical, toxic / hazardous, radioactive, etc. Construction and demolition waste, and agricultural waste are managed separately, and each are covered in the KPVCs above. Also, Ukraine has a major challenge in post-conflict contamination, pollution, general debris and wastes of all kinds.

Key ‘upstream’ activities include: all material-based supply chains, from ‘post-extraction’ raw materials to industry. Key ‘downstream’ activities include: any material flows, post-production or post-consumer, and available for recycling or recovery.

(*Classifications: key sectors are defined in the ISIC as ‘sewerage; waste management and remediation activities’ – E(37-39). Key products (i.e. materials) are defined in the CPC as ‘Wastes or scraps’ – 39*.)

Summary of baseline conditions and challenges: ‘wastes’

(*Source*: Based on survey and panel results, UNIDO 2023, CE Foundation 2024)
Also see figure below on UA waste generation.

Upstream issues (i.e. material flows into ‘wastes’ system

- Majority of industrial waste and household waste is sent to landfill or abandoned
- Low rates of landfill tax with little incentive for business

Downstream issues (i.e. material flows through and out of ‘wastes’ system

- National Law on Waste Management is adopted, with implementation in progress:
- Current lack of facilities, technologies, finances etc. for upgrading waste management

Circular economy issues

- Current lack of awareness in business and communities of the CE potential
- Many manufactured products are repaired and re-used by necessity
- Some CE-based policies, programmes, enterprises, are taking shape even in war conditions.

Waste management issues

- “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 landfilled or abandoned. In accordance with the Ukrstat data for 2020, only 9% of Municipal Solid Waste was recovered, while 3.73% incinerated, and the remaining 87.67% was landfilled. Comparatively in the EU, nearly half of municipal waste is recycled.
- It is important to note that the landfill tax in Ukraine is far below EU levels (0,15 EUR per tonne versus for instance 107 EUR per tonne in the Netherlands). To increase this tax, however, necessitates 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.

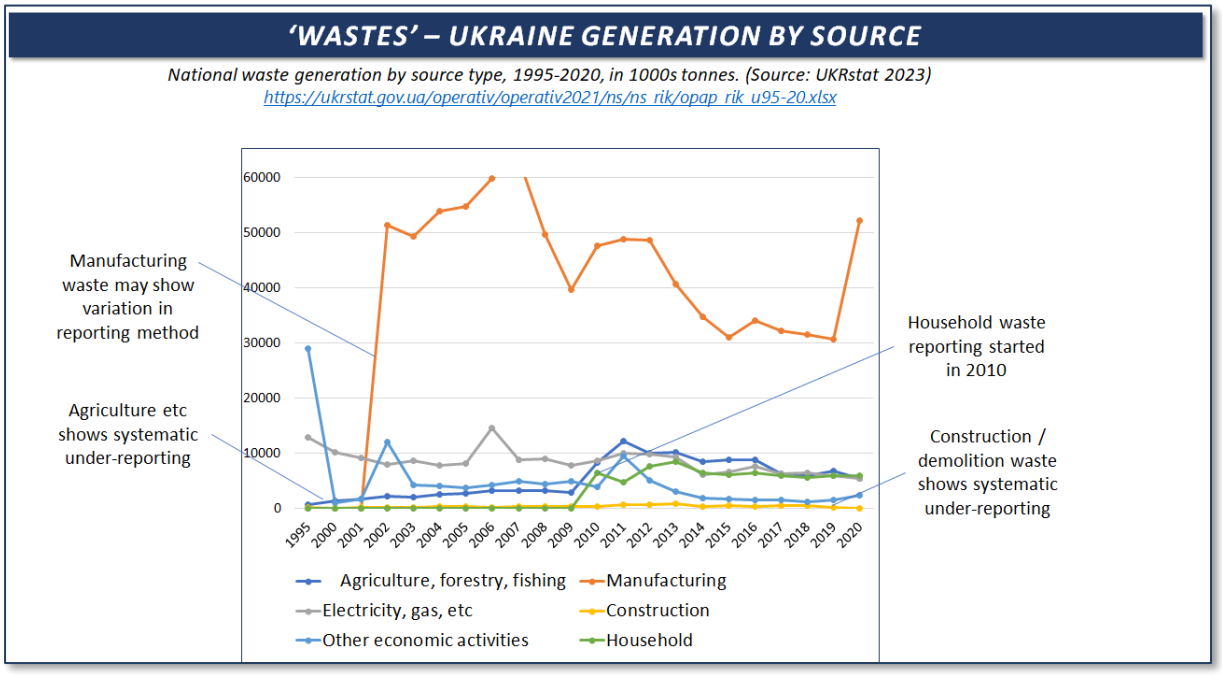


Figure 16: 'Wastes' – Ukraine generation by source

8.2. What if? - scenarios for 'wastes'

Much depends on the prospects for the national economy, whether more or less integrated with the EU and others, the level of technology innovation, infrastructure development, and reconstruction. The human factors are also crucial – public awareness and the commitment of entrepreneurs and workers to low-waste circular economy principles. This scenario framework provides an overview of alternative future possibilities:

Alternative future scenarios for 'wastes'

- ***'Globalized Circular Society':*** a 'zero-waste economy', where all products and materials are re-used, repaired, recycled, as part of international circular trade systems. Both industrial producers and household consumers are fully committed to the social-economic 'circularity potential'.
- ***'Local Circular Society':*** a 'low-waste economy' with most products and materials re-used, repaired, recycled – mainly within Ukraine borders. This works for both industry and households.
- ***'Local Circular Industry':*** a 'medium-waste industrial economy', where industrial production can profit from materials exchange and symbiosis. One firm's waste is another' raw material.
- ***'Global Circular Industry':*** a 'low-waste industrial economy', where industrial production is now fully integrated into EU and international value chains. The industrial symbiosis is more successful by working across borders and sectors.

8.3. What is possible? - future visions for 'wastes'

These 'visions for transformation' were developed in the panel workshop. Each started with a general goal, responded to challenges, and then formed a broad vision and direction of travel. The general timescale is a 'Horizon 3' of 10-25 years.

(a) ***Rethinking waste and resources:*** future materials management will be organized around integrated public / private partnerships: for the 'push' factors of regulation and tax incentives, and the 'pull' factors of infrastructure and markets

(b) ***Organic and food waste***: Ukraine will host a network of integrated public / private platforms for food waste sharing, redistribution, and recycling across the value chain

(c) ***Integrated resource economy:*** a national transformation programme will work with the waste streams of all KPVCs and industrial sectors, to enable the transition, increase skills and awareness, and provide finance for circular enterprises and systems.

8.4. How to achieve? – pathways for 'wastes'

The diagram in Figure 17 shows an outline of three systems-level pathways to meet the KPVC 'visions'. At this stage these are directions for exploration and development, which need to respond to future challenges and opportunities.

8.4.1. *'Waste not want not' pathway*

(household / municipal waste focus: based on combinations of social-government-infrastructure systems)

The circular economy starts with the domestic economy of households and communities, where re-use repair and recycling can grow, in kitchens, gardens, local shops and local workplaces. This calls for public education and awareness, which then enables social enterprises for re-location and re-purposing of items such as clothing, furniture, household equipment.

