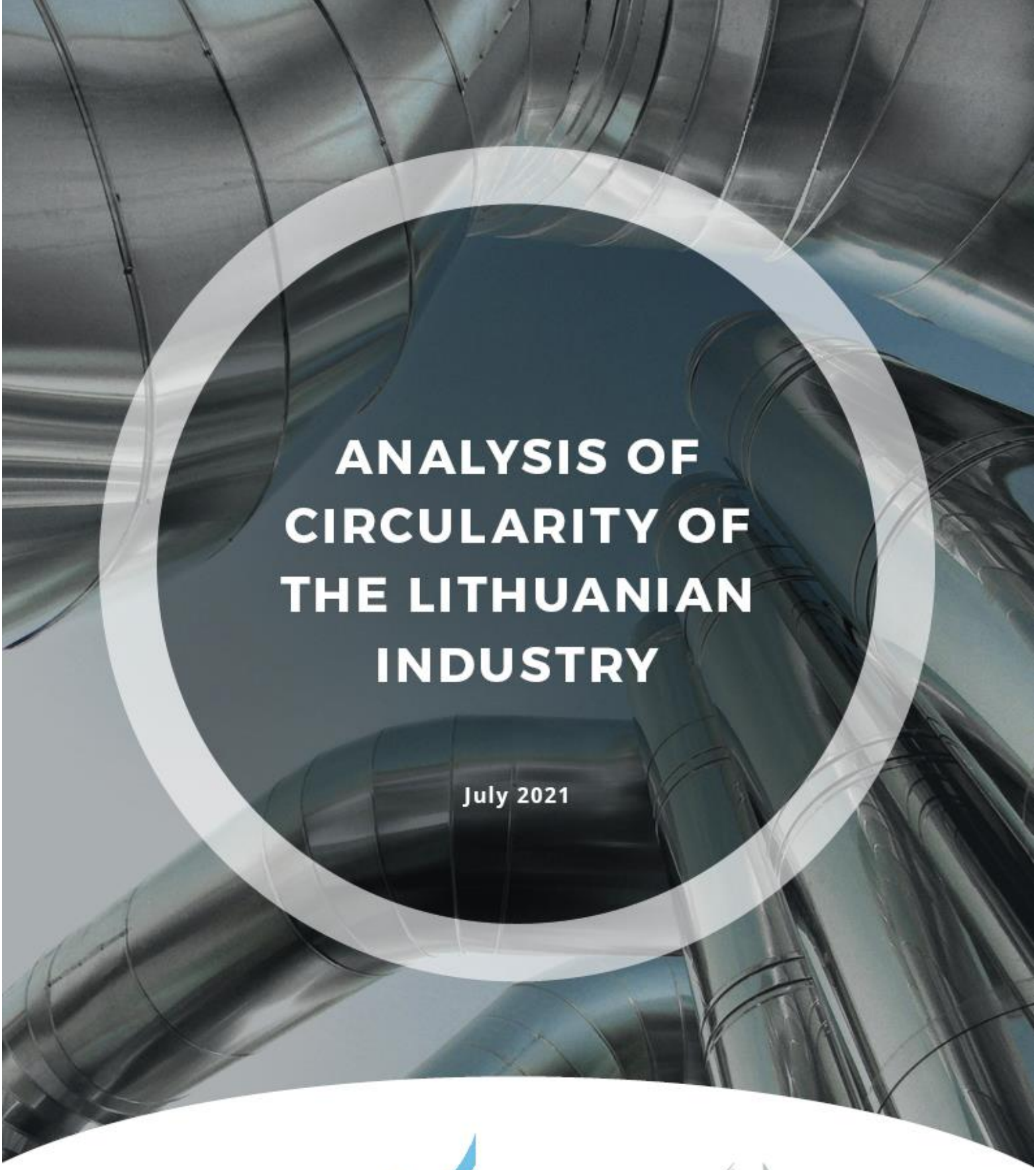

ANALYSIS OF CIRCULARITY OF THE LITHUANIAN INDUSTRY

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CIRCLE ECONOMY

MINISTRY OF THE ECONOMY AND INNOVATION

mita

European Commission

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Abstract

Lithuania's economy is fast-growing, largely linear and characterised by a strong trade profile and specialisation in industrial processes. The nation is only 3.3% circular—leaving a large Circularity Gap of over 96%—and its population consumes 30 tonnes per capita, per year. In light of this metric and consumption footprint, this study evaluates circular economy opportunities for one of Lithuania's most prominent impact areas, industry, honing in on strategies in the food, construction, textiles, plastic and furniture value chains. Industrial transitions are complex processes that necessitate strong policy and increased collaboration between stakeholders. Therefore, this study examines the policy landscape across the EU and in Lithuania; followed by a metabolism analysis of the country, revealing its state of circularity and consumption footprint. The study dives into an opportunity analysis of the aforementioned sectors, highlighting 15 opportunities for Lithuania to increase its circularity. The analysis explores the feasibility, scalability and impact of each, noting the available—and necessary—industrial, technological and innovation infrastructure. All opportunities were found to have significant impact across environmental, economic and social spheres. The report concludes on a specific set of policy recommendations, which stress the relevance of production-based measures in transforming Lithuania's industrial action in line with EU objectives for circularity.

List of Acronyms and Abbreviations

AM	Ministry of Environment of the Republic of Lithuania
CE	circular economy
CEAP	Circular Economy Action Plan
CO2	carbon dioxide
C&DW	construction and demolition waste
DMC	Domestic Material Consumption
DMI	Domestic Material Input
EC	European Commission
EEA	European Environment Agency
EGD	European Green Deal
EIMIN	Ministry of Economy and Innovation of the Republic of Lithuania
ENMIN	Ministry of Energy of the Republic of Lithuania
EPA	Lithuanian Environmental Protection Agency
EPR	Extended Producer Responsibility
ESF	European Social Fund
EU	European Union
GDP	gross domestic product
GHG	greenhouse gases
GPAIS	Lithuanian waste accounting system
GPP	Green Public Procurement
GVA	gross value added
HPWP	High-performance workplace practices
ICT	information and communication technology
KETs	Key Enabling Technologies
KTU	Kaunas University of Technology
LCA	Life Cycle Assessment
LIC	Lithuanian Innovation Centre
MBT	mechanical biological treatment
MCV	Mass-Carbon-Value
MFA	Material Flow Analysis
MITA	Lithuanian Agency for Science, Innovation and Technology of
MSW	municipal solid waste
NACE	Statistical classification of economic activities in the European Community
OECD	Organisation for Economic Co-operation and Development
OSP	Lithuanian Official Statistics Portal
PBL	Dutch Environmental Assessment Agency
PET	polyethylene terephthalate
PIANOo	Dutch Public Procurement Expertise Centre

R&D	research and development
R&I	research and innovation
RMC	Raw Material Consumption
RME	Raw Material Equivalents
RMC	Raw Material Input
RTC	Regional Tripartite Council
S3	Smart Specialisation Strategy
SDGs	Sustainable Development Goals
SER	Economic and Social Council of the Netherlands
SMEs	Small and medium-sized enterprises
STRATA	Government Strategic Analysis Center of Lithuania
VET	vocational education training
VGTU	Vilnius Gediminas Technical University
VRM	Ministry of the Interior of the Republic of Lithuania
WEEE	Waste electrical and electronic equipment
WISE	Work Integration Social Enterprise
ZUM	Ministry of Agriculture of the Republic of Lithuania

Glossary: Terms and Definitions

Domestic Material Consumption (DMC) expresses overall impacts related to the consumption of goods and services generated within an economy. It considers only the direct material footprint and excludes materials used abroad to create products and services consumed domestically. [Source]

Greenhouse gases (GHG) constitute a group of gases contributing to global warming and climate change. The term covers seven greenhouse gases divided into two categories. Converting them to **carbon dioxide equivalents** (CO_2e) makes it possible to compare them and to determine their individual and total contributions to global warming. [Source]

Global Warming Potential (GWP) is the heat absorbed by any greenhouse gas in the atmosphere, as a multiple of the heat that would be absorbed by the same mass of carbon dioxide (CO_2). GWP is 1 for CO_2. For other gases it depends on the gas and the time frame. [Source]

Mass-Carbon-Value (MCV) nexus provides a dynamic conceptual framework for identifying and evaluating key variables. Three different lenses—Mass, Carbon, and Value—are used to scrutinise the combined inputs and outputs from these steps and understand fully how these activities contribute to meeting our societal needs. It shows the development for material extraction (Mass), greenhouse gas emissions (Carbon), and financial value creation (Value). A systemic MCV approach can be employed to illustrate how four resource groups (Non-metallic Minerals, Metal Ores, Fossil Fuels and Biomass) satisfy the seven societal needs. [Source]

Material footprint describes the demand quantification for material extractions (Non-metallic Minerals, Metal Ores, Fossil Fuels and Biomass) triggered by consumption and investment by households, the public sector and businesses. [Source]

Material flows present the amounts of materials in physical weight that are available to an economy. These material flows comprise the extraction of materials inside the economy and the physical imports and exports (*id est,* the mass weight of goods imported or exported). Air and water are generally excluded. [Source]

Material metabolism essentially builds on the schematic material footprint diagram by linking how four resource groups (Non-metallic Minerals, Metal Ores, Fossil Fuels and Biomass) satisfy the seven key societal needs and wants (Housing, Nutrition, Mobility, Communications, Services, Consumables and Healthcare).

Raw material consumption footprint expresses overall material impacts related to the consumption of goods and services, including trade. This is based on raw material equivalents and therefore includes materials wasted and lost abroad. [Source]

Raw Material Equivalents (RME) is a virtual unit that measures how much material was extracted from the environment, domestic or abroad, to produce the product for final use. Especially for finished and semi-finished products, imports and exports in RME are much higher than their corresponding physical weight. For example, traded goods are converted into their RME to obtain a more comprehensive picture on the 'material footprints'; the amounts of raw materials required to provide the respective traded goods. [Source]

Raw Material Consumption (RMC) represents the domestic final use of products in RME. RMC, also called 'material footprint', captures the total amount of raw materials required to produce the goods used by the economy. In other words, the material extraction necessary to enable the final use of products. [Source]

Secondary materials are waste materials collected for recycling and recycled materials that can be used in manufacturing processes, either instead of or alongside 'virgin' raw materials. [Source]

Sector is a term to describe any collective of economic actors involved in creating, delivering and capturing value to consumers tied to their respective economic activity. We apply different levels of aggregation here—aligned with classifications as used in Exiobase V3. These relate closely to the European sector classification framework NACE Rev. 2.

Executive summary

The what, why and how of circularity in Lithuanian industry. Lithuania has a fast-growing and largely linear economy: fairly dependent on imports and export-oriented, with a thriving trade profile and a specialisation in industrial processes. As countries across the EU take steps to formalise circular economy strategies and targets and Lithuania looks to redirect its industrial action in line with this goal, the nation is well poised to learn from best practices and apply circular strategies. To this end, this study evaluated circular economy opportunities for the industrial transition, concluding on practical opportunities in the food, construction, textiles, plastic and furniture value chains. Yet such industrial transitions are complex, multi-faceted, multi-level processes: a circular industrial transition will require a holistic, systemic approach backed by strong policy, collaboration and cooperation among stakeholders. This report has evaluated the policy landscape, conducted a metabolism analysis and assessed where the strongest opportunities for change lie, concluding on a set of specific policy recommendations.

Lithuania's economy is 3.3% circular—leaving a Circularity Gap of over 96%. The country is frequently cited as a recycling champion in Europe, yet the nation's high consumption footprint—30 tonnes per capita per year—stems from its dependence on large-footprint imports and use of fossil resources, and is nearly twice as large as the Netherlands'. Lithuania's footprint is fed annually by 8.9 million tonnes of additions to stocks such as buildings, 8.3 million tonnes of fossil fuels combusted and 2.2 million tonnes of materials dispersed through product use. The country is also characterised by a large biomass footprint—much of which cannot be conclusively classified as circular.

Going circular: how Lithuania's key industrial players can leverage circular strategies in closing its Circularity Gap. The results of the metabolism analysis highlight 15 practical opportunities for Lithuania to circularise its industry across five sectors. Strategies—which range from bolstering the use of recycled materials, valorising 'waste' and designing for reusability, to stimulating collaboration between stakeholders—were assessed for feasibility and scalability. The context of Lithuania's available industrial and technological infrastructure, innovation infrastructure and policy landscape were also considered. The impact of applying circular strategies is holistic, with demonstrated environmental, social and economic benefits.

Food and Agriculture. This industry giant accounts for 22% of Lithuania's annual material consumption, 18% of its GHG emissions and 11% of its gross value added (GVA). Opportunities—which range from shifting to a bioeconomy, scaling the use of mono-material packaging for food products and standardising date labelling—can bring plentiful benefits: allowing the sale of food beyond the

'best before' date, for example could annually divert 50,000 tonnes of food from landfill,[1] while shifting to mono-material packaging for food products could cut production costs for manufacturers by 58%.[2]

Construction. The construction sector is responsible for 12% of annual material consumption, 8% of GHG emissions and 14% of GVA in Lithuania—and represents a significant waste stream of 798,000 tonnes. While much of this waste is currently reused, low-value applications—like granulate or backfilling—are most prevalent. Opportunities that target the country's huge stockpile of phosphogypsum, extend building lifetimes and repurpose existing buildings to prevent demolition represent impact hotspots. Annual waste management costs could be reduced by up to €13 million by shifting to more circular fertiliser production processes,[3] limiting phosphogypsum production, while doubling buildings' current lifetimes of around 60 years could cut environmental impacts by 44%.[4]

Textiles. Textiles maintain a relatively low footprint, making up 2.4% of annual material consumption, 2.2% of GHG emissions, and 1.8% of GVA. Yet the sector cannot be overlooked: approximately 7,200 tonnes of the textile waste collected in Lithuania is not cycled, with 80% of the discarded items going to landfill or incineration annually. Opportunities focused on scaling textile recycling and reuse and extending garment lifetimes offer a chance for significant growth: currently, the value lost due to waste textiles amounts to €20.5 million a year in Lithuania alone. Environmental benefits are also plentiful, as bolstering the use of secondary fibres in apparel manufacturing can cut energy use by 53%, water use by 99% and chemical use by 88%.[5]

Plastics and Packaging. Plastics and packaging currently accounts for 6% of annual material consumption, 4% of GHG emissions and 3% of GVA. Opportunities focused on increasing recyclability, making better use of the available mechanical recycling capacity for plastics and collaborating with stakeholders across industries to boost the demand for secondary plastic could deliver marked environmental and social benefits. Increasing plastic recycling, for example, sparks the creation of jobs in collection, sorting, and recycling: processing 10,000 tonnes of waste at landfill creates one full-time equivalent (FTE), compared to 11 FTEs when the same waste is taken to a sorting centre.[6]

Furniture. The furniture sector's current impact is relatively small, responsible for just 1.5% of annual material consumption, 1.2% of GHG emissions and 5.2% of GVA; and what's more, boasts impressive recovery (95%) and recycling (70%) rates for the wood waste it produces. Nonetheless, negative

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[1] Based on EU averages, this assumes 10% of the 502,957 tonnes of food estimated above to be wasted in Lithuania is due to confusing or ineffective date labelling practices. Source: European Commission. (2018). *Market study on date marking and other information provided on food labels and food waste prevention*. Retrieved from: Publications Office of the EU website

[2] Grassl, P. (2018, October). Monomaterial packaging: A solution to the global plastics crisis. *OndrugDelivery Magazine*. Retrieved from: ONdrugDelivery Magazine website

[3] Based on current Lithuanian annual phosphogypsum production of 2.6 million tonnes.

[4] Marsh, R. (2016). Building lifespan: effect on the environmental impact of building components in a Danish perspective. doi:10.1080/17452007.2016.1205471

[5] Ellen MacArthur Foundation. (2020). Fashion: Two circular investment opportunities towards a low-carbon and prosperous future. Retrieved from: Ellen MacArthur Foundation website

[6] Idem.

impacts can be reduced by boosting the use of secondary materials for fills and fabrics, redesigning furniture with simplicity and disassembly in mind, and utilising digital design systems to cut input materials. Reusing one piece of furniture, for example, can save up to two tonnes of GHG emissions,[7] while applying circular strategies to Lithuania's furniture industry offers a €490 million opportunity to increase annual total GVA.

An economy full of potential: kickstarting Lithuania's circular journey. The Lithuanian economy has tangible potential for circularity: the proposed opportunities will serve to reduce GHG emissions, save material resources, boost job creation and cut costs across industries. But how can the nation turn this possibility into reality? Recommendations address the complexity of the task at hand, and emphasise the crucial role of a fit-for-purpose regulatory framework, as well as leveraging fiscal incentives, technology and innovation to increase resource efficiency and strengthen competitiveness. Measures should predominantly be production-based: encouraging strengthened collaboration and industrial symbiosis and overhauling green taxation systems, for example, coupled with the creation of a stronger market pull for circular goods through Green Public Procurement and the expansion of Extended Producer Responsibility schemes. Overarching societal trends towards circularity, from raising awareness and engagement to fostering collaboration across the spheres of governance, culture and market design, can lead the way in facilitating industry-specific action.

[7] European Environmental Bureau (EEB). (2017). Circular opportunities in the furniture sector. Retrieved from: EEB Website

1. Introduction

The transition to a circular economy is fundamentally a paradigm shift, a transformation of the current economic model. It is, therefore, a multidimensional, highly complex, and policy-driven process that requires a contextualised analysis of Lithuania's economic, political, regulatory and cultural spheres to support an effective industrial transition to circularity.