This pathway also starts with creating infrastructure at the local level, both physical logistics and material exchanges, and the socioeconomics of local business activity and investment. Technology will also help via data management on wastes and resources, platform marketplaces for exchange, and advanced materials. This combines with demand-driven innovation for products which are long-lasting and easily repaired or recycled.

8.4.2. *'Resources for life' pathway*

(bio-materials management focus: based on combinations of eco-industrial-innovation-business-government systems)

This pathway starts with the results of the 'food products' KPVC. On the household and demand side, composting of kitchen and garden waste can provide valuable materials for fertilizers and conditioners before recovery for the industrial system. For retail and catering operations, food management of product quality and sell-by dates, and then sharing of surplus via food banks and similar, are the practical starting points.

On the industrial side, agricultural and forestry waste can be bio-methane: industrial bio-waste can help to nurture agricultural production and fish farming. Technology innovation is crucial, with a rapid shift of many industrial components and products towards bio-degradable materials, which can then enter the bio-industrial system.

8.4.3. *'Symbiosis for growth' pathway*

(industrial waste focus: based on combinations of eco-industrial-governance-business-infrastructure systems)

Industrial symbiosis is the guiding principle, for an extended systems and networks of circularity in resources, primary materials, components, semi-finished and final products. The ongoing modernization and digitization of the wider economy will have a key role to play in logistics for resource management, with technologies such as robotic separation, component RFID tracking, smart AI-driven logistics and energy / materials platforms. Over time all new materials in products and packaging will be designed for easy separation, recycling and recovery.

The key to success is in practical 'valorization' of the CE potential for almost all material-based firms, with business models, financial models, production lines and extended service systems. This depends on new levels of cooperation along the value chain, where the opportunities for symbiosis are created and tested at each stage of production.

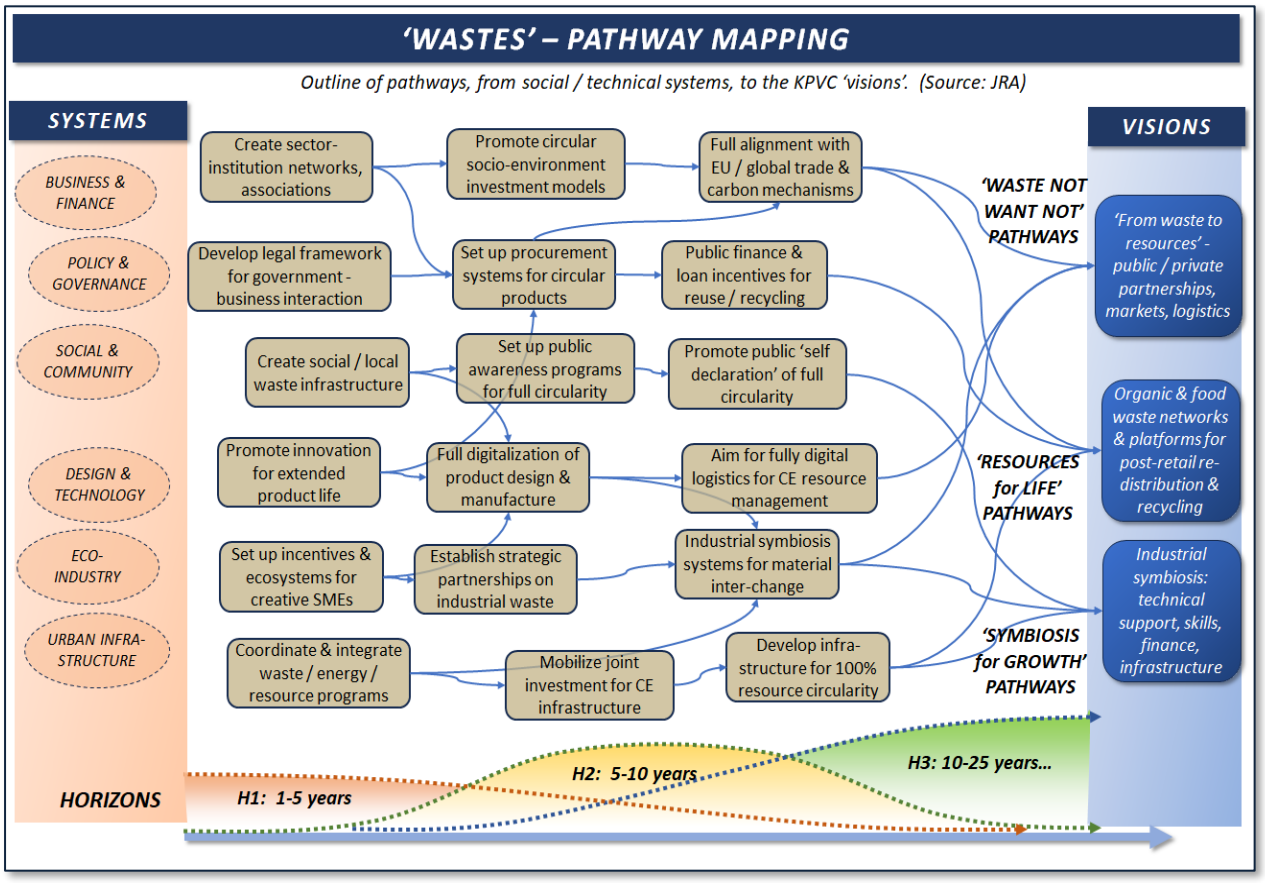


Figure 17: 'Wastes': pathway mapping

8.5. Who can do this? Key stakeholders and enablers

For ***business and finance***, there is growth potential for a whole new sector of 'resource management' – high value, hi-tech and high-skill. This depends on investment channels for zero-waste integrated supply chain business models.

For ***government and policy***, the lead role is for coordination and promotion of integrated zero-waste supply-demand chain partnerships. This depends on a policy eco-system of regulation, joint investment, managing EU alignment and international import / export rules.

For ***social-community*** issues, promotion of public awareness and worker skills combines with support for social / ecological enterprises, with public services in health and education leading the way. For ***design, technology and innovation*** systems one looks for integrated supply chain design, bio-material innovation programmes, new forms of synthetics and nano-materials, advanced materials management systems.

For ***eco-industrial*** management, there is a process of strategic re-thinking of industrial processes and components for waste minimization, re-use and recycling. And for ***urban infrastructure,*** the post-war reconstruction can combine with retrofit of housing and workplaces for sharing, re-use and recycling of common materials and products.

8.6. When? - 3 horizons for 'wastes'

These pathways then play out as a strategic transformation programme, as seen with the 3-horizon perspective:

- Horizon 1 (2030): Post-war reconstruction and the start of circular materials management: set up initial innovation systems for key sectors and supply chains
- Horizon 2 (2035): Mobilize strategic industrial change in all material-based sectors: investment and modernization in waste-management facilities
- Horizon 3 (2050): Full transformation from 'waste management' to 'resource management', with to near-zero-waste industrial production, near full circularity of all waste / resource flows on supply and demand sides.

An initial project proposal is in discussion (from CE Foundation):

> *"evaluate Ukraine's existing monitoring mechanisms related to the Circular Economy to identify strengths, weaknesses, and areas for improvement, conduct targeted workshops and training sessions for relevant stakeholders to enhance their understanding of Circular Economy concepts and improve data collection methodologies, and finally align with EU Standards, fostering compatibility and comparability."*

9. Conclusions and forward agendas

This section brings together the previous notes on the value chains, with general conclusions on the CE-transformations, and the roles of key stakeholders, presented as 'forward agendas'. It concludes with recommendations for next steps in the CE-Ukraine development process.

9.1. Forward agendas: international cooperation and EU alignment

The over-arching agenda for the Government, business, trade, finance, technology and human resources is for international cooperation and, in particular, EU alignment. With the EU as the largest and most effective international trading bloc in the world, its CE action plan is more advanced (at least in principle) than any other.[31] The many CE-related applications such as EU Taxonomy, EU Characterization, EU Carbon Border Adjustment mechanism and similar schemes aim to mobilize the CE agenda for Member States and partners. Together these cover a wide range of trade agreements, product standards, material classifications, corporate compliance, credit-worthiness, consumer standards, environmental objectives and others.[32]

EU Taxonomy Regulation example

(*Source*: European Commission 2023)

This 'taxonomy' sets out 4 overarching conditions that an economic activity must meet in order to qualify as environmentally sustainable:[33]

- Making a substantial contribution to at least one environmental objective;
- Doing no significant harm to any of the other five environmental objectives;
- Complying with minimum safeguards;
- Complying with the technical screening criteria set out in the Taxonomy delegated acts.

The benefits from this are firstly to producers and consumers, and then to wider society:

(a) creates a frame of reference for investors and companies;
(b) supports companies in their efforts to plan and finance their transition;
(c) protects against greenwashing practices;
(d) helps accelerate financing of those projects that are already sustainable and those needed in the transition.

This is not to suggest that following the stated policy will make everything simple or easy. As the CE transformation may bring negative impacts to some firms in some sectors, so it is important to keep a clear view of the goals, visions, and longer horizons. This "exploratory foresight" aims to contribute to that.

[31] European Commission, 2015.
[32] European Commission, 2015 and 2020.
[33] European Commission, 2023.

International cooperation: recommendations

- Each industrial sector and stakeholder community should investigate in detail the EU alignment agenda for all CE-related activities. This includes:
- (a) Sector and KPVC-based agendas, such as food products or packaging:
- (b) General cross-cutting conditions, such as on corporate ESG, financial instruments, product standards and trade agreements.

9.2. Forward agendas: national and sectoral cooperation

Each stakeholder group has a role in the CE transformation, to be explored and developed further. However, such roles are not simple to organize, and may not follow from any simple plan or policy.

The key question of how to enable and mobilize synergy and cooperation for transformation points to the concept of a *'collective circularity intelligence'*.[34] This is basically the capacity for mutual learning, communication, co-innovation and co-production, between:

- ***wider*** communities of stakeholders (across all sections of society)
- ***deeper*** layers of value (connecting economic with social, ecological, political values)
- ***further*** horizons of change (from short term problems to longer term transformation).

For ways to mobilize these general principles, there are practical recommendations in the sections below. Each of these can be helped and mobilized with a systematic approach to capacity-building for cooperation, as shown by other international experience.[35] As an important part of capacity-building for the Ukraine CE transformations, such 'resources, tools, spaces, and platforms' would include:

Capacity-building resources and spaces: recommendations

- ***Resources and tools:*** in each stage of the above, technical resources need to combine with human processes. Online resources should be set up for training and skills, information and guidance, project management and public surveys. On-site resources and tools are more effective for deliberation, collaborative thinking, community building, and creative demonstration.
- ***Spaces and platforms:*** The creative thinking of stakeholders generally works better in a 'forum', 'agora', symposium or similar. Physical spaces are important for the psychology and inter-personal exchange: online spaces can be more practical for multi-local information exchange. The combination of online information flow with on-site discussion may be the most effective.

[34] Ravetz, 2020.

[35] SITRA, 2020

Some valuable comments on these roles and opportunities came out in the first and second survey (Survey A and Survey B of this project). Here for example, are comments on the crucial question of industrial cooperation (further comments are shown in the Annex Table A.4):

Participant feedback on industrial cooperation
*(Source: Foresight Survey. A report)***:**

Question 1:
What circular business models (e.g., leasing, sharing, take-back) are applicable to the industry?

- To a greater extent, joint use and concession have proven themselves in the world of practice. But it is possible to develop and implement a new synthetic tool based on benchmarking analysis of positive world practice.
- Sharing, cooperation, outsourcing with transparent reporting.
- Repair and restoration; modularity and adaptability; production of products from biodegradable or renewable materials; partnerships with suppliers and consumers to optimize supply chains.

Question 2:
How can industries engage with each other and policymakers to create an enabling environment for circular initiatives?

- Based on associations, platforms, and social agreements.
- B2B partnership with further coverage of the benefits received. Organization of joint activities to bring together a common denominator for policy-making at the State level, taking into account the opinion of the private sector.
- Industrial companies can collaborate with research institutions and universities to develop new technologies and solutions aimed at the circular economy. The Government can support such initiatives through grants, tax breaks, and other financial incentives.
- Development and implementation of standards for the circular economy that would promote interaction between different industries and ensure their compatibility. The authorities can decide on the implementation of such standards.
- Industries can collaborate to share resources, such as recycled materials, water resources, and energy. Governments can contribute to this by regulating and stimulating industrial symbiosis.
- Different industries can collaborate to effectively manage waste, recycle, and reuse materials. The Government can support such initiatives through legislation and financial instruments.

9.3. Recommendations for KPVCs

Combining the various points in the KPVC chapters above, this section shows a summary of practical recommendations. In each of the selected KPVCs, an overview is shown for horizons 1–3, followed by a summary table of actions for each system / stakeholder type. The tables are colour coded for visibility, in the same scheme as the

KPVC chapters (‘constructions’ in pink, food products in green, electronics in purple, plastics in yellow, ‘wastes’ in brown).

The tables show recommendations for each of the three horizons; however, these overlap and inter-connect in the following ways:

- Horizon 1 (2030): Practical action programmes, to be set up as soon as possible
- Horizon 2 (2035): Strategic change objectives and plans for the medium term
- Horizon 3 (2050): Full transformation in the longer view: this provides goals and also guidance which may help with short term actions and medium term plans.

(The horizon 3 recommendations are shown in italics, as they would be revised and developed as that time period approaches.)

9.3.1. *‘Constructions’- recommendations*

These recommendations address both the production of new buildings: the repair / maintenance / upgrading of the existing stock: and the end of life materials management. The KPVC visions and pathways include a *‘Construction resources pathway’* for material management: a ‘*Construction innovation pathway’* for advanced technologies and materials: and a *‘Construction procurement pathway’* on the demand side.