Lithuania at a glance

Spanning 65,300 square kilometres, Lithuania is a country in the Baltic region of Europe hosting a population of 2,794,184.[8] Most of Lithuania's population live in cities, with ~67.4% of the population living in urban or intermediate areas at the beginning of 2020, and although the rural population shows a declining trend over the last decade, the country remains amongst the 10 countries in the EU with the highest share of rural population.[9]

The Gross Domestic Product (GDP) per capita in Lithuania in Purchasing Power Standards (PPS) in 2019 represented 84% of the EU-27 average, demonstrating a steady growth in the economy from 2011 when it was around 67% of the EU average.[10] As of January 2021, despite Lithuania's economy shrinking slightly in 2020 (~2%) due to the economic and social crisis derived from the COVID-19 pandemic, GDP is still projected to grow on average by around 3% in 2021 and 2022.[11]

Key economic activities

The country's largest value-added economic activities come from trade, transport and services (28.2%), followed by industrial activities excluding construction (18.7%), and manufacturing (16.1%).[12] Small and medium-sized enterprises (SMEs) play a significant role in Lithuania's economy, representing 69.4% of the economy's value added compared to the EU average of 56.4%.[13] Further, the public administration share of the economy, 4th in Gross Value Added (GVA) (13.3%), has a significant potential to drive forward multiple CE strategies, through instruments such as Green Public Procurement (GPP) amongst others.

Economic structure (% GVA per economic activity, 2019)

- Wholesale and retail trade, transport, accommodation and food service activities 28.2
- Industry (except construction) 18.7

[8] European Commission. (2020). Lithuania: Population: Demographic Situation, Languages and Religions. Retrieved from: EC website (Last accessed on 03 February 2021)

[9] Official Statistics Portal of Lithuania. (2020). Population of Lithuania: Urban and rural residents. Retrieved from: OSP website

[10] Eurostat (n.d.). GDP per capita in PPS. Retrieved from: Eurostat (Last accessed on 03 February 2021)

[11] OECD. (2020). Economic Forecast Summary, December 2020. Retrieved from: OECD website

[12] Eurostat. (n.d.). Gross value added and income by industry breakdowns. Retrieved from: Eurostat (Last accessed on 19 May 2021)

[13] European Commission. (2019). SBA Lithuania factsheet. Retrieved from: EC website

- Manufacturing 16.1
- Public administration, defence, education, human health and social work activities 13.3
- Construction 6.6
- Professional, scientific and technical activities; administrative and support service activities 6.5
- Real estate activities 5.8
- Information and communication 3.4
- Agriculture, forestry & fishing 3.2
- Financial and insurance activities 2.1
- Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies 2.1

Trade profile and industrial structure

Lithuania is a relevant trading nation considering its geographic and demographic size, with a global market share and trade profile growing in complexity during the last twenty years.[14] In 2019, the country presented a trade surplus slightly above €200 million, with top exports by product category being refined petroleum, furniture, rolled tobacco, wheat, and polyacetals. Main export markets are concentrated in the geographical proximity of the country: Russia, Latvia, Poland, and Germany. Ukraine and Saudi Arabia are also fast-growing export markets with which Lithuania has relatively high trade surpluses. Conversely, in 2019, Lithuania's top imports were crude petroleum, cars, packaged medicaments, refined petroleum, and electricity, mostly imported from Poland, Russia, Germany, and Latvia.

In addition to the country's trade profile, considering the structure and orientation of the Lithuanian industry is also crucial. Firstly, the Lithuanian industry is mainly export-oriented, with the share of exports of goods and services representing 77.5% of the country's GDP in 2019, a big part of which is destined to non-EU countries like Russia.[15] Secondly, there is a heavy reliance on intermediate, low value-added goods, particularly in manufacturing. However, there is also a high-tech niche market that specialises in the production of complex photonic products such as laser technologies. Thirdly, scale is a relevant topic. The vast majority of Lithuanian industrial companies are SMEs; making them agile and flexible but also hindering their competitiveness on the global stage. Fourthly, ownership in crucial sectors, such as energy, automotive, and textile, is primarily foreign-controlled, resulting in a lack of independence to implement change in industrial processes, particularly in manufacturing. Lastly, to focus on markets that will recognise the value of the green commitments and practices, there is also a need for a strategic restructuring of the Lithuanian economy and reorientation of trade flows towards integration into European value chains.

[14] Observatory of Economic Complexity. (n.d.). Lithuania. Retrieved from: OEC website

[15] World Bank (WB). (2021). Exports of goods and services (% of GDP). Retrieved from: WB Data website

Lithuania's demography

Lithuania has an increasingly ageing and declining population. As of 2019, around one in every five (19.8%) Lithuanians were 65 years old and over; slightly below but on par with the EU-27 average of 20.3% and the Baltic EU countries average of 20.1%. There are also high levels of unemployment in this age group, with older workers representing 40% of unemployed people in Lithuania in 2016.[16] However, employment for the 60-64 age group has been increasing in recent years.[17] Since its independence in 1990, which brought amongst other things increased options for staying abroad, Lithuania has suffered from *'brain drain'*, as it struggled to retain and attract highly-skilled students and workers at the same time as presenting low rates of immigration, as compared to other Baltic countries.[18] Between 2008 and 2017, there was a 44% decline in students staying in the country. The demographic dynamics have had a negative impact on consumption patterns and the economy as a whole.[19] In 2019, however, Lithuania saw a 9% reduction in emigration and positive net migration, resulting in the first increase in the country's population in 28 years.[20,21] Further, a quota for non-European Union (EU) migrant workers is planned to be introduced in 2021 to strengthen the regulation of the labour market situation and control of worker inflows.[22] However, the impact that the COVID-19 pandemic will have on migration flows is yet unclear. Outside of the immediate impacts of the COVID-19 pandemic, there is growing inequality between urban and rural areas, where the gap, in terms of GDP per capita, has been steadily rising since the beginning of the decade[23] and educational attainment is lower in rural areas.[24]

Total population: 2.794 million
Composition by age: 0-14: 15.1% | 15-64: 65.2% | +65: 19.7%[25]
Employed persons (aged 20-64): 78.2%
Living in: 67.4% urban (or intermediate) areas | 33.6% rural areas
Average people per household: 2.17[26]

[16] OECD. (2018). OECD Economic Surveys: Lithuania. Retrieved from: OECD website
[17] Mosta. (2019). Human Capital in Lithuania 2019. Retrieved from: STRATA website
[18] Czerniak, A. (ed) et al. (2019). No time to waste: unlocking the circular potential of the Baltic Sea Region. Retrieved from: Interreg website
[19] Martinaitis, Z. et al. (2020). Higher Education for Smart Specialisation: The case of Lithuania. Retrieved from: EC website
[20] Official Statistics Portal of Lithuania. (n.d.). Demographic trends. Retrieved from: OSP website (Last accessed 14 January 2020)
[21] Idem.
[22] Ministry of the Interior of Lithuania. (2019). Government approves VRM proposal for quota setting for entry of foreigners. Retrieved from: VRM website
[23] OECD. (2020). OECD Economic Surveys: Lithuania. Retrieved from: OECD website
[24] Idem.
[25] OECD. (n.d.). Population. Retrieved from: OECD website (Last accessed on 03 February 2021)
[26] Official Statistics Portal of Lithuania. (2020). Income and living conditions of the population of Lithuania. Retrieved from: OSP website (Last accessed on 03 February 2021)

2. Assessing the current state of Lithuania's policy landscape for a circular industrial transition

2.1 Policy analysis

2.1a Introduction

To ensure that we stay within planetary ecological boundaries, human demand for environmental resources and services has to decrease, and, thus, industrial production needs to become circular. However, industrial transitions are complex, multi-faceted and multi-level processes that transcend a nominal transformation of industrial production processes. The shift to a circular industry ultimately requires a holistic and systemic approach since the transition to a circular economy (CE) model fundamentally changes the functioning of entire societies. For example, technological innovations play a key role in ecodesign but so do consumer behaviour, national regulations and new business models. Hence, the assessment presented in this section not only strictly addresses industrial policy (including innovation and education policies) but also other critical areas related to governance, organisational thinking, business models, culture, society, and financing methods.

Within this context, policy is a key lever for the advancement of the CE. The aim of this section is, thus, to assess Lithuania's current policy landscape in regards to CE to support the country's circular industrial transition. To this end, key EU strategies and policies are also assessed, as they directly impact Lithuanian industry and influence its transformation. Furthermore, for the purpose of providing context and best practices from other EU member states, Estonia, the Czech Republic and the Netherlands are used as comparative case studies.

The analysis for the section (2.1) is based on a literature review and content analysis of international publications and circular economy-related policies and initiatives from the EU, Lithuania, and the three comparison countries. Semi-structured interviews and consultations with local experts have also been carried out to validate findings and add further insights to the section.

The section is divided into two main parts. Firstly, an overview of the Lithuanian and EU policy landscape, the current institutional setup in Lithuania and an analysis of skills and innovation in regards to CE is presented (2.1b). Thereafter, Circle Economy's National Policy Instrument and Key Elements frameworks are used to structure the assessment of Lithuania's CE policy landscape and provide best practices from the comparative countries (2.1c). The second part focuses on identifying the different barriers and enablers for the CE within Lithuania and the other three comparison countries (2.1d). It aims to draw up similarities and differences and provide a more contextualised picture of the driving factors and obstacles regarding the advancement of circularity.

2.1b Assessing Lithuania's circular economy policy landscape

While a national CE strategy is yet to be produced, circular economy principles and key enablers are already embedded in strategic government plans and are being tackled via different policy instruments. Considerable progress is already being made on resource and energy efficiency as well as waste management. However, the fragmentation of these policies and the governmental institutions and actors involved, the lack of effectiveness in their implementation so far, as well as the lack of an National CE Action Plan and Strategy, suggest that further coordination of efforts, integration with other policy areas like skills and employment, and a wider number of circular sectoral strategies would strengthen Lithuania's progress towards a new sustainable and competitive economic and industrial model. At the same time, the potential to streamline current and future policies into a coherent and coordinated overarching CE Strategy and Action Plan to advance Lithuania's resource and energy efficiency and security, will also be directly influenced by the EU policy landscape.

KEY TAKEAWAYS:

- There are several areas of a CE model that are currently being tackled by a diverse set of strategic documents and action plans already. Although the overarching strategic document or guidance for the circular economy is yet to be put in place, several studies on the possibilities of a circular economy in Lithuania have already been initiated across different ministries. Further coordination and monitoring of these initiatives is needed to ensure their effectiveness.
- Current policies have a strong focus on energy and resource efficiency as well as waste management.
- Areas of the circular economy that could be further strengthened by policies are linked to designing for circularity, prioritising alternative and service business models, developing industrial symbiosis partnerships across sectors, as well as incorporating digital technology and innovation to the transition.
- Strong governance is key. Firm political commitment, an effective institutional set-up, and proactive stakeholder engagement are essential enablers for the transition to kick off and develop.
- Taxation, Green Public Procurement (GPP), Extended Producer Responsibility (EPR) schemes, as well as the proper implementation of internationally recognised mandatory and voluntary standards are core instruments to promote resource efficiency, circularity and sustainability.
- Targeted support and educational programmes and policies that foster an enabling sociocultural environment and provide favourable conditions are effective methods to support, enhance and guide the transition.

This section presents the assessment of the existing CE policy landscape in Lithuania. It starts by introducing the most relevant CE policy landscape at the European Union level, the impact of which is

analysed further in the final part of the section, enablers and Barriers. Afterwards, an overview of the Lithuanian policies and strategies relevant to the CE and the national institutional framework is presented. Thereafter, Circle Economy's Key Elements and National Policy Instrument Frameworks are used to structure the assessment of the Lithuanian CE policy landscape and provide existing best practices from the three selected comparison countries.

European Union Circular Economy Policy Landscape

At the EU level, a series of legislative and non-legislative packages, ranging from sectoral strategies and programmes to financing instruments constitute the policy landscape related to CE. For example, the Circular Economy Action Plans (CEAPs), GPP policy, and the recent amendments to EU Waste Directives and Regulations further support, guide and drive the establishment of circularity at the national level. Hereunder, an overview is presented of the most crucial EU CE-related policies which directly and indirectly influence the transition of Lithuania's industry to circularity.

Roadmap to a Resource Efficient Europe.[27] In 2011, for the first time it provided a framework on how the EU's economy can transform to become sustainable by 2050. By analysing key resources from a life-cycle and value-chain perspective and proposing ways to reduce resource use and pressures on the environment, it set out a structural and strategic vision to design and implement necessary policy, industrial and technological change. It also outlined policy action areas, highlighted cross-cutting priority themes, and proposed actions on highly impactful identified sectors (such as nutrition, housing and mobility).

EU Circular Economy Action Plan, 2015.[28] It intended to cover the entire economic cycle — from production to consumption, repair and remanufacturing, to waste management and secondary raw materials. It is also linked to the fulfilment of the Sustainable Development Goals (SDGs). The focus is on material flows from five priority areas: Plastics, Food waste, Critical raw materials, Construction and demolition, Biomass and bio-based products. This CEAP also included a revision of EU waste legislation[29], mainly: the Waste Framework Directive[30]; Landfill Directive; Packaging Directive[31]; and Directives on end-of-life vehicles, batteries and accumulators, and waste electrical and electronic equipment (WEEE).[32] The emphasis is placed on cross-cutting areas: 1) innovation, investment, and other horizontal measures, and 2) progress monitoring.

[27] European Commission. (2011). Roadmap to a Resource Efficient Europe. Retrieved from: EUR-Lex website

[28] European Commission. (2015). Closing the loop - An EU action plan for the Circular Economy. Retrieved from: EUR-Lex website

[29] Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste. Retrieved from: EUR-Lex website

[30] Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste. Retrieved from: EUR-Lex website

[31] Directive (EU) 2018/852 of the European Parliament and of the Council of 30 May 2018 amending Directive 94/62/EC on packaging and packaging waste. Retrieved from: EUR-Lex website

[32] European Parliament. (2018). Circular economy package. Four legislative proposals on waste. Retrieved from: European Parliament website

Updated Bioeconomy Strategy.[33] Presented in 2018, follows up on the first European Bioeconomy strategy[34] from 2012. The updated version sets the overarching strategic direction across the EU to ensure food and nutrition security, manage natural resources sustainably, reduce dependence on local and foreign non-renewable resources, and mitigate and adapt to climate change. It highlights the potential of integrating the bioeconomy with sustainable and renewable industrial processes as well as the role of innovation and cooperation in doing so. To this end, the Strategy highlights the following three core action lines: 1) strengthen and scale up bio-based sectors, unlock investments and markets, 2) deploy local bioeconomies rapidly across Europe, and (3) understand the ecological boundaries of the bioeconomy.

European Green Deal (EGD).[35] It is the EU's roadmap and strategic framework to achieve climate neutrality and decouple economic growth from resource use by becoming sustainable by 2050. The circular economy, through the CEAP 2020 together with "Mobilising industry for a clean and circular economy" as one of the policy areas, is one of the central pillars of this overarching framework.

Circular Economy Action Plan, 2020.[36] It is the updated and expanded but still initial and broad policy framework for advancing CE in the EU. The core goal is to reduce waste and promote sustainability by making products fit for a climate-neutral, resource-efficient and circular economy. Priority is given to addressing product groups identified in the key selected sectors and value chains: Electronics and Information and Communication Technologies (ICT), Batteries and vehicles, Packaging, Plastics, Textiles, Construction and buildings, Food, water and nutrients, and Furniture and High impact intermediary materials (steel, cement, and chemicals). Throughout 2021 the Commission will begin publishing tailored sector-by-sector strategies; for example, the upcoming EU strategy for sustainable textiles.[37]

Farm to Fork Strategy.[38] Part of the EGD and strongly linked to meeting SDG 12.3 on global food loss and waste, it sets the strategic guidelines to transition the EU's food system along three lines: 1) making sustainability and circularity its cornerstone, 2) reducing waste and its environmental and climate footprint, and 3) ensuring food and nutrition security by building its robustness and resilience. In regards to food waste, the European Commission proposes the introduction by end 2023 of legally binding food waste reduction targets for Member States to take action. The Strategy also proposes the revision of food labels and date marking, by end 2022, to reduce waste among consumers and retailers and the implementation of other policies and instruments to advance sustainability across the whole food system.

[33] European Commission. (2018). Updated Bioeconomy Strategy. Retrieved from: Publications Office of the EU website
[34] European Commission. (2012). Innovating for Sustainable Growth: A Bioeconomy for Europe. Retrieved from: EC website
[35] European Commission. (2019). The European Green Deal. Retrieved from: EC website
[36] European Commission. (2020). Circular Economy Action Plan. Retrieved from: EC website
[37] European Commission. (2021). EU strategy for sustainable textiles. Retrieved from: EC website
[38] European Commission. (2020). Farm to Fork Strategy. Retrieved from: EC website

European Climate Law.[39] In March 2020, the European Commission proposed the creation of an EU Climate Law that would set the long-term strategic, cross-cutting and irreversible direction to achieving climate-neutrality by 2050. Despite still being in the development stage, the proposal included EU-wide legally binding objectives as well as the creation of a monitoring progress system for tracking the implementation of national energy and climate plans.