Overview of horizons:

- Horizon 1 (2030): 10 million tons of waste: urgent need for reconstruction
- Horizon 1 (2035): Transition towards a material / energy efficient building stock in both physical and economic terms
- Horizon 1 (2050): Near-zero-waste construction and net-zero buildings in use, which integrates all social, technical, economic and environmental systems.

Table 5: 'Constructions' - recommendations

'CONSTRUCTIONS'	Horizon 1: 1-5 years	Horizon 2: 5-10 years	Horizon 3: 10-25 years
Business	Support creative micro-start-ups for circular design	Promote circular construction business models	*Fully align with EU trade and carbon mechanism: Promote eco-valuation financial models*
Governance	New building regulations and circular EPR schemes	Public procurement for circular materials and designs	*Set up public finance and loan schemes for reuse / recycling*
Social	Promote public CE awareness and workforce skills	Set up building owners / users programme for circularity	*New 'self declaration' standards for circularity*
Technology	New digitalization programme for design and production	Set up RTD hubs and labs for circular materials and design	*Complete full digitalization of building performance: Innovate for hi-performance bio-materials*
Industry	Resource management programme for post-war damage	Investigate advanced materials and components	*Set up industrial symbiosis for material interchange. Plan industrial transformation to zero-waste LCA*
Infrastructure	Coordinate energy and material efficiency systems	Set up logistics and storage for materials and components	*Develop infrastructure for 100% circular materials and components*

9.3.2. *Food products – recommendations*

These recommendations address the whole food products value chain: from primary inputs, to agriculture, to manufacturing and distribution, to consumption by households and catering, and then to post-consumer waste and surplus. The KPVC visions and pathways include a *'Food efficiency'* pathway focused on the food manufacture and distribution chain: a *'Food health'* pathway on the consumer and household side: and a *'Food livelihood'* pathway which addresses the role of food products in both rural and urban economies and communities.

Overview of horizons:

- Horizon 1 (2030): Post-war restoration, de-contamination of land and water: first steps in production / supply chain efficiency and circularity
- Horizon 2 (2035): Strategic steps for supply-side production innovation: and demand side shift in food markets, logistics, infrastructures
- Horizon 3 (2050): Transformation to near zero-waste and low-energy food production, processing, distribution and packaging: combined with shift to healthy affordable food livelihoods in households and communities.

Table 5: Food products - recommendations

FOOD PRODUCTS	Horizon 1: 1-5 years	Horizon 2: 5-10 years	Horizon 3: 10-25 years
Business	Support local food SMEs with circular business models	Promote new regenerative farming business models	*Align with EU on trade and farm / food health standards. Plan ahead for whole industry circular transformation*
Governance	Set farm regulations for low-input low-waste production	Public procurement for circularity in food supply and waste	*Make rural / green belt policies for circular livelihoods. Set land ownership rules and markets to support circularity*
Social	Realize rural-urban linkages for food and livelihood	Promote public awareness for food health and circularity	*Set up urban / local food as integral to circular food systems*
Technology	Promote digitalization of urban circular food systems	Set up innovation programmes for low-input low-waste food	*Tech innovation for full circularity of food system. Explore new food sources for global climate futures*
Industry	Reclaim war damaged land and water systems	Agri-food symbiosis for bio-waste, bio-methane etc.	*Promote advanced precision and regenerative farming. Mobilize new methods of local / urban food symbiosis*
Infrastructure	Set up local hubs for food re-distribution, storage, recycling	New logistic systems for bio-waste, composting and recovery	*Develop full circularity of agri-food waste and process materials*

9.3.3. *Electronics and I.C.T. – recommendations*

These recommendations address the whole value chain, from primary raw materials (many of them 'critical'), to manufacture and distribution. This is a globalized value chain driven by very rapid innovation and high levels of wastage. The KPVC visions and pathways include: a *'Technology for life'* pathway on the production and market supply side: a *'Device literacy'* pathway' on the consumer and demand side: and an *'Industry 5.0'* pathway, for the whole economy agenda of full digitalization.

Overview of horizons:

- Horizon 1 (2030): Service and leasing models: Extended producer responsibility: Collaborative circular standards and regulations
- Horizon 2 (2035): Circular literacy at home and workplace: Innovation for "Extended Product Life": Industrial cross-integration
- Horizon 3 (2050): Social welfare circular platforms: Digital supply chain integration: Reverse logistic hubs for re-use and recycling.

Table 6: Electronics and ICT recommendations

ELECTRONICS and ICT	**Horizon 1: 1-5 years**	**Horizon 2: 5-10 years**	**Horizon 3: 10-25 years**
Business	Support micro-start-ups for circular design, re-use, repair	Set up national industrial strategy and tech transfer	*EU / global trade alignment for circularity and critical materials*
Governance	Set up EPR and EPL regulations and incentives	Public procurement for circular devices and systems	*Set up Digitalize-Industry 5.0 - public / private partnership programme*
Social	Promote awareness and skills for circularity systems	Industry skills programme and logistics for re-use and repair	*Plan for 'Smart cities and communities' with embedded circularity*
Technology	Support design innovation for disassembly, repair	Mobilize national CE-digitalization hubs and platforms	*Strategic innovation for full economic digitalization*
Industry	Build capacity in tech and skills for industrial CE	Promote advanced materials and component manufact	*Develop industrial symbiosis for material inter-change*
Infrastructure	Set up infrastructure for e-waste recycling	Advanced Infra structure for critical materials security	*Develop logistics platforms for circular materials*

9.3.4. *Plastics and packaging – recommendations*

This combined value chain addresses two interconnected systems which are embedded in all other KPVCs. The visions and pathways include: *'What goes around comes around'* pathway, on the packaging industry supply side: a *'Packaging for life'* pathway, focused on the social / demand side of re-use and recycling: and a *'Plastics for life'* pathway, for the materials supply side, industrial symbiosis and innovation process.

Overview of horizons:

- Horizon 1 (2030): Service and leasing models: Extended producer responsibility: Collaborative circular standards and regulations
- Horizon 2 (2035): Circular literacy at home and workplace: Innovation for "Extended Product Life": Industrial cross-integration
- Horizon 3 (2050): Social welfare circular platforms: Digital supply chain integration: Reverse logistic hubs for re-use and recycling

Table 7: Plastics and packaging - recommendations

PLASTICS and PACKAGING	**Horizon 1: 1-5 years**	**Horizon 2: 5-10 years**	**Horizon 3: 10-25 years**
Business	Set up extended producer responsibility regime	Create supply/demand value system for recyclable packaging	*Develop fully circular social / environment investment programme*
Governance	EPR and EPL fiscal and regulatory incentives	Set common standards and regulations for recyclability	*Strategic partnerships in circular procurement*
Social	Promote circular home/work education and socio-eco enterprise	Circular platforms for socially recyclable packaging containers	*Promote household transformation to near zero waste*
Technology	Subsidize plastic recycling material innovations	Set up RTD hubs for circular plastic materials and design -	*Aim for fully circular 'plastics-Industry 5.0' innovation*
Industry	Promote eco-design for recycling of suitable plastic	Advanced materials and component manufacturing	*Set up industrial symbiosis for material exchange / joint processing*
Infrastructure	Set up reverse logistics hubs for reuse or recycling	Advanced recycling kiosks for building and industrial materials	*Set up digitalized logistics for full circular plastic management*

9.3.5. *'Wastes' – recommendations*

This addresses a wide variety of inter-connected systems, which are embedded in all KPVCs, and with potential for a rapid transition from 'wastes' towards 'resources' management. The KPVC visions and pathways include: a *'Waste not want not'* pathway, focused on household / municipal waste: a *'Resources for life'* pathway, working with bio-materials from food and other manufacturing: and a *'Symbiosis for growth'* pathway, covering all kinds of industry with potential for materials exchange, enabled by full digitalization.

Overview of horizons:

- Horizon 1 (2030): Post-war reconstruction and the start of circular materials management: set up initial innovation systems for key sectors and supply chains;
- Horizon 2 (2035): Mobilize strategic industrial change in all material-based sectors: investment and modernization in waste-management facilities;
- Horizon 3 (2050): Full transformation from 'waste management' to 'resource management', with to near-zero-waste industrial production, near full circularity of all waste / resource flows on supply and demand sides.

Table 8: 'Wastes' - recommendations

'WASTES'	**Horizon 1: 1-5 years**	**Horizon 2: 5-10 years**	**Horizon 3: 10-25 years**
Business	Create sector-institution wide networks, forums, associations	Promote circular socio-environment investment models	*Full alignment with EU / global trade and carbon mechanisms*
Governance	Develop legal framework for government - business interaction	Set up procurement systems for circular products	*Public finance and loan incentives for reuse / recycling*
Social	Create social / local waste infrastructure	Set up public awareness programmes for full circularity	*Promote public 'self declaration' of full circularity*
Technology	Promote innovation for extended product life	Full digitalization of product design and manufacture	*Aim for fully digital logistics for CE resource management*
Industry	Set up incentives and ecosystems for creative SMEs	Establish strategic partnerships on industrial waste and special wastes.	*Industrial symbiosis systems for material inter-change*
Infrastructure	Coordinate and integrate waste / energy / resource programmes	Mobilize joint investment for CE infrastructure	*Develop infrastructure for 100% resource circularity*

9.4. Recommendations: key systems, stakeholders and institutions

All key stakeholders and institutions in Ukraine have a part to play in the CE transformation process. This overview of recommendations is based on all results from the panel discussions and survey responses.

Again, these recommendations apply to the three horizons, which overlap and interconnect in the following ways:

- Horizon 1 (2030): Practical action programmes, to be set up as soon as possible
- Horizon 2 (2035): Strategic change objectives and plans for the medium term
- Horizon 3 (2050): Full transformation in the longer view: this provides goals and guidance for the short term actions and medium term plans.

9.4.1. *Business and finance*

This includes finance options: start-up, joint venture, collaterals: and investment options such as green / carbon markets, and regional banking. In more detail the various market options need to be explored for CE potential, as trading platforms, aggregators, securitization etc. Meanwhile the market / product innovation pathways are crucial, with bridges, advance options, service agreements. On a practical level the industrial community can develop a range of logistics options, with hubs, platforms, zones, and networks, at different levels from local to national.

Recommendations

- Major businesses should set up strategic planning / transformation programmes, looking ahead at their 'value proposition', innovation systems, productivity and markets in a CE-focused economy of the near future.
- Specific CE models such as EPL and EPR, can be investigated and built into strategic product / service development programmes.
- Finance also should set up strategic planning / transformation programmes, for CE-focused start-up, joint venture, collaterals: with investment options in green / carbon markets.
- Financial-government partnerships can be set up for green / regional banking; finance mechanisms in trading platforms, aggregators, securitization products etc.
- Develop CE-focused innovation finance programmes, i.e. bridges, advance options, service agreements, infrastructure / logistics solutions for hubs, platforms, networks.
- Set up integrated value-chain industrial forums, networks or hubs, for the coordination of material / resource flows across sectoral boundaries.

9.4.2. *Policy and governance*

This area includes regulation and legal process: strategic planning and coordination: fiscal policy and combinations of tax, levy, subsidy. Then follow areas of market policy: investment and market support, public-private partnerships: forums, exchanges, sector clubs and networks. There is an interface with innovation policy: advance commitments, joint ventures, technology transfer. This then extends to general industrial sector policy: quotas, tariffs, franchise: public procurement policy with bulk discount, strategic purchase: and general support and capacity-building, via skills, awareness, firm support programmes and agencies.

Recommendations

- Set up CE-focused strategic planning and coordination mechanisms, via a pilot CE agency / hub / forum, or similar alternative format. This should be set up to combine a ministerial / departmental mandate, with open partnership / community building structure. Through this, develop:
- (a) strategic programme of regulation and legal structures, fiscal policy with tax, levy, subsidy: and market policy of investment, market support;
- (b) public-private partnerships, collaborative agreements, with the main aim of pilot development, for advance strategic procurement commitments;
- (c) capacity-building: programmes for labour skills, consumer awareness, firm support programmes and agencies;
- (d) sectoral specific policies for resource flows, resource intensity, via quotas, tariffs, franchise operations, trade agreements;
- (e) public-private procurement policy: bulk discount, strategic purchase, innovation prototyping, underwriting of product / service demonstrations.
- Regional and local administrations can apply the above at various levels, depending on powers and resources.

9.4.3. *Social and community*

This broad transformation sees the potential for society to move beyond the narrow materialist role of ‘consumers’, towards a more integrated and inclusive role as citizens, based on full participation and co-production.

Recommendations

- General CE public awareness and capacity-building, particularly in consumer facing retail and catering sectors, and in community-facing education and health organizations.

- Set up support / enabling programmes for social / ecological enterprises at community level, for re-use / recycling, surplus sharing via food banks, furniture banks etc.
- Explore the potential for local livelihoods, on the United Nations 'Leave No One Behind' principle, in value chains such as food products, or CE-activities in re-use, repair, remanufacturing, etc.

9.4.4. *Design and technology*

Innovation policy development includes SME support and capacity-building: fiscal incentives / tax break / subsidy: strategic advance procurement: innovation finance and joint ventures: and strategic STI grants and investment. They also include international collaborations and exchange: researcher support and mobility; and further more detailed technology foresight and road-mapping.

The over-arching technology agenda is a strategic program for full digitalization of all sectors of production and consumption, and its application via product RFID, digital passports, and SMAC based management systems.[36]

(Note: the current report does not cover specific technologies: this important question should be a priority for future phases of the foresight programme.)

Recommendations

- Develop strategic CE innovation systems with multi-helix partnerships: national scale with EU and international linkages.
- Develop systems for advanced strategic partnerships, innovation procurement commitment, joint ventures, innovation finance, technology transfer.
- Set up incentives for SME support and CE capacity-building in start-ups and social enterprises.
- Coordinate with the Government on CE fiscal incentives / tax breaks / subsidy regimes.
- Set up mission-oriented programmes with strategic STI grants, incentives, joint investment.
- Promote international collaborations and exchange, with researcher support and mobility schemes.
- Follow up on technology foresight and road-mapping programmes in key sectors and value chains.