European Industrial Strategy.[40] It was presented in 2020 to transform the European industry by making it more sustainable and digital while enhancing its competitiveness on the global scene. A key component was also to build European Industrial Ecosystems by bringing together key stakeholders such as academia and market players, both large and small. The Strategy highlights the leading role that the EU's industry must play in the green transition (reducing its carbon and material footprint), and the importance of embedding circularity across the entire economy. Similarly, it underscores the relevance of shifting away from linear towards circular production processes to ensure not only the sustainability of Europe's industry but also its international competitiveness and job creation capacity.

In May 2021, the Commission announced an update[41] to address the new economic situation in the aftermath of the COVID-19 pandemic, focusing on strengthening the single market, accelerating the twin green and digital transitions, and supporting employment and European SMEs.

SME Strategy.[42] The strategy aims to support European SMEs in becoming fit-for-purpose in the 21st century. The central pillar aims to support SMEs in capacity-building and the transition to sustainability and digitalisation by, among other things, updating the Skills and training programmes, expanding innovation infrastructure and supporting collaboration. Another pillar is to ease the regulatory burden they face, such as administrative barriers, which disproportionately affects SMEs, and improving their access to the single market, particularly for the manufacturing sector. The last major pillar concerns improving financing as a key condition for implementing the first two pillars.

EU Strategy for plastics in a Circular economy.[43] It focuses on four pillars: the Revision of Waste Plastics Bag, the Directive, the Ecodesign Working Plan, and the Marine Strategy Framework Directive. It aims to achieve the following four goals: 1) improve the economics and quality of plastics recycling; 2) drive investments and innovation towards circular solutions; 3) curb plastic waste and littering; and 4) harness global action to tackle plastic pollution. The Strategy also expands Extended Producer Responsibility (EPR) schemes and eco-modulation fees to different types of plastic, particularly packaging, aiming to improve efficiency and promote eco-design.

[39] European Commission. (2020). European Climate Law. Retrieved from: EC website

[40] European Commission. (2020). A New Industrial Strategy for Europe. Retrieved from: EC website

[41] European Commission. (2021). Updating the 2020 New Industrial Strategy: Building a stronger Single Market for Europe's recovery. Retrieved from: EC website

[42] European Commission. (2020). An SME Strategy for a sustainable and digital Europe. Retrieved from: EC website

[43] European Commission. (2018). A European Strategy for Plastics in a Circular Economy. Retrieved from: EUR-Lex website

EU Chemicals Strategy for Sustainability.[44] It presents a long-term strategic vision for the European chemicals industry. It aims to step up innovation for the green transition of the chemical industry and its value chains, enhance its resilience, and make safety and sustainability their cornerstone.
Green Public Procurement (GPP).[45] It is a voluntary yet vital instrument to promote resource efficiency across the EU's economy. To this end, the European Commission has encouraged national governments to make their public procurement more sustainable by drawing up non-legally binding National Action Plans (NAPs). It has also developed GPP criteria for several sectors such as wastewater infrastructure, furniture and electricity, and published the *Buying green!* Handbook[46] and Circular Procurement Guide[47].
Eco-design and Energy Labelling Regulation[48] and the **EU Ecolabel**[49] are also relevant informational instruments enhancing circularity. By establishing a common regulatory framework and harmonising EU-wide standards, ecolabelling promotes energy efficiency, reduces waste and pollution, and increases resource productivity in the production of a wide range of product groups. It also supports GPP and stimulates consumer demand by providing well-defined, baseline criteria for 'green' products and purchases.
Eco-Management and Audit Scheme (EMAS).[50] This is a management tool that, since 1995, allows European companies to measure, monitor, and enhance their environmental performance.
EU taxonomy for sustainable activities.[51] It is a tool for transformation that clearly defines criteria for environmentally-sustainable economic activities. It aims to guide financial and economic reforms and channel investments to projects and activities that support the implementation of the EGD. CE is one of the six objectives to which an investment or economic activity has to contribute to in order to qualify as 'green' and 'sustainable'. Additionally, manufacturers are obliged to disclose to end-investors the impact on sustainability of their activities and investments.

Lithuania Circular Economy Policy Landscape

[44] European Commission. (2020). Chemicals Strategy for Sustainability. Retrieved from: EC website
[45] European Commission. (n.d.). Green Public Procurement. Retrieved from: EC website
[46] European Commission. (2016). Buying green! A handbook on green public procurement. Retrieved from: EC website
[47] European Commission. (2017). Public procurement for a circular economy. Retrieved from: EC website
[48] European Commission. (n.d.). Ecodesign and Energy Labelling. Retrieved from: EC website
[49] European Commission. (n.d.). EU Ecolabel. Retrieved from: EC website
[50] European Commission. (n.d.). Eco-Management and Audit Scheme. Retrieved from: EC website
[51] European Commission. (2020). Sustainable finance taxonomy - Regulation (EU) 2020/852. Retrieved from: EC website

An non-exhaustive overview of the policies and national strategies reviewed for the Lithuanian policy landscape is presented below, in order to provide a clear picture of how these policies relate to the circular economy, by hindering or supporting Lithuania's industrial transition.

National strategies and roadmaps
National Sustainable Development Strategy.[52] Set in 2009, and adopted in 2011, it has aimed to achieve, by 2020, the average of EU15 countries of 2003 of economic and social development indicators as well as to the efficiency in consumption of resources. Additionally, the strategy aims for Lithuania to stay within the EU's permissible limits with respect to environmental pollution indicators. The rational consumption of natural resources is a key priority within the strategy and it highlights both the decoupling of resource use from economic growth, as well as the importance of local and renewable resources, two keys to a circular economic model.
National Environmental Protection Strategy.[53] Approved in 2015, it followed the strategic directions previously covered by the 1996 State Environmental Protection Strategy: 1) sustainable use of natural resources and waste management; 2) improvement of environment quality; 3) maintenance of ecosystem stability; and 4) mitigation of climate change are key principles of the strategy. It intends to enable them by eco-efficiency, pollution prevention and responsibility measures, ensuring the integration of environmental protection policy, the use of best available technologies, implementing precautionary and substitutive measures, as well as by strengthening partnerships, democratic decision-making processes and public participation. For its implementation, it is further supported by monitoring laws such as the **Environmental Impact Assessment of the Proposed Economic Activity, the Environmental Protection State Control and the Law on Environmental Monitoring**, all of them last amended in 2020.
Smart Specialisation Strategy (S3).[54] It was first established for the period of 2014-2020, obliged by the new Multiannual Financial Framework (2014-2020) approach for all EU members to formulate R&I Strategies for Smart Specialization (RIS3) which guide further R&D and innovation system development. The overall objective is to concentrate resources in a limited number of priority areas, where public intervention could boost knowledge-driven growth and competitiveness. The six initially defined priorities have been: 1) energy and sustainable environment; 2) health and biotechnologies; 3) agro innovation and food technologies; 4) new production processes, materials and technologies; 5) transport, logistics and ICT; 6) inclusive and creative society. After an interim evaluation in 2019 it was concluded that the implementation is slow; although the 2014-2020 period has doubled the investments in R&I infrastructures compared to the previous period. The proposals for a new period of S3 (2021-2027) are currently being revised, which suggests that the new focus may be more strategically focused on key priorities 1) health and biotechnologies; 2)

[52] SDG Toolkit. (n.d.) National Strategy for Sustainable Development Lithuania. Retrieved from: SDG toolkit website

[53] Ministry of Environment of Lithuania. (2016). National environmental protection strategy. Retrieved from: AM website

[54] European Commission. (2020). Higher Education for Smart Specialisation: The case of Lithuania. Retrieved from: EC website

new production processes, materials and technologies; 3) ICT.
National Climate Change Management Policy Strategy.[55] Approved in 2012, it sets the vision that Lithuania by 2050 will have ensured the adaptation of the domestic economy to environmental changes caused by climate change and climate change mitigation through the reduction of greenhouse gas emission; developed a competitive low-carbon economy; implemented eco-innovative technology; and achieved energy generation and consumption efficiency and the use of renewable energy sources in all sectors of the domestic economy. The key sectors in scope for this strategy are energy, industry, transport, agriculture, households, environmental protection and rational use of national resources (forestry, ecosystems, biodiversity, landscape), spatial planning and regional policy, health care, research and development (R&D), education and provision of information to the public, and international cooperation. The strategy has been encouraged by the previously approved **Law on Financial Instruments for Climate Change Management** in 2009; and supported in its implementation by the **Climate Change Management Group** led by the Ministry of Energy.
Lithuanian Industry Digitisation Roadmap.[56] Established for the period 2020-2030 and led by the Ministry of the Economy and Innovation, it is considered the first milestone for the new Smart Specialization Strategy and serves as the basis for the Science, Technology and Innovation Strategy and for the National Progress Programme. In its 2030 vision, it expects Lithuania to become a regional industry leader for digitisation (amongst Latvia, Estonia, Belarus and North Poland). Based on the four pillars of knowledge, people, infrastructure and environment, it points out opportunities for end users in the following value chains to implement digital and new technologies: 1) machinery and equipment; 2) timber and furniture; 3) electrotechnics; 4) plastics; and 5) food. The roadmap was based on the draft developed as the main output of the project "Developing a roadmap for the industry digitisation initiative in Lithuania" (SRSS/C2018/002) funded by the European Union via the Structural Reform Support Programme. The "Pramonė 4.0" (Industry 4.0) platform has also been established as an outcome of this roadmap with the aim to create an active dialogue between industry, research, education and governmental institutions.
National Skills Strategy.[57] Initiated in 2020 as a collaboration between Lithuania and the Organization for Economic Co-operation and Development (OECD), the main objective is to identify opportunities and policy recommendations for strengthening Lithuania's skills performance. Following an overall assessment, the key priorities identified are: 1) Equipping young people with skills for work and life; 2) Raising adults' and enterprises' participation in learning 3) Using people's skills more effectively in workplaces; and 4) Strengthening the governance of skills policies. The

[55] Seimas. (2012). Resolution approving the national strategy for climate change management policy. Retrieved from: Seimas website

[56] Lithuanian Innovation Centre. (2020). Lithuanian Industry Digitisation Roadmap 2020-2030. REVISED DRAFT updated within a framework of the "Follow up" project. Retrieved from: EIMIN website

[57] STRATA. (2020). National skills strategy. Retrieved from: STRATA website

strategy will also include two horizontal themes: developing key competencies, including in non-formal learning and reducing skills imbalances in the economy. The final National Skills Strategy should be presented to the general public during Q2 2021.
National programmes, plans and laws
Law on Environmental Pollution Tax.[58] First adopted in 1999 and last amended 2020, it determines taxpayers as polluters and declares who must pay the taxes for pollutants discharged into the atmosphere from mobile and stationary sources. The main taxpayers for air pollution are usually large enterprises such as oil refineries, cement production, chemical industry, furniture and others. Tax reliefs are available and applied to natural and legal persons who reduce the amount of pollutants discharged, as well as to, for instance, new car fleets. So far taxes have been considered too small, so in order to control the situation more effectively, taxes and fines for environmental pollution have been set to increase from 2021 onwards. Further, energy products that have a direct impact on the volumes used of fossil fuels are taxed under the **Law on Excise Duty** since 2001 (last amended 2019), and it constitutes the largest part of environmental tax revenues. Lastly, considering Lithuania's car fleet is 15 years old on average and mostly diesel fuelled, the **Law on Registration tax for motor vehicles,** implemented since July 2020, introduced a tax based on the vehicles CO2 emissions and fuel used. This tax does not apply to electric vehicles.
The **Law on Waste Management** was adopted in 1998, and last amended in 2020. **Waste management rules**, approved in 1999 and last amended in 2018, introduces detailed requirements for waste collection, sorting, temporary storage, other waste management operations, as well as sets requirements for distributors of the products and the procedure of general waste accounting requirement. The **Waste Management Plan** was first set up for the period 2014-2020, with 2020 targets aimed at preparing for reuse and recycling half of the paper and cardboard, metal, plastic and glass waste generated. The Ministry of Environment has been preparing a 2021-2027 plan, based on an assessment of the current situation and identification of new waste prevention and collections schemes from other member states. Ten **regional waste management plans** are set up to support and meet the requirements of the National Waste Management Plan. Further, the **National Waste Prevention Programme (2014-2020)** aimed to provide an analysis of the current state of waste prevention, including identification of priority waste streams, objectives, and tasks and measures for their implementation.[59]
Targets on Recovery and (or) Recycling of Taxable Goods and Packaging Waste[60] were approved in 2006 and amended in 2017, for tyres; batteries and accumulators; filters; glass, plastic, composite, metal, paper and cardboard, wood and other packaging materials. Although these targets have

[58] Seimas. (2020). Law of the Republic of Lithuania on Environmental Pollution Tax No. Act of Amendment VIII-1183. Retrieved from: Seimas website

[59] European Environmental Agency (EEA). (2016). Overview of National Waste Prevention Programmes: Lithuania. Retrieved from: EEA website

[60] Seimas. (n.d.). Law on Pollution Tax. Retrieved from: Seimas website

been in many cases reached, the recovery into low-value applications and export for recovery abroad is still common practice.
Bans on landfilling[61] biodegradable waste from gardens, parks and greeneries and accumulators and batteries have been active since 2003. Untreated waste disposal has been banned as well since 2013, although it does not remain entirely clear what the definition for 'properly treated' entails. Coupled with a landfill tax since 2016, the policies are substantially encouraging incineration as the preferred waste disposal form.
Programme for Renovation (Modernisation). Launched in 2005, it has helped improve energy efficiency in multi-apartment dwellings. 92 buildings were already renovated by mid 2010 accounting for nearly 25% of the budget. It is also maintaining employment in the relevant construction sub-sectors – by mid 2010, 443 companies had been involved in the works creating or securing 24 000 jobs, also on a regional level.[62] In the period from 2005-2018, 74% of the expected multi-apartment houses had been renovated.[63]
Eco-design requirements for placing on the market and putting into service small solid fuel, for **energy-related products** and application of its implementation measures were approved in 2007, and last amended in 2014.
Lithuania's National Programme for the Development of Studies, Scientific Research and Experimental (Social and Cultural) Development (SR&ED) for the period 2013-2020 was established to inform the direction in this area, aiming to encourage sustainable development of people and society, improve the country's competitiveness, and comply with the key provisions of the National Progress Strategy "Lithuanian Progress Strategy 'Lithuania 2030'; the National Progress Programme for 2014–2020 and the Commission Communication "Europe 2020: A strategy for smart, sustainable and inclusive growth".[64] The 2021-2027 consultation processes are ongoing and the new Programme should be launched soon.
Law on Corporate Income Tax of the Republic of Lithuania (2008)[65] has been amended in 2008 enabling enterprises to deduct their costs for R&D from income three times. Potentially, this law can cover incentives for companies developing eco-innovations.

[61] European Commission. (2011). BiPRO Country Factsheet for Lithuania. Support to Member States in improving waste management based on assessment of Member States' performance. Retrieved from: EC website

[62] European Commission. (2019). Policy fact sheet Lithuania: Multi-apartment renovation programme. Retrieved from: BuildUp website

[63] National Audit Office of Lithuania. (2020). National Audit Office: at the current pace, modernisation of all energy-inefficient multi-apartment houses would be completed in 100 years. Retrieved from: vkontrole website

[64] Ministry of Education, Science and Sport of Lithuania. (2019). Programme for Development of Studies and R&D for 2013-2020. Retrieved from: SMM website

[65] Eco-Innovation Observatory. (n.d.). Lithuania country profile 2016-2017. Retrieved from: EC website

Eco-Innovation LT & LT+ Programmes or the Investment Promotion and Industrial Development Programme for 2014–2020 aimed to encourage micro-, small- and medium-sized enterprises to install eco-innovative technology to reduce the adverse effects of climate change and the greenhouse effects. Programme budget was € 86.8 million. Its key areas of investment related to negative environmental effects and waste reduction; modification of existing technology and equipment to reduce pollution and modification of raw materials, auxiliaries or product qualities to reach lower toxicity and more durable alternatives.
Investment Promotion and Industrial Development Programme (2014–2020) co-financed by the European Union Structural Funds has been aimed at raising the country's competitiveness, investment in service and production sectors, with a focus on encouraging businesses to use materials and energy more efficiently and secure supply of raw materials is key. These funds have been used for example to implement skills upgrading and competency development initiatives using "competency vouchers", which makes upskilling more available to small and micro enterprises.
Entrepreneurship Action Plan (2014-2020) and **Entrepreneurship Promotion Fund Lithuania** (2014-2020)[66] enables access to finance, 'responsive administration , skills & innovation,' and internationalisation for SMEs. It represents the instrument for the implementation of the measures of the Small Business Act (SBA) for Europe.
National rural development programme is managed nationally and funded under the European Agricultural Fund for Rural Development (EAFRD) and national contributions. It sets out priority approaches and actions to meet the needs of the specific geographical area it covers. The managing authority is the Ministry of Agriculture of Lithuania. It has funded in the past initiatives with a focus on organic and regenerative agriculture, although they are not as prominently represented as other measures.
Sustainable Urban Mobility Plan (SUMPs) started in 2015, when the Ministry of Transport and Communications adopted the SUMP Guidelines based on the main provisions of the EU's Green Paper, White Paper, and Action Plan on urban mobility. Municipalities with more than 25,000 inhabitants have been recommended to prepare SUMP. Additionally, Vilnius is participating in the Interreg-funded InnovaSUMP project which aims to introduce improvements in preparation, adoption and monitoring of SUMPs based on the established EU methodology.
Lithuania's National Programme for the Implementation of Green Procurement (2016-2020) was established by the Ministry of Environment with the objective is to promote green procurement and ensure that the goods, services or works purchased through public procurement procedures are as environmentally friendly as possible. It dictated that procuring organisations should apply green criteria to at least 40% of total procurements. The full evaluation of the programme is yet

[66] European Commission. (2019). SBA Fact sheet Lithuania. Retrieved from: EC website

not readily available, although a revision to this programme has proposed an improved and flexible methodology to set the procurement criteria. In addition to targets, guidelines should allow for smooth implementation of the practices. The Ministry of Economy and Innovation has published **Guidelines on Innovative Public Procurement** as well as drafted the **Law on Pre-commercial procurement** for those products where no innovative solutions are yet on the market. Finally, in 2020, the Lithuanian Innovation Centre (LIC) launched a **Regional Handbook for Circular procurement,** which may serve as a basis to align the next steps of GPP in Lithuania with the circular transition.