[36] Burmaoglu et al 2021

- Set up a strategic program for full digitalization of all sectors of production and consumption.

9.4.5. *Industry and environment*

This includes production lines, materials handling, environmental assessment and management). Looking beyond current programmes for resource efficiency and cleaner production, this is about very practical changes in industrial processes, materials management and logistics.

Recommendations

- Accelerate current programme development in resource efficiency and cleaner production.
- Investigate on sector basis and KPVC basis, the potential for industrial symbiosis / resource exchange schemes.
- Promote cross-sector innovation for new products and new processes, which enhance overall circularity in the combinations of materials / energy / water / land etc.

9.4.6. *Urban and infrastructure*

This includes material logistics, local economies, spaces, land and buildings. The transformation starts with spaces and buildings at the local level, and over time creates capacity for 'reverse logistics', exchange hubs and storage zones, all the way to urban / regional scale facilities.

Recommendations

- Promote retrofit, renovation and new design in housing and commercial buildings, to enable localized re-use, segregation, repair and recycling.
- Ensure that reverse logistic systems in every sector / KPVC are fully financed, resourced and operational
- Strategic programme for conversion of waste management facilities towards 'resource management' and recirculation facilities.
- Set up larger scale hubs, exchange, and storage zones, coupled with advanced resource management and reprocessing facilities.

9.5. Forward agendas: from foresight to strategic capacity-building

This 'exploratory foresight' has created so far an outline of challenges and opportunities, as a starting point. Success then depends on the follow up.

For the CE-transformation, the foresight approach can continue to guide a continuous programme of learning, co-innovation, and co-production, between all stakeholders. Here the

longer-term horizon 3 agenda (10-25 years), can help to guide practical activities in the shorter horizon 1 (1-5 years), and horizon 2 (5-10 years).

In practical terms this approach can guide the ideas for a CE-Ukraine agency or centre, as suggested in the UNIDO Industrial Diagnostic Report.[37] This or similar ventures would benefit from a systematic 'wider-deeper-further' approach:

Recommendations on strategic capacity-building

(a) Set up a ***wider*** 'CE ecosystem' of actors / stakeholders, for co-innovation and co-production. For Ukraine this suggests a connected set of networks, skills sharing, technology transfer and knowledge exchange.

(b) Build capacity for a ***deeper*** 'CE value-system' which integrates technologies and markets with other social, cultural and ecological values. For Ukraine, follow-on programmes can explore the potential of cooperative enterprise, regenerative farming, civil society renewal, and active citizenship of many kinds.

(c) Explore the ***further*** 'CE transformation' which connects short-term problems with longer term horizon 3 agendas. For Ukraine, this may start with the most 'mission critical' and urgent issues, such as:

- How to increase Ukraine's energy security in times of disruption and shortage?
- How to ensure a viable future for Ukrainian farming in times of water crisis?
- How to turn the problem of Ukraine's waste, into new business opportunity?

9.6. Next steps

The next steps are for Ukraine to decide. However, this project can make a practical recommendation, for the national stakeholder community of public, private, civil, academic organizations.

The overall recommendation is to follow through this project, with a programme of structured discussions, to explore in more detail the opportunities and pathways ahead.

This programme can work with the KPVCs, key sectors and technologies: and also generally across the Government and wider governance.

Ukraine in its current context and uncertainties has great challenges and great potential. The 'potential opportunity' perhaps looks beyond the agenda of 'catching up' with the EU and others – it looks to Ukraine as forerunner in the circular economy transformations ahead.

[37] UNIDO, 2023.

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Project working papers:

These interim reports are provided for further detail and background, and are available on http://www.recpc.org/circular-economy/

UNIDO (2023a). Exploratory Strategic Foresight for Circular Economy in Ukraine: SCOPING REPORT;
UNIDO (2023b). Exploratory Strategic Foresight for Circular Economy in Ukraine: SURVEY (A) RESULTS;
UNIDO (2023c). Exploratory Strategic Foresight for Circular Economy in Ukraine: VISIONS REPORT;
UNIDO (2024a). Exploratory Strategic Foresight for Circular Economy in Ukraine: FUTURE SCENARIOS REPORT;
UNIDO (2024b). Exploratory Strategic Foresight for Circular Economy in Ukraine: SURVEY (B) RESULTS;
UNIDO (2024c). Exploratory Strategic Foresight for Circular Economy in Ukraine: PATHWAYS REPORT.

PART III

Annex

Summary tables

Project background and resources

SUMMARY TABLES

A.1. KPVC scope and definition

The following table summarizes the United Nations official classification of 'products' and 'sectors' for each of the selected KPVCs, as a starting point for more detailed analysis.[38]

Table A.1: Classification of KPVCs in terms of products and sectors

CE-Ukraine Foresight terms	EU action plan terms	CPC term	CPC digit	ISIC term and digits
'Constructions'	Construction and buildings	Constructions	53, 54	'Construction' – F: and 'Real estate activities – L
Food products	Food, water and nutrients	Agriculture, forestry and fishery products	0 (01-04)	Agriculture, forestry and fishing – A:
"		Food products and beverages	2 (21-24)	Manufacturing - C (10-11: food products and beverages): and 'Accommodation and food service activities' - I
Electronics and ICT	Electronics and ICT	Office, accounting and computing machinery	45 (451, 452)	Manufacturing -C (26: computer, electronic and optical products): 'Information and communication' – J
Plastics and packaging	Plastics + separate item - Packaging	Rubber and plastics products	36	Manufacturing – C (20- chemicals and chemical products: 22- rubber and plastics products)
"		Packaging products of plastics	369	'Transporting and storage' – H
'Wastes'		Wastes or scraps	39	'sewerage; waste management and remediation activities' – E37-39

[38] United Nations, (2008): United Nations, (2015)

A.2. KPVC transformations over 3 horizons

This table is a summary of the '3-horizons' results for each of the KPVCs.

Table A.2: Key product value chains transformations over 3 horizons

	HORIZON 1	HORIZON 2	HORIZON 3
KPVCs	**'Recovery'**	**'Transition'**	**'Transformation'**
'Constructions'	10 million tons of waste: urgent need for reconstruction	Transition towards an energy efficient building stock in physical-economic terms	Zero-waste construction and net-zero buildings in use, which integrates all STEEPCUT[a] systems
Food products	Land cleaning and reclamation: reconstruction of agri-food industry and trade	Transition towards RE food production, CE bio-methane systems, reduce food waste and packaging	Zero-waste farming with low input / high precision, for local / organic food production and consumption
Electronics and ICT	Stabilization and consolidation of the electronics / IT sector	Transition to home-grown production and value-added, with CE recovery built in	Transformation to circular ICT production and consumption
Plastics and packaging	Initial clean-up of packaging systems and plastic waste streams	Transition to low-waste high circularity packaging, low impact plastics and recovery systems	Fully zero-waste packaging and reverse logistics, coordinated and bio-degradable plastics systems
'Wastes'	Cleaning up / recovery of local / regional waste management systems	Transition to improved recycling, recovery of common waste streams	Transformation to fully circular near-zero-waste economy

a 'socio-technical-economic-ecological-political-cultural-urban-territorial' (with many variations9

A.3. Stakeholder agendas

Each stakeholder group has a key role to play in the wider collaboration needed for the CE transformation. This table summarizes the consultation results from panel discussions and survey responses.

Table A.3: Stakeholder roles, challenges and opportunities

	KEY ROLES	CHALLENGES	OPPORTUNITIES
Government Ministries	As policymakers via regulation, tax / subsidy, procurement, infrastructure and resources.	Often disconnected from business, subject to short term politics.	New ways of partnership governance to achieve longer term goals.
Regional and local administrations	In CE practices at the local level, with SMEs, civil society	For example, lack of skills, resources, infrastructure.	Local CE procurement, and social innovation / social enterprise with households,

	organizations, landowners, and citizens.		communities and interest groups.
Higher education	In development of skills and qualifications.	The general disconnection from other stakeholders.	New ways of teaching and knowledge sharing.
Research / technology organizations	In underpinning CE research and innovation in many technologies and value chains: as enablers for a circular 'innovation ecosystem'.	The mainstream research and innovation system is geared to products and technologies rather than whole circles.	These may come from exploring such circles.
Industrial businesses	As primary producers and secondary manufacturing.	The most current business models are based on selling materials and products in a linear economy rather than circular flows.	In the shift towards circular integrated supply-demand value chains with service-based business models.
Service / advisory businesses	As enablers of the core CE principles, of extended product lifetimes and leasing models.	Individual firms may lack incentives to take on whole value chains.	New markets and propositions, ahead of the curve.
Financial institutions	As investors in the CE, for firms, product innovations, and infrastructures.	Private finance is generally short term; public investment may not respond.	From strategic public / private investment in whole circular systems and strategic supply chain partnerships.
Civil society organizations	In social innovation for partnership working, new 'eco-socio-enterprise' models for cooperatives, non-profits, local hubs, etc.	The general under-funding of civil society organizations/ non-governmental organizations.	In new forms of partnership governance.
Creatives and designers	Not only in new products, services and value chains but also in goals, visions, and cultural shifts which are essential.	Much of the design profession is focused on short-term novelty.	In new processes of social/ecological design with citizens, civil society organizations, enterprises, etc.

A.4. Participant feedback

The following two tables show a selection of the detailed comments from survey participants, on leading questions concerning:

- The feasibility of CE in Ukraine, by social and technical systems.
- Collaboration for the implementation of the CE policies in Ukraine

Table A.4: Feasibility of CE development in Ukraine: survey responses

	BARRIERS and CHALLENGES	OPPORTUNITIES and VISIONS
GENERAL COMMENTS	Lack of awareness and understanding; economic challenges; policy implementation challenges; infrastructure gaps; limited access to technology; resistance to change; global economic conditions; inadequate skills and expertise; limited awareness and understanding of the circular economy concept among businesses and the general public can hinder its adoption.	Shift from the traditional linear model of "take, make, dispose" to a more sustainable and regenerative approach. Several factors can act as enablers or barriers for this transition in Ukraine: government policies and regulations, public awareness and education, collaboration and partnerships, access to finance, technological innovation, waste management infrastructure. Harmonize current legislation with the world examples of that are most realistic for Ukraine (given the gap of 30-40 years). Develop incentives for the transition to a circular economy that can accelerate the transition. Tomorrow, develop the principles of HDD (manufacturer's responsibility) and clearly define the deadline for its implementation (2-3 years maximum).
BUSINESS-FINANCE	Concentration of private interests in the relevant economic sectors, their influence on public policy (including through officials), as well as the lack of legislation on lobbying, low level of accountability (legal and social consequences) for cases of conflicts of interest (including non-obvious ones). Creating new ESG strategies. Obstacles: lack of sufficient funding for the implementation of circular economy measures.	The level of technological development, consumer awareness, the availability of infrastructure for recycling materials, waste legislation and incentives for companies to implement circular practices. Legislative and financial incentives for the use of secondary resources should be introduced. Especially in road construction and the production of building materials. Value proposition, benefits and benefits for businesses that integrate circular economy practices.

GOVERNANCE-POLICY		The impact of the legislation of developed countries. The openness of the markets of developed countries for products created within the framework of the requirements of the circular economy. Joint regulations, mutual control, accountability. Ukraine's membership in the EU and relevant requirements, directives, EU standards, etc. can help accelerate the transition to a circular economy.
SOCIAL-COMMUNITY	A shortage of skills and expertise in circular economy practices may slow down the transition, requiring investments in training and capacity-building. Acceptance for recycled products in the community. Lack of education of the population, including officials. Lack of management awareness and will. Lack of a sufficient number of specialists and eco-responsibility among citizens.	Integrating a course in educational institutions to increase the social responsibility of citizens. Teaching CE courses at schools and universities; providing support (including financial) to private entrepreneurs with CE components in their activities. Changing the ideology of society: sharing products and consuming services while maximizing service life. Acceptance for recycled products in the community. Lack of education of the population, including officials. Lack of management awareness and will.
DESIGN-TECHNOLOGY	Insufficient/lack of resources for implementation and development.	
ECO-INDUSTRY	Unwillingness to allocate funds, corruption, low environmental awareness, preference for profit over environmental protection. Interruption of production chains due to disintegration.	Resource efficiency, availability of funding and global sustainability initiatives are also important. Reducing the use of natural resources through the introduction of renewable energy (solar, wind).

Table A.5: Collaboration for CE policies in Ukraine: survey responses

	SPECIFIC and SECTORAL NOTES	GENERAL GOVERNANCE NOTES
BUSINESS-FINANCE	Cluster initiatives and collective integrated solutions, deregulation in the joint organization of production and derivative (service, auxiliary) processes. Simplification of licensing procedures (product certification, permits) with increased responsibility for violations (taking into account the negative consequences caused, rather than a formal approach, so that companies are not destroyed but supported in the right direction of development).	Adoption of legislative acts regarding the openness of markets for products created within the framework of CE. Multi-actor collaboration along single industry value added chains. In addition to the EU, cooperate with the countries of America (USA, Canada, etc.), Asia (Japan, Republic of Korea, etc.), Australia, etc. which also have experience and relevant developments in the field of circular economy.
GOVERNANCE-POLICY		Cooperation between the EU and the Government of Ukraine with the aim of bringing the country's legislation closer to European legislation. Cooperation with government agencies is needed to develop and implement regulatory requirements for