Extended Producer Responsibility has been established for the following products: packaging waste, batteries and accumulators, waste electrical and electronic equipment (WEEE), internal combustion engine or fuel oil filters, car hydraulic (oil) shock absorbers, used tyres, end-of-life vehicles, and oils.

National Energy and Climate Plan of the Republic of Lithuania for 2021-2030.[67] The main strategic documents integrated into the National Plan are the National Energy Independence Strategy (NEIS) adopted in 2018 and the National Strategy for the Climate Change Management Policy adopted in 2012 and updated in 2019 as well as the National Air Pollution Reduction Plan adopted in 2019. The National Plan sets national and EU-level targets for Lithuania in order to contribute to the agreed general EU energy and climate change targets for 2030. It also includes the provision of including education programmes on benefits and practical possibilities of using Renewable Energy Sources in the curricula of Lithuanian general education schools as well as Lithuanian universities and non university higher education institutions. Through the **Climate Change Program,** in the period 2014-2020, €2 billion from the EU structural and investment funds and the State budget were available to be invested in the implementation of measures related to climate change mitigation, including for eg. the purchase of cleaner means of mobility for natural persons and public transport vehicles.

National Progress Programme for the Government of the Republic of Lithuania for the period 2016 - 2020 and the targets set there had strong links to the CE in relation to waste collection and recovery, composting requirements, end-of-waste criteria and pollution tax reviews. This programme also set quite ambitious targets to reach 20% of innovative public procurement of all the PP in 2030, whereas that percentage lies currently closer to 1%. The Government is currently in the process of putting together and presenting the 2021-2027 Programme.

Operational Program for the European Structural and Lithuanian Investment Funds.[68] The programme has brought together for the period 2014-2020 EU investment funds that are aimed

[67] Government of Lithuania. (n.d.). National Energy and Climate Action Plan of the Republic of Lithuania for 2021-2030. Retrieved from: EC website

[68] European Commission. (n.d.) Operational Programme for EU Structural Funds Investments for 2014-2020 - Lithuania. Retrieved from: EC website

at supporting Lithuania's economic development, tackling social exclusion, unemployment and other matters such as energy security. It reflects the goals of the Europe 2020 strategy, posing a clear focus on increasing research and innovation, building SME competitiveness, supporting the shift to a low-carbon economy, and promoting sustainable and quality employment and supporting labour mobility. The programme for the period 2021-2027 should be made publicly available soon. Additionally, Lithuania has recently applied to €2.2 billion in grants for the **Recovery and Resilience Facility Plan**[69] from the European Commission aimed at building a stronger economy and society out of the COVID-19 pandemic. One of the key components of the plan is to secure green and digital transitions and includes measures in areas such as renewable energy, energy efficiency, sustainable transport, digital skills and research and innovation. Ye, the proportions of investment expected in relation to the green and digital transition are 37% and 20% respectively of the full grant.

Institutional Framework in Lithuania

Currently, several institutions take part in the management and implementation of Lithuania's sustainability- and circularity-related targets. The leading national ministries that play a key role are the Ministry of Environment (AM), the Ministry of Economy and Innovation (EIMIN), and the Ministry of Energy (ENMIN). Firstly, the Ministry of Environment[70] sets environmental regulations for responsible natural resources and waste management. AM also administers the Environmental Protection Support Programme.

Secondly, the Ministry of Economy and Innovation[71] is responsible for competitiveness and productivity. In essence, EIMIN implements horizontal measures aimed at reducing market regulatory risks. Its main goal is to transform industry and business by implementing the New Industrial Strategy for Europe[72] and the SME Strategy for a sustainable and digital Europe[73]. Therefore, it is responsible for handling green investment programmes, coordination with industrial actors to shift towards a circular economy, and the roll-out of energy efficiency measures and greater use of renewable energy sources.

Thirdly, the Ministry of Energy[74] is responsible for energy policy, including the development of renewable and alternative energy sources. ENMIN also manages energy efficiency and renewable energy sources policy design and implementation, and hosts the Climate Change Management Group.

Fourthly, both the Ministry of the Interior (VRM) and the Ministry of Agriculture (ZUM) also play a direct, albeit secondary, role. VRM, which is responsible for the development of Lithuanian regions

[69] European Commission. (2021). Press release. Recovery and Resilience Facility: Croatia and Lithuania submit official recovery and resilience plans. Retrieved from: EC website
[70] Ministry of Environment of Lithuania. (2019). Activities. Retrieved from: AM website
[71] Ministry of the Economy and Innovation of Lithuania. (2020). Activities. Retrieved from: EIMIN website
[72] European Commission. (2020). A New Industrial Strategy for Europe. Retrieved from: EC website
[73] European Commission. (2020). An SME Strategy for a sustainable and digital Europe. Retrieved from: EC website
[74] Ministry of Energy of Lithuania. (n.d.). Retrieved from: ENMIN website

(municipalities), plays a role in implementing circularity at the regional level. For example, certain implementation matters such as the roll-out of the Waste Management Implementation Plans are dependent on each of the country's 10 regions. ZUM, which is responsible for the bioeconomy and food sector, functionally works closely with EIMIN in many matters related with circularity and sustainability.

Additionally, other institutions that respond to these ministries are accountable for state environmental monitoring. For instance, for the emission of permits and material resource evaluation and accounting as well as for subsidising investments related to environmental impact reductions. These are the Environmental Protection Agency (EPA)[75], the Lithuanian Geological Survey Institute[76], and the Lithuanian Environmental Investment Fund[77], respectively.

Besides, the National Industry Digitalisation Platform, *Pramonė 4.0* (Industry 4.0)[78], also plays a part in advancing Lithuania's industrial transition to circularity. By bringing together all the major stakeholders, representatives of the public sector, science and academia, and the business community, the platform serves as a form of collective leadership and is the leading national industrial consensus-building instrument.[79] Although the platform was initially formed to implement the Industry 4.0 revolution, with the emergence of the circular economy, its composition has been supplemented and the relevance of a green and circular transition for the manufacturing segments has been recognised in the latest version of the Industry Digitisation Roadmap.[80]

Skills and innovation for the circular economy

The CE transition will both shape the skills required in the labour market as well as depend on those skills already available.[81] Lithuania has one of the highest participation rates in tertiary education in the EU, whilst participation in vocational education training (VET) pathways and apprenticeships is relatively low. This is in part due to overlaps in the programmes offered by VET providers in the same areas.[82] Employment in knowledge-intensive sectors in Lithuania (3.3% of total employment) is well below the EU-average (4.6%)[83], with far fewer employed in research and development (R&D) in industry than in higher education. Addressing the fragmentation of the R&D system, knowledge transfer between business and higher education, as well as the fragmentation of incentives and investment instruments in research and innovation (R&I) for these stakeholders, are cited as key priorities for increasing competitive wages and the country's innovation power as a whole. Despite good progress on innovation performance - 27% increase between 2011 and 2019 - it has not been

[75] Lithuanian Environmental Protection Agency (EPA). (2013). Retrieved from: EPA website
[76] Lithuanian Geological Survey. (2021). Retrieved from: LGT website
[77] International Energy Agency (EIA). (2013). The Lithuanian Environmental Investment Fund. Retrieved from: IEA website
[78] Platform 'Industry 4.0'. Retrieved from: Industry 4.0 website
[79] Platform 'Industry 4.0'. Structure. Retrieved from: Industry 4.0 website
[80] Lithuanian Innovation Centre. (2020). Lithuanian Industry Digitisation Roadmap 2020-2030. REVISED DRAFT updated within a framework of the "Follow up" project. Retrieved from: EIMIN website
[81] Circle Economy. (2020). Jobs & skills in the circular economy. Retrieved from: Circle Economy website
[82] European Commission. (2020). Lithuania 2020 country report. Retrieved from: EC website
[83] Eurostat. (2020). Employment in technology and knowledge-intensive sectors at the national level. Retrieved from: Eurostat

fully exploited to meet the structural needs of the labour market and industrial transition to high value-added and smart specialisation. This is also reflected in low skills use in the country and the fact that only 15% of jobs employ high-performance workplace practices (HPWP), those that have shown to improve an organization's capacity to effectively attract, select, hire, develop, and retain high-performing personnel, compared to EU-average of 26%.[84] Nonetheless, in 2020, the Lithuanian Government together with the Organisation for Economic Co-operation and Development (OECD) initiated a national Skills Strategy project, led by the Government Strategic Analysis Center (STRATA), an independent government institution tasked with Higher education and Smart Specialisation in Lithuania.[85] This project will build towards a whole-of-government and cross-sectoral approach to skills policy, that in conjunction with HPWP could enhance workforce skills, enabling a better uptake of innovation by the industry. The strategy is expected to be presented publicly during Q2 2021.

Additionally, Lithuania has a large productivity gap, compared to the OECD average, resulting in income gaps particularly for disadvantaged groups.[86,87] Employment in production of low value-added products results in low labour productivity for the manufacturing sector despite the overall number employed in the sector. This entails falling behind in sectors such as electricity, gas, steam supply; real estate operations; mining and quarrying; information and communication.[88,89] Investment in innovation and the production of cutting-edge smart and circular technological solutions could help to address productivity and wages in the manufacturing sector. The renewed focus of Smart Specialisation priorities in both ICT and New production processes, materials and technologies might help direct public R&D investments into testing and implementation of these solutions within businesses. For this matter, the awarding criteria for the Smart Specialisation budget as well as the type of cooperation (or lack of) proposed between business and scientific institutions across different financial instruments will be key to the implementation of these solutions at scale.

2.1c Comparative case-studies

Three countries are used as comparative case-studies to help provide a better picture of circular economy policies and experiences.[90] Policies that front-running or similar in size and transition stage EU member states have adopted to transition the industry toward circularity may serve to draw

[84] OECD. (2020). OECD Skills Strategy Lithuania, Recommendations, Consultations, September 2020. Priority area 3: Using people's skills more effectively in Lithuania's workplaces.

[85] Government Strategic Analysis Centre (STRATA). (2020). Retrieved from: STRATA website

[86] OECD. (2018). OECD Economic Surveys: Lithuania. Retrieved from: OECD website

[87] OECD. (2018). OECD Jobs Strategy: Lithuania. Retrieved from: OECD website

[88] Lithuanian Innovation Centre (LIC). (2020). Lithuanian Industry Digitisation Roadmap 2020-2030. Retrieved from: EIMIN website

[89] European Commission. (2019). Lithuania's labour productivity assessment. Retrieved from: EC website

[90] The final selection of these three countries was made from a long-list proposed to the Steering Group comprising representatives from the Lithuanian institutions EMIN and MITA and the Commission's external High Impact Action Coordinator. The long-list presented a comparative socioeconomic assessment of countries at similar stages of transition to circularity as well as frontrunning countries in the transition. This initial list included the following countries: Czech Republic, Latvia, Estonia, Poland, the Netherlands and Denmark.

relevant conclusions for Lithuania from best practices and lessons learned by others, in due consideration that there is no silver bullet, no one-size-fits-all solutions, and each country will set up and follow its distinct path to achieve this transition based on their own context. The best practices included in this chapter are extracted from Estonia, the Czech Republic, and the Netherlands and can be found in the case boxes within each section.

Estonia, geographical peer. It is the most similar peer in geographical, demographic, and social terms and has the most similar economic structure profile to Lithuania. The Estonian Government has since 2017 started to organise stakeholder engagement, and circular economy indicators were first developed in 2019. The Ministry of Environment of Estonia, in consultation with an external organisation, is currently developing a circular economy strategic document, which is expected to be adopted in 2021.

Czech Republic, legacy peer. It is a country with a similar economic structure, relatable household consumption per capita, and similar trade profile to Lithuania. The Central European country has since mid-2018 been developing with the help of the OECD its national strategy 'Circular Czechia 2040'. The Ministry of the Environment (MoE) leads and coordinates these efforts. However, given the CE transition's systemic nature, MoE receives support from other Ministries, particularly the Ministry of Industry and Trade, which already has several programmes directly related to resource efficiency. The national strategy creation process involves a stakeholder working group consisting of Ministries and public institutions, regions and municipalities, business associations, universities, and NGOs, which provides feedback on the intermediate outputs delivered by the MoE and the OECD. The launch of the 'Circular Czechia 2040' strategy and adoption by the Government is expected by the end of 2021.

Netherlands, aspirational peer. Although it presents a different economic structure, it has a similar trade profile as Lithuania, both countries having export-oriented economies and, overall, relatable recycling rates. As a frontrunner, pace-setter country in the transition to circularity, the Dutch Government presented in 2016 its national circular economy roadmap: 'A Circular Economy in the Netherlands by 2050'. Besides, the country has one of the highest circular material use rates in the EU[91], and it is one of the leading Member States regarding environmental taxes (as % of GDP) and public spending in environmental protection (as % of GDP). It also has a strong innovation scene, reflected by the number of patents related to recycling and secondary raw materials currently held.[92] Dutch civil society and stakeholder platforms also play a crucial role in engaging broader segments of society in the transition to circularity.

In order to implement the key elements and strategies of the circular economy in the industrial transition, policies currently in place need to be assessed on their role and degree in supporting or hindering circularity. The regional, national and European policies introduced above have been categorised and analysed in further detail, according to the type of influence they exert (mobilise,

[91] Ecopreneur. (2019). Circular economy update. Retrieved from: European Circular Economy Stakeholder Platform
[92] Eurostat. (2016). Patents related to recycling and secondary raw materials. Retrieved from: Eurostat website

educate, manage, incentivise, regulate); as well as the key elements of the circular economy they tackle, as presented in the frameworks below. The National Policy Instrument Framework[93] and the Key Elements of the Circular Economy Framework[94] have been developed by Circle Economy with the purpose of supporting decision-making by helping standardise the language of the circular economy and structure practical examples of how instruments and strategies are being applied across territories and industries to advance the circular economy and other sustainability-related paradigms.

National Policy Instrument Framework
MOBILISE sets the direction of and builds momentum towards long-term change, while also dictating how this direction is determined and governed. **EDUCATE** increases the overall level of awareness and builds the necessary skills and knowledge around the circular economy to foster long-term change. **MANAGE** influences the use and function of physical and material elements within the national environment. **INCENTIVISE** sends market signals and support to businesses, citizens and governments to promote certain activities. **REGULATE** changes the rules of the systems to achieve compliance through enforcement.

Figure 1. The national policy instrument framework to support the circular economy.

Key Elements of the Circular Economy	
	**CORE ELEMENTS** PRIORITISE REGENERATIVE RESOURCES | Ensure renewable, reusable, non-toxic resources are utilised as materials and energy in an efficient way
	STRETCH THE LIFETIME | While resources are in-use, maintain, repair and upgrade them to maximise their lifetime and give them a second life through take back strategies when applicable.
	USE WASTE AS A RESOURCE | Utilise waste streams as a source of secondary resources and recover waste for reuse and recycling.

[93] Circle Economy. (2021). The national policy instrument framework. Retrieved from: Circle Economy website
[94] Circle Economy. (2021). The key elements of the circular economy. Retrieved from: Circle Economy website

	ENABLING ELEMENTS RETHINK THE BUSINESS MODEL | Consider opportunities to create greater value and align incentives through business models that build on the interaction between products and services.
	TEAM UP TO CREATE JOINT VALUE | Work together throughout the supply chain, internally within organisations and with the public sector to increase transparency and create joint value.
	DESIGN FOR THE FUTURE | Account for the systems perspective during the design process, to use the right materials, to design for appropriate lifetime and to design for extended future use.
	INCORPORATE DIGITAL TECHNOLOGY | Track and optimise resource use and strengthen connections between supply chain actors through digital, online platforms and technologies that provide insights.
	STRENGTHEN & ADVANCE KNOWLEDGE | Develop research, structure knowledge, encourage innovation networks and disseminate findings with integrity.

Figure 2. The key elements framework of the circular economy.

MOBILISE

The state plays a central role in the transition to a circular economy, not only as a driving force and enabler but also as a steerer to ensure that political commitment, technological development and social sensitivity align in the same direction. In this sense, the elements that are essential for good governance include a robust political commitment that delivers a clear national vision, sets a target and outlines a detailed plan of action is a necessary step to kick-start the transition. Additionally, a well-configured cross-sectoral legislation underpinned by a whole-of-government institutional set-up and a participatory governance structure, as well as an active stakeholder engagement is fundamental to advance the circular agenda.

Influence	Activity	Instrument (eg.)
MOBILISE	Visions and ambitions	Roadmaps; strategies and targets
	Govern the transition	Institutional design to enable circularity

		- Tripartite councils - Cross-governmental steering committees - Participatory governance through independent advisory bodies
	Convene towards action	Matchmaking platforms Multi-stakeholder commitments

Table 1: Instruments to mobilise the circular economy transition.