		the use of secondary resources instead of primary resources. Ukraine needs collaborations with European countries experienced in CE and can support Ukraine with a suitable strategy for the future.
SOCIAL-COMMUNITY	First of all, communicating information to the majority of Ukrainian citizens about this in a format that is understandable to people! Provide internships to gain experience and new skills, learn best practices, exchange experts, and provide advice.	Cooperation between the Government, business and civil society. It is important to establish an effective exchange of information and resources between these sectors to develop and implement circular economy strategies. International partnerships, associations/consortia of businesses and organizations. Knowledge sharing, coordination between waste producers and processors-think about it at the design stage, study trips, twinning projects, investment projects.
DESIGN-TECHNOLOGY	Unified technological standards, Best Available Technologies, Digital standards EU Data Spaces, etc. Assistance in obtaining modern technologies in the field of circular economy and their practical implementation.	Cooperation between universities and institutes with the inclusion of Ukrainian scientists and research teams in European programmes with project financing and acquaintance of specialists with practices in the field of CE, conducting training programmes.
ENVIRONMENT-INDUSTRY		Inclusion of Ukrainian companies/companies located on the territory of Ukraine in material supply/processing chains within the CE concept.
URBAN and INFRASTRUCTURE	already pilots/projects in the field of achieving CE that can be implemented in Ukraine: reusable collateral packaging, textile reuse, etc. Organization of waste sorting and recycling, support in implementing energy management measures.	Cooperation of municipalities within the framework of programmes to demonstrate achievements in the field of CE in the most promising sectors for Ukraine (processing of solid household waste, use of waste energy flows, use of alternative and renewable energy resources). Cooperation between recycling companies to develop products, materials and services based on the existing recycling library.

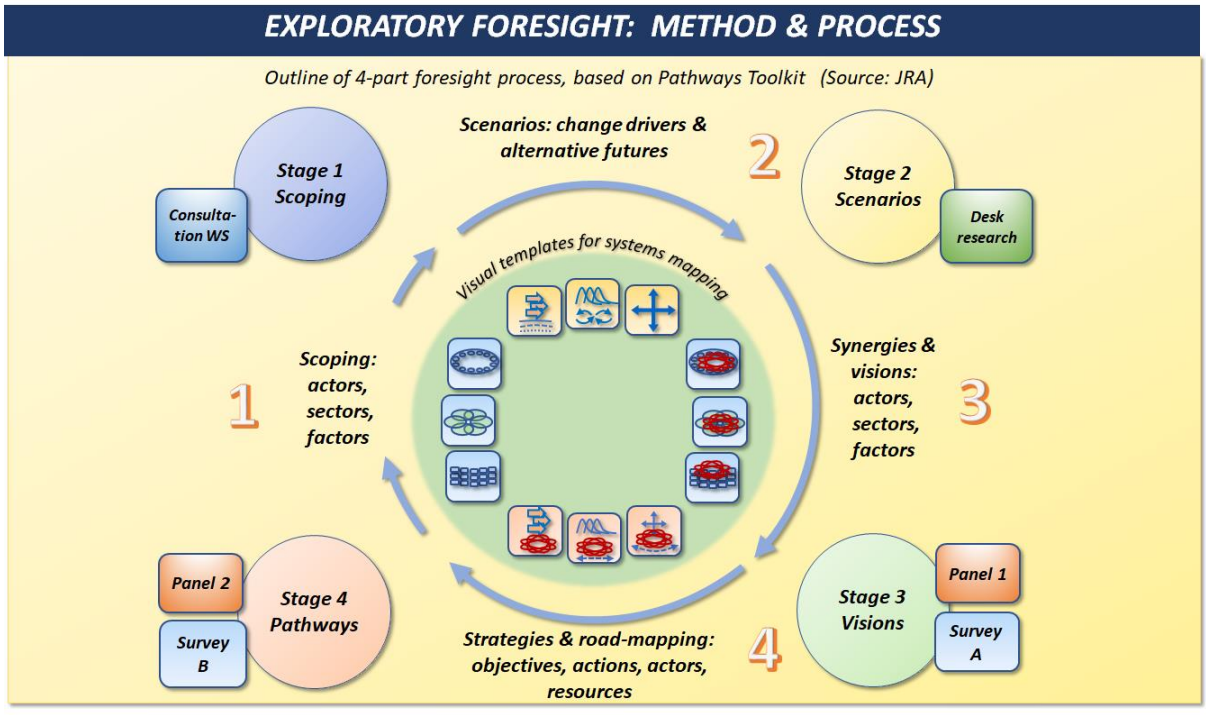
PROJECT BACKGROUND AND RESOURCES

For a complex project such as the development of a national circular economy (CE), a process involving many stakeholders and experts needs to draw on a shared framework and pathways.

For this purpose, and in view of the current situation in Ukraine, this 'exploratory foresight exercise' has been launched to highlight the most important systemic elements of a functioning circular economy for a horizon of 2025-2040. The use of practical foresight methods with selected priority regions, economic sectors and value chains will help to mobilize the main systemic drivers of the future for the circular economy in the country.

A.5. Project methods

The foresight methods and tools follow the UNIDO experience in promoting, developing and applying the foresight concept to countries' and regions' policy- and strategy-making through guidelines, training and advisory services in a series of technical assistance programmes. The present project was enriched by considering the synergistic approach and its Pathways Toolkit developed by Joe Ravetz (Ravetz, 2020: Ravetz & Miles 2016) and the Systemic Foresight Methodology (SFM) by Ozcan Saritas (Saritas, 2013 and 2020; Miles et al., 2016). This has been drawn up as a practical way of working with foresight challenges, which look beyond direct 'problem-fixing' towards 'transformative innovation'.



The present project follows a 4-stage work methodology, including (1) scoping and analysis of the challenges and opportunities of CE development in Ukraine; (2) future scenarios elaboration; (3) future visions; (4) pathway-mapping the transformation for development of CE. The process is composed by evolving desk research, surveys, interactive workshops and

panels of experts. Each of these 4 main stages includes a set of templates for visual thinking, system mapping, and collaborative thinking. This is proposed in response to the 'multiplicity' of the CE agenda and its many socio-technical systems, which include business, governance, community, technology, industrial ecology, and infrastructure.

A.6. Project context

EU4Environment programme

The "European Union for Environment" (EU4Environment – Green Economy) action plan helps the Eastern Partnership countries preserve their natural capital and increase people's environmental well-being, by supporting environment-related action, demonstrating and unlocking opportunities for greener growth, and setting mechanisms to better manage environmental risks and impacts.

The programme is funded by the European Union and implemented by five Partner organizations – OECD, UNECE, UNEP, UNIDO, and the World Bank – over the 2019-2024 period, with a budget of EUR 20 million.

For more information, please visit: www.eu4environment.org.

Green Recovery of Ukraine programme

This programme's objective is to provide technical support to the Government of Ukraine in conceptualizing and operationalizing a strategic approach towards green industrial reconstruction and development through the coherent, evidence-based and result-oriented green recovery programme for inclusive and sustainable industrial development, which is to be led and owned by the Government.

Through the project, UNIDO will work to support the establishment of an enabling environment for the green recovery of the country's industry, job creation, resilience building, sustained economic growth and the strengthening of the productivity and competitiveness of priority industrial sectors with high growth potential and investment attractiveness. The efforts on promoting circular economy and strengthening of recycling capacities of the country will focus on capacity-building among civil servants and municipalities' employees as well as contributing to the strategy on CE implementation in Ukraine as a whole, and specific supply chains or regions in particular.