Political commitment and legislative stimuli are key mobilizing factors for the transition, where a roadmap and action plan ought to clearly assert what the circular economy transition aims to achieve and how it can do so. To set the direction and build momentum towards long-term and systemic change, roadmaps and high-level strategy policies must be set. These both steer the direction of other instruments and actions, as well as establish the way they are governed. In Lithuania, several high-level strategies embed concepts of the circular economy within them. However, strategy setting is not the final solution nor outcome sought. A currently ineffective coordination of all of these strategies brings forward the importance of collaborative and structured governance and monitoring systems, as well as high-level commitment that allows to act upon the circular economy transition in a streamlined way. For instance, the National Sustainable Development Strategy set in 2009,[95] the National Environmental Protection Strategy[96], the Strategy for National Climate Change Management Policy by 2050[97] and the National Progress Programme 2021-2030[98] for the Government of the Republic of Lithuania.[99] Further, certain laws and programmes set the direction for waste management and resource recovery, such as the Law on Waste Management, the Waste Management Plan and the National Waste Prevention Programme.[100] All of these strategies connect to a myriad of targets and indicators that are used to measure progress on the subject. However, for some of these targets, progress is harder to achieve. For example, although there is a National Strategy for the Development of Renewable Energy Sources (2010), renewables in certain sectors, such as the transport sector, are much more limited than in others. Therefore, Lithuania is far away from reaching the EU target of at least 14% renewables in transport, and its own target of at least 15% by 2030. In 2017, this indicator showed a share of only 4.3% of renewables in this sector. A large increase in fuel and energy consumption (42.4%) between 2010-2018, seems to indicate increased road transport which depends on outdated car fleets that consume high amounts of non renewables, especially diesel fuel. The renewable energy shares in this sector mostly relate so far to biofuels and a small share of electricity consumption in public transportation, such as railways and trolley buses. An

[95] Government of Lithuania. (2009). National Strategy for Sustainable Development. Retrieved from: Ecolex website

[96] Government of Lithuania. (2016). National Environmental Protection Strategy. Retrieved from: AM website

[97] Government of Lithuania. (2012). National Strategy for Climate Change Management Policy. Retrieved from: LSE Grantham Research Institute website

[98] OECD. (n.d.) STIP Compass Lithuania. Retrieved from: STIP OECD website

[99] Government of Lithuania. (2016). Programme of the Government of the Republic of Lithuania (Foreign Policy part). Retrieved from: Ministry of Foreign Affairs website

[100] Government of Lithuania. (1998). Waste management Law. Retrieved from: Seimas of Lithuania website

aligned national approach to circular economy objectives and strategy would facilitate the coordination of an industrial and economic transition for Lithuania.

Establishing a clear national vision: the Dutch experience

The CE transition requires coherence across policy areas. A horizontal policy mix approach and policy coordination, aligning both cross-cutting and sectoral policies, is critical to advance the transition. To this end, policy coordination and policy integration are two crucial strategies for ensuring policy alignment. Promoting sectoral and cross-cutting policies —education, fiscal, innovation—, addressing incoherence and inconsistency across policy, and identifying and correcting misalignments are key factors for developing effective policy.

As one of the leading Member States on the topic, the Netherlands exemplifies how legislative action that enables the transition process could look and be developed. The country presented in 2016 its bold programme to achieve a fully circular economy by 2050, including a 50% reduction (interim) target in the use of virgin raw materials by 2030.[101] To this end, the policy effort developed is far-reaching but also detailed and specific. The strategic objective is clear: to develop a holistic policy framework that connects complementary domains and seeks synergies between cross-cutting policy areas (such as climate change, manufacturing, energy, transport, environmental protection, and foreign trade, to name a few). Accordingly, the government's integrated programme was developed by ministries responsible for infrastructure and the environment, economic affairs, interior and kingdom relations, and foreign affairs, and focuses on five high-priority areas: 1) biomass and food; 2) plastics; 3) manufacturing industry; 4) construction; and 5) consumer goods. These include voluntary sectoral transition agendas supported by ancillary initiatives.[102]

It is noteworthy to highlight that several characteristics define the Dutch experience regarding the circular economy. Firstly, a broad political and social consensus on circularity as a compelling environmental imperative and a sound economic strategy to strengthen competitiveness and create jobs. Secondly, a culture of dialogue, collaboration and compromise has also played a vital role in generating this consensus. Thirdly, for translating this consensus into an effective policy mix, strong commitment, ambition, and leadership at the highest political levels have been crucial.

Promoting an active circular and sustainable community while engaging the private sector and other national stakeholders is also vital to organise, accelerate and guide the use of secondary materials and better management of waste. A clear area of progress measured in Lithuania relates to municipal solid waste (MSW) management. Although still depositing the majority of its MSW in landfill, during the decade between 2004-2014 Lithuania went from sending 92% of its MSW to landfill, to

[101] Government of the Netherlands. (2016). A Circular Economy in the Netherlands by 2050. Retrieved from: Government of the Netherlands website

[102] Other adopted policies by the Government of the Netherlands that include circular economy principles: Top sector innovation support and the Smart industry initiative, 2016; Bioeconomy Strategy, 2016; Strategic vision for sustainable of biomass and bioenergy, 2016; Third national waste management plan, 2017; and A vision for circular agriculture, 2018.

59%.[103] Further, guided under the National Waste Management Plan during the period between 2014-2020, almost 50% of paper and cardboard, metal, plastic and glass waste generated is being collected and prepared for re-use and recycling (based on the total amount of waste). This target however does not guarantee or monitor its further reuse, recycling, or recovery rate, but only its collection and handling for recovery. The municipal waste generation is already low in comparison to the EU average (348 kg/y/inhabitant compared to around 487kg between 2008-2010)[104] and further enabled by policy instruments such as the setting of recovery targets, as well as other economic and market incentives, such as taxes for packaging and other chargeable goods, deposit-refund systems for beverage packaging as well as incentives for the set-up of reuse centres. AM is now responsible for rolling out the 2021-2027 plan based on the assessment of the previous plan, its effectiveness as well as the areas for further improvement.

Engaging stakeholders to accelerate the transition and reach targets

In Estonia, the *'Annual Partnering Day'* is considered good practice for promoting stakeholder engagement. Since 2017, the Ministry of Environment gathers stakeholders and partners to explore solutions to improve waste management and develop the national circular economy strategic plan.[105]

In the Netherlands, the *Grondstoffenakkoord* (Raw Materials Agreement)[106] is a national commitment signed in 2017 with the primary goal of contributing to the national circular economy strategy on a sectoral basis. More than 80 organisations, including the central government, regional and local authorities, and partners from business, trade unions and civil society, contributed to its elaboration. Over 400 organisations have now endorsed it. In 2019, to directly support the implementation of the *Grondstoffenakkoord*, the government launched the joint public-private initiative *Versnellingshuis* (Acceleration House[107]). This acceleration platform brings together public and private stakeholders to inform, connect and offer knowledge and support to entrepreneurs interested in the circular economy.[108]

Because of the scope and multidimensional nature that distinguish the process, the CE transition must be a whole-of-government effort. The systemic nature of the circular economy requires an institutional set-up that provides structural support and enhancement to the transition process

[103] Merta, E. (2016). Municipal solid waste management. Lithuania Country factsheet 2016. VTT Technical Research Centre of Finland. Retrieved from: Eionet portal

[104] European Commission. (2012). Lithuania country factsheet. Retrieved from: EC website

[105] European Environment Agency. (2019). Resource efficiency and the circular economy in Europe 2019. Retrieved from: EEA website

[106] Raw Materials Agreement. (2017). Retrieved from: Government of the Netherlands website

[107] Circular economy acceleration house. (n.d.). Retrieved from: Acceleration House website

[108] Ecopreneur. (2019). Circular economy update. Retrieved from: European Circular Economy Stakeholder Platform

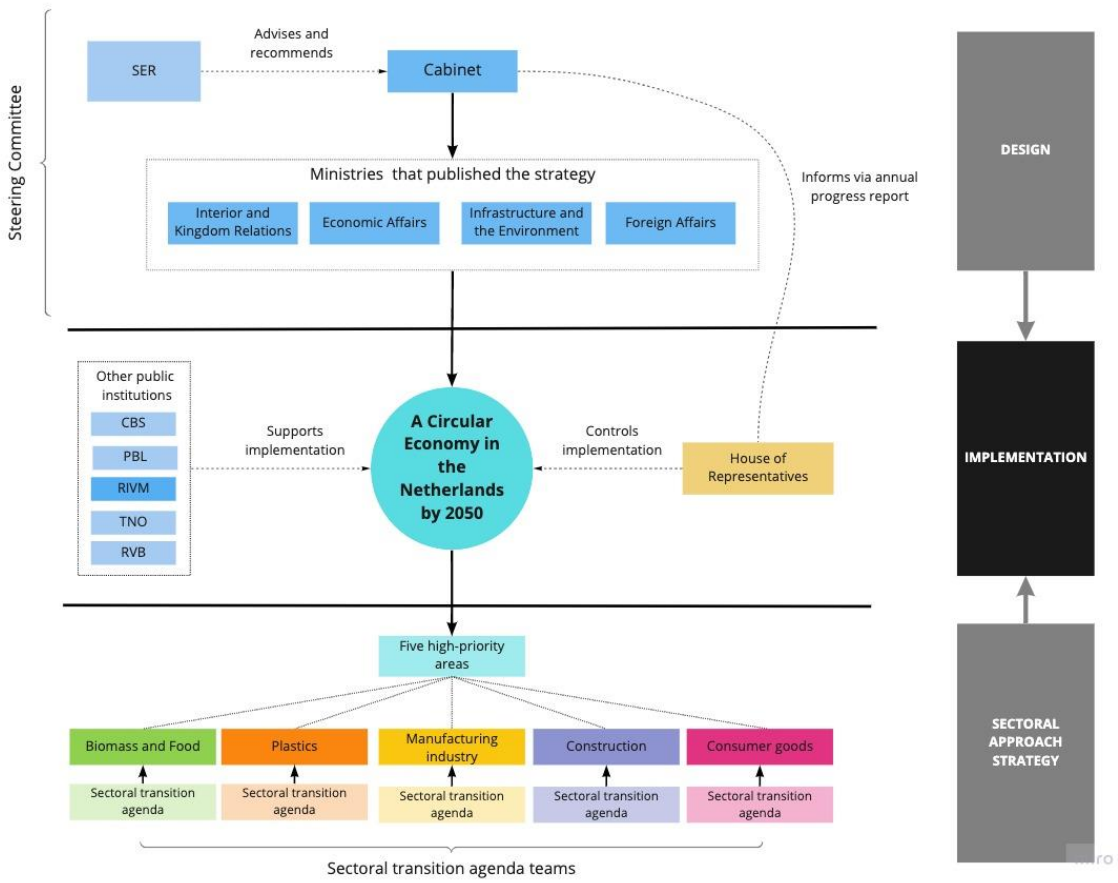
through an effective division of tasks, responsibilities and competences. To this end, it is crucial to link up and engage as many governmental institutions as possible to promote cross-sectoral interconnectivity and cooperation. However, at the same time it is essential to avoid duplication of efforts and ensure consistency, coherence and efficiency. In Lithuania, this will be addressed partly by priority 4 of the Skills Strategy, strengthening governance of skills and policies. Effective participatory governance mechanisms ensure that not only the design but also the implementation of the circular economy agenda is as democratic, transparent and inclusive as possible. The Tripartite Council of the Republic of Lithuania (TCRL) already plays an important role at the national level to ensure coordination and consultation between government, industry and trade unions on all labour-market related legislation.[109] As with the economic crisis in 2008, the TCRL and regional tripartite councils (RTCs) will have an important role to play in facilitating social dialogue to address damages to the labour market resulting from the COVID-19 pandemic at the same time as embracing green recovery and economic transition. Forms of tripartite governance or other shared structures established by other countries might serve as a starting point for this.

Developing unified, cross-sectoral, and participatory governance

In the Netherlands, the government-wide effort is led by a cross-sectoral steering committee made up of various stakeholders and the six ministries responsible for implementing the circular economy programme.[110] Besides, made up of the same parties, a project group is responsible for operationalising the circular economy agenda's implementation. In this regard, it is noteworthy the importance of the circular economy agenda depending directly on the Prime Minister's office and the cabinet informing Parliament annually via a progress report. Such high-level political alignment is key to the steering committee's effective functioning, overcoming political and administrative obstacles, and, overall, to the effective implementation of the circular economy agenda.

[109] Blažiene, I. & Gruževskis, B. (2017). Lithuanian trade unions: from survival skills to innovative solutions. Retrieved from: ETUI websiteI

[110] Ministries jointly responsible for carrying out the circular economy agenda are those in charge of: Economic Affairs and Climate Policy (EZK); Infrastructure and Water Management (I&W); Agriculture, Nature, and Food (LNV); Interior and Kingdom Relations (BZK); and Foreign Affairs (BZ). However, EZK and I&W are tasked with overall coordination of the circular economy agenda.



Vertical coordination across governance levels is vital for the transition to progress. Ensuring reinforcement between all levels of governance requires mechanisms that promote intra-government dialogue and enable smooth information flow. Multiple specialised government agencies also play a supportive role, ranging from specific policy development to progress monitoring and evaluation.[111] A government-wide effort also allows the mutually-reinforcing horizontal principles and core values of the circular economy transition—like resource efficiency and sustainability—to embed and permeate all overlapping policy areas and public institutions.

Establishing participatory governance mechanisms and social dialogue promotion are also crucial. The Economic and Social Council (SER)[112] of the Netherlands is an independent advisory body in which employer associations, trade unions, and independent experts collaborate on various social and economic topics. SER primarily gives policy advice to the Dutch Cabinet and Parliament for critical socioeconomic subjects, including education and the labour market. It also facilitates

[111] Other government agencies are tasked with monitoring, identifying specific preconditions and exploring solutions: Statistics Netherlands (CBS), the Netherlands Environmental Assessment Agency (PBL) and the National Institute for Public Health and the Environment (RIVM). The Netherlands Organisation for Applied Scientific Research (TNO) also analyses the achievement of sub-goals.

[112] Social and Economic Council of the Netherlands. (n.d.). About the SER. Retrieved from: SER website

agreements on other areas such as the environment and energy but focusing on the socioeconomic perspective.[113]

EDUCATE

Increasing the overall levels of awareness and building the necessary skills and knowledge around the circular economy also supports the transition. Education, information, and knowledge are crucial mechanisms to implement social, contextual, and cultural changes. To foster social sensitivity and transform the social mindset towards circularity and sustainability is essential to lay the ground, prepare the context, and minimise the risk and backlash against this paradigm shift.

Influence	Activity	Instrument (eg.)
EDUCATE	Communication and awareness	Information campaigns Awareness raising events and tools
	Education and curriculum	Schools and higher education (university and vocational education) programmes Education centre networks Encourage workplace training Extra-curricular education
	Knowledge management	Data, knowledge and information sharing Increase standardised data collection
	Research and development	Conduct research Implement innovation programmes National competitions and contests

Table 2: Instruments to educate the circular economy transition.

Citizen participation and social movements are effective mechanisms that promote necessary social and contextual lifestyle changes related to the circular economy. Effective national campaigns such as the annual 'Let's do it' cleaning campaign in Lithuania, where citizens participate to jointly clean public spaces such as parks, streets and riverbanks,[114] are good examples to guide the creation of new campaigns aimed at advancing the circular economy. Although this initiative specifically fosters a once a year cleaning of the public space, these types of mechanisms provide a relevant example of activities that are essential to implement in order to change social habits and cultural traits that play a crucial role in the transition process. However, future initiatives should be focused on higher CE strategies such as promoting reduced and conscious consumption behaviours and encouraging proper waste disposal and management practices throughout the year.

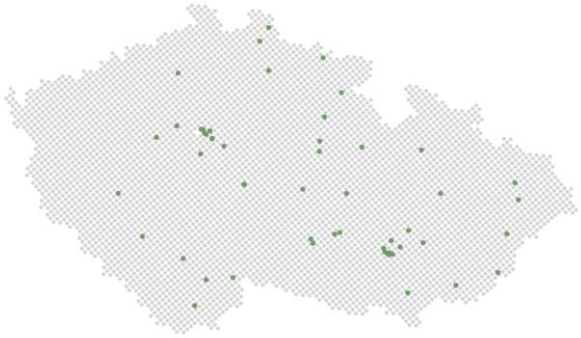
[113] Social and Economic Council of the Netherlands. (2017). The transition to a circular economy. Retrieved from: SER website
[114] Delfi. (2015). Lithuania PM becomes patron of Let's Do It cleanup campaign. Retrieved from: Delfi website

Strengthening community-based initiatives

The systemic nature of the CE transition requires profound cultural and social mindset changes. To this end, social and grassroots innovations are essential to engage civil society directly and strive for transformative economic rationales while also questioning cultural trends such as consumerism. In this sense, bottom-up initiatives are very effective in mobilising and educating communities with the objective of creating systemic change.

Founded in 1996, Pavučina[115], the Network of Environmental Education Centres in the Czech Republic, is an umbrella organisation for 46 environmental NGOs involved in promoting environmental education in the country.[116] Over 100 centres operated nationally and locally carry out grassroots activities to support environmental education via offering training, seminars, and workshops to the youth, environmental educators, and the general public. For example, the joint project EKOPOBYT[117] offers mainly primary and secondary school pupils, teachers, and families one- or multi-day (usually five-day) stays aimed at strengthening the relationship with nature and respecting the principles of sustainability.[118]

Pavučina
Síť středisek ekologické výchovy



Educational programmes are crucial social influence mechanisms to raise awareness and foster knowledge development and shape attitudes, consumer choices, and behaviour change. Active educational programmes in Lithuania tackle the benefits and possibilities of using Renewable Energy Sources, as well as discuss waste issues.[119] Further, awareness raising is being carried out through competitions or contests, such as the Product of the Year from Recycled Materials competition

[115] Pavucina. (n.d.). Czech Network of Environmental Education Centres (n.d.). Retrieved from: Pavucina website

[116] European Commission. (2019). Environmental Implementation Review. Czech Republic country report. Retrieved from: EC website

[117] EKOPOBYT joint project. (n.d.) Retrieved from: EKOPOBYT website

[118] Pavucina. (n.d.). Promotional material. Retrieved from: Pavucina website

[119] Government of Lithuania. (n.d.). National Energy and Climate Action Plan of the Republic of Lithuania for 2021-2030. Retrieved from: EC website

organised by EIMIN or the 'European Week for Waste Reduction' coordinated by AM.[120] Specific programmes for circular economy expert education for government and industry that could ensure there is an expert pool available locally, such as train-the-trainer programmes, have not been identified currently in Lithuania through this research.

Advancing knowledge through school programmes and national competitions

The Czech government, via the State Programme of Environmental Education and Awareness and Environmental Counseling for the years 2016-2025, is integrating circular economy, sustainable consumption, and environmental topics into primary and secondary education curricula.[121] Similarly, through the nationwide *MRKEV* (Methodology and implementation of comprehensive ecological education) and *Mrkvička* (Methodology and implementation of comprehensive ecological education for kindergartens) programmes, the abovementioned *Pavučina* network supports teachers from 1,600 schools with methodological materials and at regional trainings in the field of environmental education. At the same time, *Pavučina* has created several tools such as the Handbook for the (eco)educator I[122] and II[123] to promote environmental education. It also organises or otherwise supports educational, training and awareness programmes and events for children and teachers. Almost 600,000 participants take part in them every year. These programmes also help society develop the necessary knowledge, skills and attitudes needed to live responsibly towards the environment.

Additionally, in cooperation with other ministries and industry associations, the Ministry of Industry and Trade has organised since 2017 the 'Turning Waste into Resources' national competition. This has proven effective in attracting a variety of actors to participate and engage in circular economy initiatives, educate on the topic and promote innovation.[124]

Increasing research and development through public support helps countries focus on innovating and designing an economy that is fit for the future. Lithuania's National Programme for the Development of Studies, Scientific Research and Experimental (Social and Cultural) Development (2013-2020) was

[120] European Week for Waste Reduction. (n.d.). Lithuania. Retrieved from: EWWR website

[121] State Programme of Environmental Education and Awareness and Environmental Counseling for the years 2016-2025. (n.d.). Ministry of the Environment of the Czech Republic. Ministry of the Environment website

[122] Pavucina. (n.d.). Handbook of the (eco)educator I. Retrieved from: Pavucina website

[123] Pavucina. (n.d.). Handbook of the (eco)educator II. Retrieved from: Pavucina website

[124] Eionet. (2019). Czech Republic country report. Retrieved from: Eionet portal

previously introduced to encourage and integrate sustainable development into training for highly skilled professionals.[125] Further, research and development programmes at higher education and professional level also increase the knowledge available, through for example studies to evaluate the impacts of current policies, or past available funding for R&D and innovation through the Eco-Consultant (2014-2020), EUREKA's Eurostars Programme or the ~8% of the Lithuanian Operational Programme for EU Structural Funds Investments (2014-2020) allocated to SME competitiveness and innovation,[126] all of which provided innovation funding to SMEs.[127] However, increasing R&D within industry and fostering knowledge exchange between industry and academic and education remains a key challenge and priority for Lithuania. Effective and standardised data collection facilitates both data sharing as well as alignment on key priorities across ministries as well as with relevant stakeholders involved in setting country-wide strategies. As a cross-cutting theme, embedded across multiple policy documents and ambitions, the circular economy calls for decision-making in terms of what are the key CE priorities for the country and what data needs to be collected to inform the targets set. Additionally, transparency through knowledge sharing platforms facilitate communication, engagement and alignment between stakeholders in terms of publicly available data and sources.

The Smart Specialisation Strategy (S3), initially defined for the period 2014-2020, and now revised and to be updated for the period 2021-2027, further supports work conducted in several priority areas. With a further specific focus from 2021 onwards on 'New production processes materials and technologies', 'Health technologies and biotechnologies' and 'ICT', it is expected to guide the use of the budget available for financing projects in line with the set priorities. Its introduction has provided a valuable framework for engaging stakeholders on strengthening R&I in Lithuania. In particular, the need for education to play a role in the design of S3 is acknowledged through the project for Higher Education for Smart Specialisation (HESS). Although not solely linked to the country's circular economy ambitions, the Skills Strategy will be key for increasing participation in VET courses that reflect priority sectors' demands, strengthening adult and life-long learning, and ensuring the current workforce's skills can be fully utilised and developed as needed. Progress under S3 and the Skills Strategy will also be supported by the Lithuanian Industry Digitisation Roadmap 2019-2030, which includes developing digital skills as a precursor for adopting new technologies and digital solutions.[128]

Raising public awareness and strengthening public participation through information access

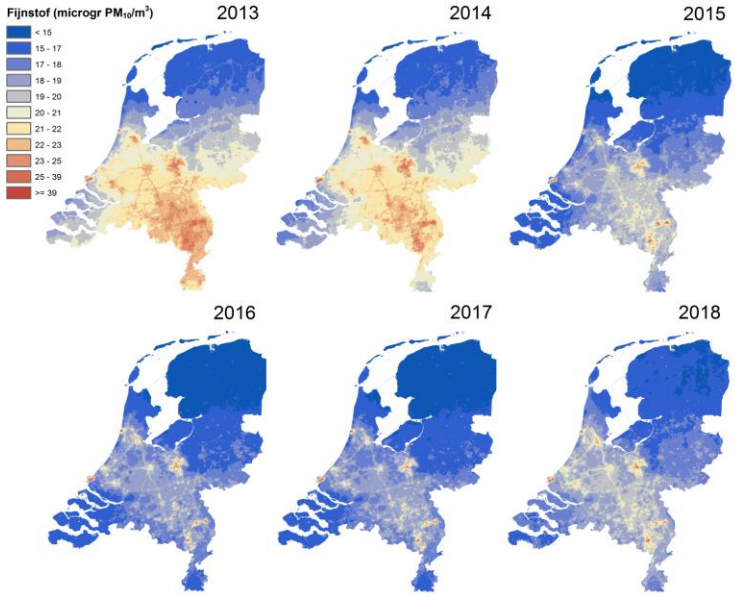
[125] Government of Lithuania. (2012). National programme for the development of studies, scientific research and experimental (social and cultural) development for 2013–2020. Retrieved from: Ministry of Education, Science and Sport website

[126] European Commission. (n.d.) Operational Programme for EU Structural Funds Investments for 2014-2020 - Lithuania. Retrieved from: EC website

[127] Eco-Innovation Observatory. (n.d.). Country Profile 2016-2017: Lithuania. Retrieved from: EC website

[128] Ministry of the Economy and Innovation of Lithuania. (2018). Lithuanian Industry Digitisation Roadmap 2019-2030. Retrieved from: Industrie 4.0 Lithuania

Dutch environmental authorities have created the *Atlas Leefomgeving* (Environmental Health Atlas)[129], an interactive online portal to make accessible complex information to the local level in the form of searchable maps. The tool allows users to interactively search maps by topics ranging from climate, nature, and water to sound and light pollution. For example, the map below shows the evolution from 2013 to 2018 of measured annual average concentration levels of particulate matter (PM10) in the air.[130]



Additionally, launched 2018, the *Grondstoffenscanner* (Raw Materials Scanner) is a specially designed self-assessment tool developed by a coalition of actors led by the Dutch Ministry of Economic Affairs to help SMEs and large companies in the manufacturing industry understand and evaluate the criticality and vulnerability of raw materials in their supply chains, as well as the environmental and social impact derived from them.[131]

[129] Environmental Health Atlas. (n.d.). Retrieved from: Atlas Leefomgeving website

[130] Environmental Health Atlas. (n.d.). Particulate Matter. Retrieved from: Atlas Leefomgeving website

[131] Netherlands Enterprise Agency. (n.d.). Raw materials scanner. Retrieved from: RVO website

Establishing a favourable digital ecosystem

The development of tangible eco-innovative solutions and new circular business models are essential enablers for shifting towards a circular model where sharing, leasing and renting are the new pillars of an economy based on product-as-service systems and sharing platforms. Estonia is well-known for being one of the most digitised societies in the world.[132] With virtually all state services being offered online, Estonia's e-government model is both an international example and a national driving force for innovation. Despite ample room for improvement, enabling conditions such as e-Services and the ease of hiring talent and doing business, derived from the e-government ecosystem foster entrepreneurship and eco-innovation to flourish.[133] This robust innovation culture has given rise to a dynamic Greentech scene, spurring startups focused on creating goods and services marked by resource efficiency and circularity.[134] For example, Suckõrs is a successful Estonian startup that uses natural and locally grown reed as an exclusive raw material to produce high-quality, fully biodegradable drinking straws. The company offers reusable and single-use reed straws and certifies that their products compost in every natural environment (242 days in a landfill; 256 days in the sea).

Other forms of education such as workplace training or reskilling and extra-curricular education could be further supported by policies to facilitate the necessary adjustments and transition of roles for

[132] e-Estonia. (n.d.). Services. Retrieved from: e-Estonia website

[133] European Commission. (2019). Environmental Implementation Review. Estonia country report. Retrieved from: EC website

[134] Global Utmaning. (2019). Circular Baltic 2030: circular economy in the Baltic sea region and beyond. Retrieved from: European Circular Economy Stakeholder Platform website

workers within the circular economy. This is particularly important given that many roles that contribute to the circular economy have been found to require more extensive in-work training than other roles. On a global level, 94% of employers expect new skills needed for the future of work to be developed on the job.[135,136] S3 and STRATA should help to produce long-term outcomes for the labour-market from reforms to Lithuania's education system. In 2019, several universities and colleges were consolidated to improve their quality, but the success of these reforms has so far been laid back by the lack of a long-term guiding strategy. VET providers have also been consolidated and the introduction of modular VET curricula seem so far to have been received well, given 70% of VET students were enrolled in modular VET programmes in 2019.[137] The success of S3, STRATA and the extent to which the national education system can support adoption of the circular economy will also be underpinned by participation of the quadruple helix: education, industry, government and civil society, who all have a vital role to play to ensure industrial changes are reflected in the education and training system, as well as collective agreements for working in sectors most affected by the new industrial strategy.[138]

MANAGE

State institutions play an essential role in managing the transition to circularity. Public procurement, infrastructure development, and asset management are core instruments to positively impact and accelerate the transition to a more resource-efficient and sustainable economy. These instruments also support political commitment, technological development and social sensitivity aligning in the same direction.

Influence	Activity	Instrument (eg.)
MANAGE	Public procurement	Circular criteria for public procurement of assets Innovation-oriented public procurement Circular procurement guide development
	Infrastructure	Infrastructure to support resource cycling (buildings, mobility, reuse centres) Develop regenerative infrastructure (energy sources)
	Asset management	Circular use of public-owned assets (land, buildings and equipment, digital marketplaces)

Table 3: Instruments to manage the circular economy transition.

Rethinking how Public Procurement can serve Lithuania's environmental goals will contribute to the public sector becoming a leader and influencer to accelerate the implementation of the circular economy. Given the high purchasing power of public authorities, calculated to represent 14% of the

[135] Circle Economy. (2020). The heterogeneous skill-base of circular economy employment. Retrieved from: Circle Economy website
[136] World Economic Forum. (2020). The Future of Jobs Report. Retrieved from: WEF website
[137] European Commission. (2020). Lithuania 2020 country report. Retrieved from: EC website
[138] Martinaitis, Z. et al. (2020). Higher Education for Smart Specialisation: the case of Lithuania. Retrieved from: EC website

EU's GDP, Green Public Procurement (GPP) is a core instrument to support and accelerate the transition to a more resource-efficient economy. With the aim to promote sustainable procurement and ensure that the goods, services or works purchased are as environmentally friendly as possible, Lithuania's National Programme for the Implementation of Green Procurement measures for the period 2016-2020 as well as the Guidelines on Innovative Public Procurement, are key documents to set the direction to the way public assets are procured.[139] Innovation-oriented public procurement, on one hand, can act as a pull mechanism to foster demand for innovative technologies, and generate traction for the development and scaling of innovations through its implementation in the production of publicly procured goods. On the other hand, innovation-oriented procurement may be used as a test bed as well as to explore and set best practices in the public sector, for the industrial sectors to build on. However, much remains to be done in this regard. In 2018, Green Public Procurement represented as little as 9.3% in value of all public procurement, whilst the set target is to reach 40%.[140] Capacity building efforts embedded within these policies have been focused on public and private contracting authorities to engage in green or circular procurement, through renewed training materials, programmes and suppliers. However, the practical implementation of the programme has lacked consistency and engagement, and the responsibility for these training has been shifted across governmental actors, from the EPA to the AM, as well as to non-governmental actors such as the Baltic Environment Forum.[141] Although the evaluation of the full programme for the period 2016-2020 has not been made publicly available, a recently amended Act[142] has already incorporated learnings from the previous period, including changes in the list of products subject to environmental criteria for public procurement, in the environmental criteria per se and in the description of the procedure for applying this criteria by contracting authorities and contracting entities when purchasing goods, services or works. These changes focus on improving the legal framework, updating and expanding the concept for green procurement by enabling contracting authorities (eg. in the field of transport and food), expanding the use of eco-labels when purchasing, and making it easier to widely adopt green procurement by contracting entities. New targets have been announced, until the end of June, when the new National Programme (2021-2025) is to be published. These targets are ambitious and foresee for example 100% GPP by 2023. In addition to the public documents, the Lithuanian Innovation Centre (LIC) has produced in 2020 a Regional Handbook for Circular Public Procurement for Lithuania, based on the experience and insights from other European countries, that highlights four key approaches to this type of procurement. Those are a focus on: 1) Better quality products 2) New circular products, 3) Product service systems, 4) Circular ecosystems.[143]

[139] OECD. (2019). Improving Lithuania's public procurement system. Retrieved from: OECD website

[140] Lithuanian Innovation Centre (LIC). (2020). Regional guidebook on circular procurement. Retrieved from: LIC website

[141] Idem.

[142] Ministry of the Environment of Lithuania. (2021). Approval of the list of products subject to environmental criteria for public procurement, the description of the procedure for the application of the environmental criteria and the environmental criteria to be applied by contracting authorities when purchasing goods, services or works. Retrieved from: e-seimas website

[143] Lithuanian Innovation Centre (LIC). (2020). Regional guidebook on circular procurement. Retrieved from: LIC website

Deploying Green Public Procurement

The Netherlands is effectively building capacity for making public procurement a key instrument in accelerating the transition to a circular economy. In 2013, it was the first Member State to introduce Green Deal Public Procurement as a voluntary initiative targeting suppliers and public authorities and supplementing other existing instruments.[144] GPP started focusing on high priority areas but targeting low-hanging fruits, but it has since been extended to more resource- and energy-intensive areas such as infrastructure.[145] In 2017, the 'Dutch Public Procurement Expertise Centre' (PIANOo) was set up aiming to optimise procurement and tendering across all government branches.[146] In 2019, the government developed an analysis of the procurement system and proposed a roadmap for establishing an effective monitoring and reporting framework to broaden and optimise GPP.[147] Likewise, the Circular Procurement Guide[148] is a useful tool developed to present available knowledge, practical tips, and inspiring examples in the field of circular procurement to involved parties in the process. Overall, the development of clear guidelines and criteria and capacity building in procurement schemes reveals the power and effectiveness of institutional purchasing to build, scale, and embed circularity in production and consumption systems.[149]

Circular asset management aids the preservation and extension of infrastructure that is already in place, while supporting changes in design for upcoming infrastructure development. For example, the 'Multi-apartment Buildings Modernisation (Renovation) Programme', launched in 2005 in Lithuania and supported substantially through an innovative EU co-funded Financial Instrument, has proven highly successful: it has reduced energy consumption, bettered security of supply via reduced gas purchases, lowered carbon emissions, and created tens of thousands of jobs. Energy efficiency in multi-apartment buildings and residential districts has improved, reducing energy consumption by 133 GWh per year and has simultaneously secured 24,000 jobs by 2010.[150] Although figures and evaluation for the full programme are not yet publicly available, in the period from 2005-2018, 74% of the expected multi-apartment houses had been renovated. Nevertheless, results from an audit show that the selection process for the buildings can be improved in order to ensure the most thermal energy saving projects are taken on, which has not always been the case so far.[151] Moreover, in 2019, through this Programme, the Ministry of the Environment has commissioned a study to facilitate the cost-effective conversion of existing buildings into almost net-zero buildings to drive these

[144] European Commission (n.d.). Green Public Procurement in the EU. Retrieved from: EC website

[145] Eionet. (2019). Resource efficiency and circular economy in Europe. Netherlands country report. Retrieved from: Eionet portal

[146] PIANOo. (n.d.). Dutch Public Procurement Expertise Centre. Retrieved from: PIANOo website

[147] Metabolic. (2019). Towards climate-neutral and circular procurement. Retrieved from: Metabolic website

[148] Circular Procurement Guide of the Netherlands. (n.d.). Retrieved from: GDCI website

[149] Ecopreneur. (2019). Circular economy update. Retrieved from: European Circular Economy Stakeholder Platform website

[150] European Commission. (2019). Policy fact sheet Lithuania: Multi-apartment renovation programme. Retrieved from: BuildUp website

[151] National Audit Office of Lithuania. (2020). National Audit Office: at the current pace, modernisation of all energy-inefficient multi-apartment houses would be completed in 100 years. Retrieved from: vkontrole website

improvements further.[152] To further incentivise these initiatives, in 2021, the Ministry of Finance, the Ministry of Environment and the European Investment Bank (EIB) have decided to invest the EU assistance in a newly developed Investment Platform to increase the financing available for renovation of multi-apartment buildings in Lithuania in order to speed up the renovation process to contribute to the aim of carbon neutrality by 2050.[153]Within households, the "Boiler replacement in households" governmental campaign helps develop home infrastructure to support sustainable lifestyles, as the replaced boilers are powered by renewable energy derived from biomass.[154] Yet, the circular use of public-owned assets such as land, buildings and equipment could be further explored. Sustainable Urban Mobility Plans are expected to be implemented in each municipality, which could also help foster the management of assets powered by renewable energies.[155] Further, living lab concepts could potentially serve as an urban hub to foster innovation locally, involving both industry and municipalities in public-private partnerships. The collaboration between these maker hubs and the Digital Innovation Centres currently set up across Lithuania could be an area of cooperation to further explore.

Digital secondary raw materials market

Cyrkl[156] is an excellent example of circular resource management. This digital waste-to-resource trading platform focusing on circularity in waste management serves as an online marketplace connecting supply and demand for secondary raw materials. With over 4000 businesses from over 60 countries participating, thanks to advanced digitisation techniques and the knowledge of in-house experts, the company effectively connects business partners from the Czech Republic and across Europe to find new high-value reuse options.[157] The company facilitates the trade between both parties and ensures that the transaction is carried out safely and legally. Product waste categories and recycled materials range from plastics, textiles and building materials to paper, glass and electronic waste.

[152] European Commission. (2011). Scheme of renovation of the public buildings in Lithuania. Retrieved from: EC website

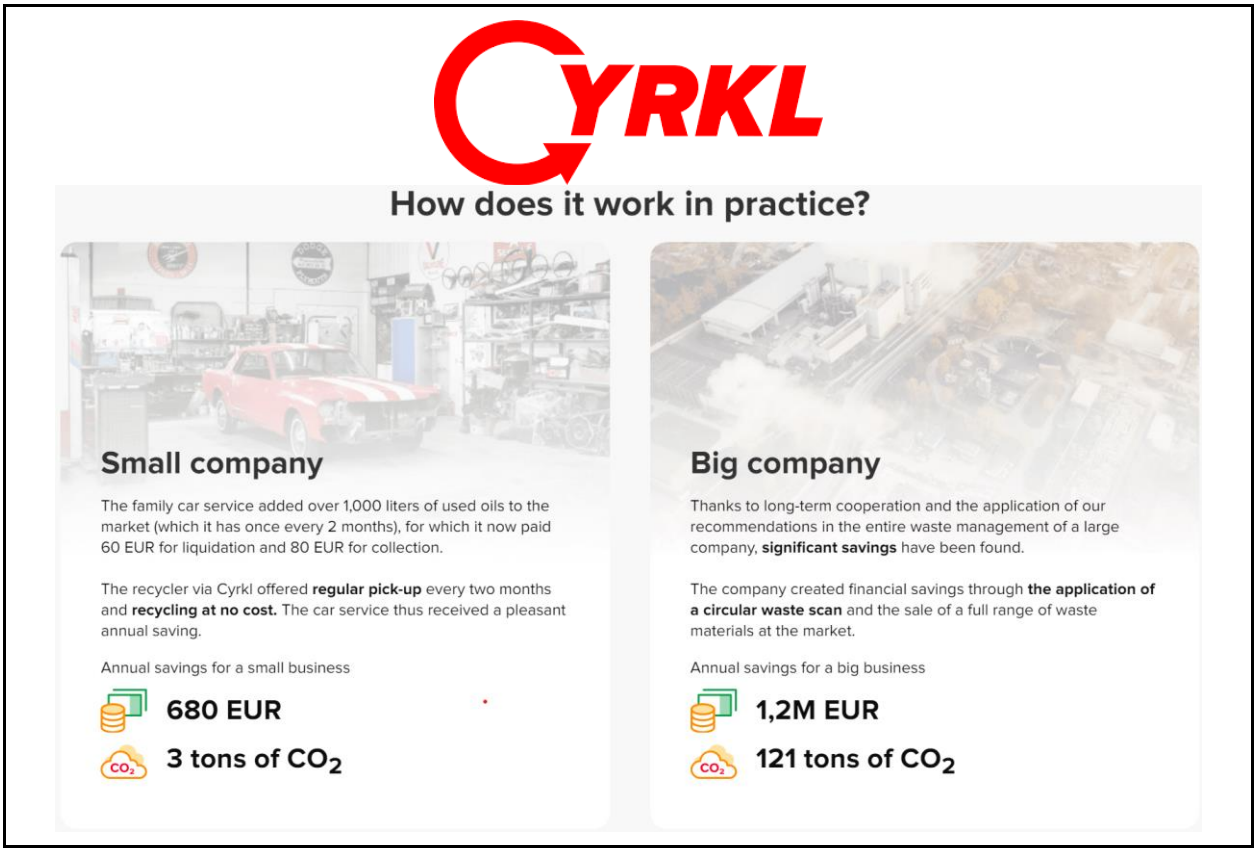
[153] Ministry of Finance of Lithuania. (2021). Renovation Wave: Innovative Investment Platform is Set Up to Increase Energy Efficiency of Multi-Apartment Buildings in Lithuania. Retrieved from: FINMIN website

[154] Amann, M. et al. (2018). Measures to address air pollution from small combustion sources. Retrieved from: EC website

[155] Eltis. (2019). Mobility Plans Lithuania. Retrieved from: Eltis website

[156] Cyrkl. (n.d.). waste2resource marketplace. Retrieved from: Cyrkl website

[157] Eco-Innovation Observatory. (n.d.). Czech Republic country profile 2018-2019. Retrieved from: EC website



Infrastructure development can also support the cycling of resources for better recovery of secondary materials. Lithuania has set up incentives for the establishment of Reuse Centres. Currently, there are diverse businesses and associations that collect used materials from different streams (i.e. electronics, batteries, light bulbs). The products are usually collected in containers at stores or supermarkets. These materials are then sorted and prepared for reuse or recycling depending on the type of waste and its potential use as a secondary material. This type of infrastructure has been incentivised since the amendment of the Waste Management Rules in 2017,[158] and has the potential to continue growing, as there are material streams that are currently underexplored. An example is the limited separate textile collection that currently lies around ~15% of the clothing consumed per capita.[159]

INCENTIVISE

Transforming production and consumption systems is fundamental to transition to a circular economy. Simultaneously, getting the economics of the transition right while promoting resource efficiency and circularity is a primary policy objective. To this end, fiscal and market incentives are vital

[158] Eionet. (2019). Country Report, Lithuania. Retrieved from: Eionet portal
[159] Watson, D. (2020). Textile flows in the baltic states (and what they tell us). Retrieved from: SEI website

to support new circular business models as well as promote the fast take-up of cutting-edge sustainable technologies.

Influence	Activity	Instrument (eg.)
INCENTIVISE	Direct financial support	Grant funding (eco-innovation, industrial development, European funds); Venture capital funding (SME support, microcredits)
		Debt financing
		Incubator and investment programmes (Climate Change Programmes; Innovation vouchers)
	Economic frameworks	Extended producer responsibility
		Public-private partnerships (strengthening R&D collaborations)
	Fiscal frameworks	Charges and tariffs (environmental pollution tax, primary resource use tax)
		Fines
		Tax breaks and reliefs (reduced pollution, secondary material use, renewable energy use).
		Subsidies

Table 4: Instruments to incentivise the circular economy transition.

Raising businesses' awareness of resource efficiency and the circular economy through targeted support programmes can incentivize or promote certain desired activities. This can be done through direct financial support, such as grant funding. The Eco-Innovation LT & LT+, or EUREKA Programme as well as the Investment Promotion and Industrial Development Programme have supported businesses in this capacity for the period 2014–2020. However, the usual fragmentation in the operationalisation of financing instruments between science and business hinders the full cooperation potential of these institutions for the uptake of circular strategies and technologies. Further cooperation and a clear assignment of responsibilities is required between the ministries in order to ensure that business and science are working together towards the country's circular ambitions and take innovations from the lab to the market.

Other funding instruments also may support the implementation of CE in Lithuania's industry, such as venture capital funding, eg. EU-supported venture capital fund for innovative businesses and eco-innovation; debt financing; SME support, eg. microcredits provided within the INVEGA Investment and Business fund; or foreign or domestic investment. Further, investment and incubator programmes such as the European EIT Climate-KIC supports startups addressing climate change through innovation with grants up to €50,000 and connects them to a large network of public and private

partners across Europe. Lithuania currently is active in one funded project under this accelerator in collaboration with Latvia, Estonia and Slovakia focused on clean technologies.[160]

Certain grant funds, as for instance, the Lithuanian Rural Development Programme funding during the period 2014-2020, have dedicated a small portion of its funds to organic farming practices (less than 15%).[161] Funded by the European Social Fund (ESF), the Entrepreneurship Promotion Fund Lithuania (2014-2020) offered microcredits up to €25,000 and supported the establishment and management of new business for start-ups, with a specific focus on creating inclusive and green job placements. The Entrepreneurship Action Plan (2014-2020) acknowledged the need to stimulate credit institutions to finance SMEs, relevant to the circular economy due to its tendency to facilitate decentralised and local industries, particularly in support of industrial symbiosis.

Targeted and direct resource efficiency implementation support

Resource efficiency support schemes and programmes targeted at industrial businesses effectively foster the diffusion of new technologies through market adoption. Given the industrial sector's weight in the Czech economy, innovation and competitiveness initiatives have primarily supported introducing new technologies focused on promoting resource efficiency.[162]

Granted by the Ministry of Industry and Trade, so-called 'Innovation vouchers' have proven to be a cost-effective policy instrument to stimulate in-house eco-innovation for businesses considering the acquisition of new sustainable technologies. Research organisations provide the supported companies with life cycle assessment (LCA) analysis, allowing them to evaluate the environmental impact of their envisioned activities better. This tool is part of a broader ministerial support programme aiming to pool resources, foster communication, and promote knowledge exchange by engaging businesses and research organisations. In this latter case, TRIO is a programme aimed at strengthening R&D cooperation between companies and research organisations. Via public tenders and direct financing from the national budget, TRIO supports applied research and experimental development on key enabling technologies (KETs)[163] and research and innovation projects in resource efficiency.[164] For example, ERC-TECH[165] is a com-pany that focuses on circular construction and that uses LCAs and invests R&D funding via the TRIO programme to develop in-house know-how and improve resource efficiency. It has developed new construction materials using secondary raw materials, and especially advanced technology for concrete production and brick recyclate.

[160] EIT Climate KIC. (n.d.). ClimAccelerator. Retrieved from: Climate-KIC website

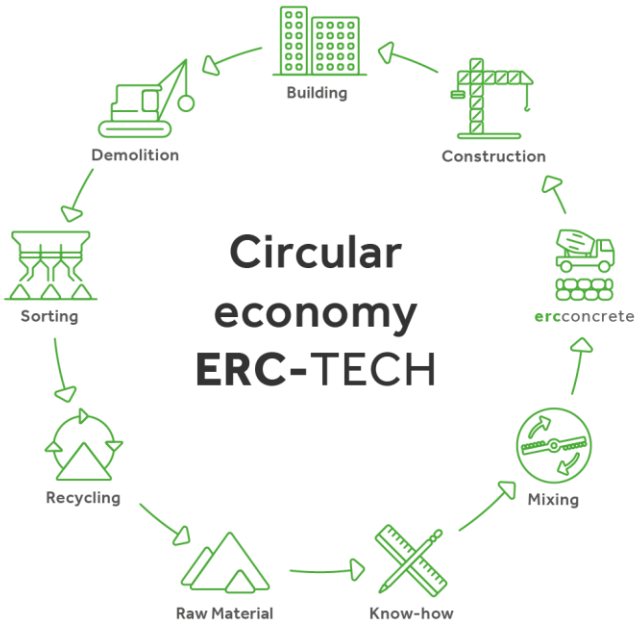
[161] European Commission. (2020). Factsheet on 2014-2020 Rural Development Programme for Lithuania. Retrieved from: EC website

[162] European Commission. (2019). Environmental Implementation Review. Czech Republic country report. Retrieved from: EC website

[163] Photonics, micro and nanoelectronics, nanotechnologies, industrial biotechnologies, advanced materials and advanced manufacturing technologies.

[164] Eionet. (2019). Resource efficiency and circular economy in Europe. Czech Republic country report. Retrieved from: Eionet portal

[165] ERC-TECH. (n.d.). Sustainability. Retrieved from: ERC-TECH website



Direct investment and allocation of capital flows to specific circular efforts are also effective mechanisms to support the transition.

Estonia has invested over €110 million in providing SMEs with more resource-efficient technologies and solutions through the EU multiannual financial framework for 2014-2020, as part of its target to achieve a 10% increase to €0.46/kg (GDP/domestic material consumption) by 2023. Supported activities include funding to raise awareness, training resource analysts, conducting resource audits, and directing investments.[166] Similarly, the Estonian Environmental Investment Centre (KIK) is an example of good practice for being an effective agency supporting sustainable businesses by financing environmental activities and investment projects.[167] KIK has been for over 20 years the national agency tasked with implementing state and EU funding in areas related to, among others, the circular economy and resource efficiency.[168]

[166] Eionet. (2019). Resource efficiency and circular economy in Europe. Estonia country report. Retrieved from: Eionet portal
[167] European Commission. (2019). Environmental Implementation Review. Estonia country report. Retrieved from: EC website
[168] Environmental Investment Centre of Estonia (KIK). (n.d.). KIK. Retrieved from: KIK website

Extended Producer Responsibility (EPR) is a crucial policy approach that has proven effective in advancing eco-design regarding waste collection and recycling. In Lithuania, EPR schemes have been introduced for packaging waste, batteries and accumulators, waste electrical and electronic equipment (WEEE), internal combustion engine or fuel oil filters, car hydraulic (oil) shock absorbers, used tyres, end-of-life vehicles, and oils.[169] Because the ultimate aim of EPR schemes is to foster improved product design to reduce waste and facilitate recovery after disposal, a closer connection to circularity driven innovation and R&D are yet to be established, especially for currently unregulated waste streams.[170]

Promoting broader, more ambitious EPR legislation

When used effectively and fairly, EPR is an excellent policy instrument to tackle waste generation. In the Netherlands, EPR schemes currently apply to a wide variety of manufacturers and importers of cars, tyres, electrical and electronic goods, packaging, and batteries.[171] A programme for the remanufacturing and refurbishment of medical equipment is also in place. Additionally, research has been carried out to improve EPR: explore the routes for the optimization of EPR, extend the scope of EPR regulation to new products and waste streams and deepen the scope of EPR within regulated waste streams to advance the circular economy.[172] The Dutch government is currently examining expanding this strategy to additional products —like mattresses and disposable nappies— and sectors such as textiles.[173]

Sound fiscal measures are a key lever for transformation and a powerful market-based instrument in the state's toolbox. For instance, by sending correct price signals, tax structures, subsidies and incentives, and fees are instrumental in providing market stimuli and creating market designs that encourage a new cycle of innovation and investment. Likewise, taxation can also be used to level the playing field by discouraging the use of primary resources and fossil fuels while allowing the secondary raw materials market and renewable technologies to grow and become competitive. The best example available in Lithuania to incentivise circular economy actions is the deposit-refund system for beverage products, such as single-use plastic, glass bottles and metal cans.[174] Collection rates for these streams have increased from 55% in 2016 to 90% in 2017, reaching the target set for 2020 three years ahead of time.[175]

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[169] European Environment Agency. (2016). Municipal solid waste management. Lithuania country fact sheet 2016. Retrieved from: Eionet portal

[170] EUROPEN. (2013). Position on Extended Producer Responsibility for post-consumer packaging in the EU. Retrieved from: Municipal waste Europe website

[171] Government of the Netherlands. (n.d.). Accelerating the transition to a circular economy. Retrieved from: Government of the Netherlands website

[172] EY. (2016). Exploration of the Role of Extended Producer Responsibility for the circular economy in the Netherlands. Retrieved from: Ministry of Infrastructure and Water Management website

[173] Government of the Netherlands. (n.d.). Accelerating the transition to a circular economy. Retrieved from: Government of the Netherlands website

[174] ACR+ (2019). Deposit-refund systems for one-way beverage packing in Europe. The case of Lithuania. Retrieved from: ACR+ website

[175] OECD. (2020). OECD Economic Surveys: Lithuania. Retrieved from: OECD website

On the other hand, ineffective taxation can hinder the uptake of environmentally sound practices. Environmental pollution taxes in Lithuania have been significantly low, although fiscal reforms are starting to move forward and tax rates for pollutants discharged are increasing. Nevertheless, positive steps are being taken in this direction with the recent amendment to the Pollution Tax Law that introduces different tax rates for recyclable and non-recyclable packaging and fines for non-compliance with packaging management requirements.[176] From the three Baltic states, Lithuania has the least of their tax revenue coming from environmental taxes, whilst spending the most on actions and programmes to protect the environment.[177] Tax reliefs are also available for those who reduce the amount of pollutants discharged by at least 5% above the set maximum allowable pollution limits. Nevertheless, no polluters in the period 2011-2019 were granted tax relief and have therefore not invested in pollution reduction measures of their own.[178]

Adjusting fiscal frameworks to meet the needs of sustainability transitions

Taxes are important instruments that change consumer behaviour indirectly by increasing prices and triggering upstream change in supply chains and production processes. The Netherlands is employing green taxation effectively, and significant tax policy adjustments are being implemented to support the circular economy and energy transitions. Ongoing initiatives aim to compensate income tax reductions with increased tax revenues from energy, environment, and consumption. In this regard, some relevant fiscal measures implemented include lower taxes for electricity—offset by a tax hike for natural gas—and the almost total elimination of fossil-fuel subsidies. CO2-based taxes are growing in prevalence and a floor price for CO2 is being considered. [179]

Additionally, there are in place several tax incentive/relief schemes and subsidy programmes related to circularity and sustainability. Firstly, a reduced VAT rate —of 9%, instead of 21%— applies to some second-hand goods and minor repairs services (such as bicycles, footwear and leather goods, and clothing and household linen).[180] Secondly, the Environmental investment rebate (MIA) allows organisations to deduct up to 36% of the investment costs for a 'green investment' (on top of regular tax deductions for investments). Thirdly, the Arbitrary depreciation of environmental investments (Vamil) allows for eligible sustainable investment costs to be written off.[181]

REGULATE

An enabling regulatory framework is crucial to support a systemic approach to the circular economy. Regulatory barriers often lock opportunities related to critical areas like collecting waste streams, the

[176] Rödl & Partner. (2021). Newsletter Lithuania 2021. Retrieved from: Roedl website

[177] Czerniak, A. (ed) et al. (2019). No time to waste: unlocking the circular potential of the Baltic Sea Region. Retrieved from: Interreg Europe website

[178] OECD. (2020). Environmental Performance Review Survey.

[179] European Commission. (2019). Environmental Implementation Review. Netherlands country report. Retrieved from: EC website

[180] Netherlands Tax and Customs Administration. (n.d.). Tax Rates and Exemptions. Retrieved from: Tax and Customs Administration website

[181] Netherlands Enterprise Agency (RVO). (n.d.). MIA and Vamil. Retrieved from: RVO website

uptake of secondary resources, and design for reuse, repair or recycling. Modifying the rules of the systems may lead to enhancing the entire cycle from production and consumption to innovation and the secondary raw materials market.

Influence	Activity	Instrument (eg.)
REGULATE	Regulation	Monitoring and enforcement: - Accounting systems - Economic activity rules
	Legislation	Bans (eg. landfill) Performance standards; International voluntary and mandatory standards Technology standards Labelling Pre-commercial procurement

Table 5: Instruments to regulate the circular economy transition.

Monitoring supports the effectiveness of established regulation and allows for continual review of these regulations. This may be done through setting clear rules for economic activities, such as the Waste management rules, including rules for preparation for reuse or setting requirements for waste incineration or on managing packaging and packaging waste.[182] Additionally, in order to assess coherently the regulations imposed, the state needs to secure effective accounting systems. The GPAIS Waste Accounting System[183] is a national example of how setting up an automated data collection, analysis and monitoring system for product, packaging and waste accounting can aid the Environment Protection Department in achieving better control of businesses and their waste behaviour. However, the system still lacks a practical and accessible approach to make it functional and efficient for businesses. A working group is currently being established and managed by AM to develop the system further and tackle these remaining issues.

Effective measuring and monitoring mechanisms

Measuring and monitoring progress is key to show whether circularity is gaining a foothold in the economy. In the Netherlands, the Environmental Assessment Agency (PBL) publishes inventories[184] and a biennial progress report to guarantee that the country keeps on course to achieving its goals, ensure consistency, and allow for necessary planning and adjustment on the way. Furthermore, PBL has published a 'Framework and baseline assessment for monitoring the progress of the circular

[182] Government of Lithuania. (2016). Law on Waste Management. Retrieved from: Seimas of Lithuania website

[183] Unified Product, Packaging and Waste Record Keeping Information System (GPAIS). (n.d.). Retrieved from: GPAIS website

[184] Netherlands Environmental Assessment Agency (PBL). (2019). Outline of the Circular Economy. Retrieved from: PBL website

economy in the Netherlands'[185] to develop indicators and ensure progress tracking. Having a clear picture of the current state is fundamental to effectively identify problems, bottlenecks, and best practices during the transition process and hence act accordingly.

Legislation may also support innovation across sectors, through updating performance and technology standards, revising labelling requirements and establishing bans to certain disposal practices or materials. In Lithuania, the most well-known bans in the country are the dumping or illegal landfilling ban, the ban for landfilling accumulators and batteries, as well as a similar ban to prevent landfilling of biodegradable waste from gardens, all of these materials which could have higher value treatment through other disposal and recovery methods.[186]

Additionally, existing legislation, such as the Law of Pre-Commercial Procurement established in 2015, allows authorities to invest in R&D services when there is no innovative product that meets those needs in the market yet (or there is no evidence that there will be a product as such in the market in less than one year).[187] Another example of legislation that may support innovation and designing for a circular future is the setting of eco-design requirements. In Lithuania, these requirements have already been set for small solid fuel for energy products,[188] but these could be proposed for a myriad of product categories to incentivise redesign in relevant sectors of the economy. The effective implementation of internationally recognised mandatory and voluntary industry standards, such as ISO 14001 on environmental management, can also support the promotion of resource efficient, circular and sustainable industry practices. Finally, the Lithuanian Law on Social Enterprises (2004 - Am. 2019) provides a legal framework for enabling social enterprises to gain financial support from the ESF. Supporting social enterprises to engage in the circular economy and work integration social enterprises (WISEs) in particular, presents opportunities when it comes to promoting local job opportunities for people that face challenges in the labour market and social innovation more widely.[189,190]

Mechanisms to keep regulatory frameworks updated and fit-for-purpose

Reviewing and updating regulatory frameworks to ensure that they are coherent and fit-for-purpose is of utmost importance to support the CE transition. In 2018, the Netherlands' government introduced an implementation programme for the period 2019-2023 to identify and eliminate regulatory bottlenecks hindering the implementation of the CE transition agenda. This programme

[185] Netherlands Environmental Assessment Agency (PBL). (2018). Circular economy: what we want to know and can measure. Retrieved from: PBL website

[186] European Commission. (2012). Lithuania country fact sheet. Retrieved from: EC website

[187] Pre-commercial procurement in Lithuania. (n.d.). Retrieved from: Interreg Europe website

[188] Government of Lithuania. (2014). Ecodesign requirements for energy-related products. Retrieved from: Register of Legal Acts website

[189] TFSSE. (2014). Social and Solidarity Economy and the Challenge of Sustainable Development. Retrieved from: UNSEE website

[190] Circle Economy. (n.d.). The social economy: a means for inclusive & decent work in the circular economy? Retrieved from: Circle Economy website

focuses on and targets the five high-priority supply chains —Biomass and food, Plastics, Manufacturing, Construction, and Consumer goods— through specific actions and projects. Thus, the government's plan seeks to review and, where necessary, shift the focus of and update regulation, amend legislation, and remove inconsistencies, administrative burdens, and legal uncertainties to accelerate the transition.[191] For example, some of the adjustments currently being carried out include: 1) the extension of EPR to multiple relevant product groups such as façade construction and for products that are important for the energy transition, 2) the establishment of the Waste Review Task Force to identify regulatory and legislative obstacles and suggest solutions in this field, 3) providing market stimuli via tracking the pricing of environmental damage, an almost twofold waste tax hike, and CO2 carbon shadow pricing in the procurement of large infrastructure projects, and (4) multiple measures related to the monitoring, knowledge, and innovation aspects of the transition, including among other things a Biennial report.

2.1d Barriers and enablers in the circular industrial transition

KEY TAKEAWAYS:

- Each country faces rather different barriers due to their distinct sociocultural profiles, politico-economic structures, and transition stages. However, there are also generic and commonly identified challenges, such as difficulties in developing a competitive market for secondary raw materials, lack of political commitment at the highest levels, an unfit for purpose regulatory framework, and low social awareness and interest.
- Lithuania's most pressing identified barriers concern: 1) policy development and integration and the institutional setup, 2) sociocultural challenges related to social behaviour and awareness, 3) the lack of a secondary materials market, and 4) an unsupportive national regulatory framework.
- Enablers are shared between countries, but their degree of significance somewhat differs. One overarching enabler for CE is the political commitment and policy landscape at the EU level, driving a strategic shift at the national level towards sustainability and circularity across all Member States. Besides that, results are mixed and context-specific.
- For Lithuania, collaboration, the policy and regulatory, and cultural factors remain minor enablers, although all show progress and promising results in the short- and medium-term.

[191] Ministry of Infrastructure and Water Management of the Netherlands. (2019). Circular Economy Implementation Programme 2019-2023. Retrieved from: Holland circular hotspot website

Barriers

Barriers to achieving a circular economy are common and widespread for all Member States.[192] *Yet, despite challenges being generic and plentiful, owing to their distinct politico-economic structures, sociocultural traits, and transition stages, each country faces more prevalent and specific barriers. At the same time, it is also important to note that, despite being categorized separately, barriers are tightly linked to one another. For example, the difficulty to develop and grow a competitive secondary materials market is closely related to a regulatory environment that supports the status quo through artificially high prices and a lack of clear, reliable fiscal incentives for secondary materials. Similarly, outdated regulation, which often stands in the way of circular and sustainable business opportunities despite their strong underlying profitability, can also hinder well-established business cultures to engage in circular practices.*

A brief explanation of the barriers categorisation made goes as follows:

Policy and regulatory barriers encompass obstacles related to: 1) a lack of a reliable and consistent policy framework and the non-availability of indicators and targets, and 2) an obstructive, not fit-for-purpose regulatory environment that serves the status quo. These two factors ultimately produce a practical and effective lack of incentives for the CE to take root.

Governance barriers encompass obstacles related to 1) a lack of an adequate institutional setup for effective policy ownership and within-government coordination, and 2) a lack of proactive multi-party stakeholder engagement.

Cultural barriers encompass obstacles related to: 1) a rigid linear business culture that can result in a failure to grasp opportunities as a result of a lack of interest, knowledge, and engagement within businesses and across the value chain, and 2) more broadly, low social awareness and unsupportive consumer behaviour fail to provide much needed momentum for upstream change to happen.

Market barriers encompass obstacles related to price signalling problems and a lack of a competitive market for secondary raw materials, for example, due to low prices for virgin materials.

Technological barriers encompass obstacles related to: 1) the low availability and high acquisition costs for new, more sustainable technologies, and 2) difficulties concerning adequate R&D and eco-innovation. To a certain extent, this category is also linked with some obstacles related to finance, such as limited availability of funds and funding conditions for the implementation of skills programmes and new business models.

[192] European Environment Agency (EEA). (2019). Resource efficiency and the circular economy in Europe 2019. Retrieved from: EEA website

	Policy & Regulatory		Governance		Cultural		Market	Technological	
	Policy framework	Regulation	Stakeholder engagement	Institutional set-up	Knowledge, engagement and business culture	Social awareness & behaviour	Secondary materials market	Availability & acquisition costs	R&D and Innovation
Lithuania									
Estonia									
Czech Republic									
Netherlands									

Table 6: Comparative heatmap of circular economy barriers in *selected EU countries.*

Most pressing barriers | Intermediate pressing barriers | Least pressing barriers

Barriers related to policy and regulation are core obstacles for the CE to advance. Lithuania lacks a comprehensive CE national roadmap with clear goals, targets and indicators. This prevents establishing a shared vision that can act as a rallying point for mobilising actors and resources to advance the transition. Active government support is starting to pick up: some of the CE's multiple dimensions, such as resource and energy efficiency and waste and pollution prevention, are already embedded in various strategic documents and policy initiatives. However, these efforts are limited and loosely connected, resulting in low effectiveness. The importance of policy and regulatory fragmentation cannot be understated. For example, a survey respondent cited "the lack of clear regulations or named guidelines for the circular economy that will guide all players in the industry equally" as a relevant obstacle standing in the way of change. A reliable policy mix and regulatory framework that integrates harmonisation of standards and definitions is critical to creating a level playing field where the key elements of the CE model can gain a foothold in industrial processes. At the same time, there appears to be a lack of coherence and alignment between industrial priorities and strategies at the European and national level, at least partially. For example, even though a strategic reorientation and integration of Lithuanian industry and trade towards European value chains are being pursued, for instance, through the European structural and investment funds, Lithuania's current export promotion policy[193] indicates a motivation to pursue an expansion of trade relations with foreign, non-EU economies. Similarly, the European Green Deal focuses on sustainability to strengthen competitiveness, while Lithuania aims to compete in emerging markets, where, for example, purchasing power is usually lower, and sustainability is not always prioritised over costs. Moreover, there is a lack of funding for circular, sustainable industrial processes since it is not

[193] Ministry of Economy and Innovation of Lithuania. (2015). Export promotion policy. Retrieved from: EIMIN website

considered a top priority for the government. Therefore, there appears to be a contradiction between Lithuanian and EU-wide sustainability and innovation policies and competitiveness strategies.

Governance is weak and policy ownership unclear. The current institutional setup negatively impacts within-government coordination, creates bottlenecks and misalignments, and hampers the harmonisation of roles and tasks, definitions, and efforts. Policy initiatives are not being matched by a provision of sustained leadership and momentum at the highest political level. Moreover, formal mechanisms for proactive stakeholder engagement and participatory decision-making at different levels are lacking. Interinstitutional cooperation and coordination and effective involvement across different government levels (national, regional and local) remains weak. All the aforementioned ultimately impacts the overall coherence and effectiveness of CE efforts, hindering the structural shift towards circularity. A clear impacted area of this lack of interinstitutional cooperation and weak governance is scientific collaboration between industry and academia. For instance, businesses struggle to find top researchers in academia to support their envisioned research and innovation initiatives. Simultaneously, while high-level joint collaboration between businesses and the scientific community does occur, the main challenge in this area relates not so much to the intensity and regularity but the purpose of the collaboration: there appears to be a lack of engagement in R&D activities generating products and services with commercial potential.[194] Therefore, in this sense, governance and institutional barriers relate to lack of effective contact points between Ministries, regions, government agencies, academia and the business community, not a lack of policy instruments.

Sociocultural and within-business challenges are also fundamental. Despite recent efforts, there is ample room for more and better information dissemination, knowledge development, and awareness-raising among businesses and citizens regarding resource efficiency, waste prevention and sustainable consumption. Circularity can only get a foothold in the industry if knowledge of the model, together with the economic and environmental benefits it brings, spreads internally (management and workers) and externally (investors and consumers). For example, most Lithuanian businesses, particularly SMEs, fail to grasp the direct benefits in terms of competitiveness and added-value that eco-investments and resource optimisation brings: only one in five actively engage in reducing waste generation in production and service provision processes.[195] There is also a lack of mindset change from competition to collaboration and focus on higher-value added production within the business community. Moreover, outside the Vilnius and Kaunas urban regions, there is a serious lack of knowledge related to ecology, sustainability and circularity. A systemic transformation of industrial processes, one where waste and pollution prevention and resource optimisation are its

[194] PPMI. (2021). Report on the Lithuanian industrial landscape and its potential to integrate into the European value chains (Unpublished). Ongoing project information can be retrieved from: PPMI website

[195] Ecopreneur. (2019). Circular economy update. Retrieved from: European Circular Economy Stakeholder Platform

cornerstones, inevitably demands higher sensibilisation and a broader change of focus and mindset by society as a whole.

From the market perspective, the failure to grasp opportunities and the lack of clear and consistent incentives is crucial. Firstly, due to cultural and structural reasons, CE is not seen as economically attractive or to provide a competitive advantage or edge. Moreover, a lack of compelling fiscal incentives and supportive policy measures foils the adoption and implementation of, among others, (eco-)innovation initiatives.[196] For example, a lack of both direct control and incentives regulation, prevents the creation of a secondary materials market. However, positive steps are being taken in this direction with the recent amendment to the Pollution Tax Law that introduces different tax rates for recyclable and non-recyclable packaging and fines for non-compliance with packaging management requirements.[197] Yet, the lack of adequate and more ambitious support instruments to other products and materials impedes the secondary raw materials market to emerge and consolidate, hindering the development and expansion of new business models. Similarly, for well-established linear business models in the industrial sector, the lack of a reliable and consistent regulatory framework and financing model gives little support to companies to rethink their revenue streams or implement eco-investments. This current position means that CE is not perceived or considered as economically attractive and/or viable by many companies.

Infrastructure development is also a weak spot hindering circularity. In general, there is a lack of well-organised waste management infrastructure. For example, recent investment in incineration infrastructure can result in overcapacity and ultimately thwart waste prevention and better waste management practices. There is also a lack of infrastructure for new investments due to poor regional planning and low acceptance of local communities, especially of production companies. Sorting infrastructure and regulation is still not the best balanced to have maximum performance (for example, separation of biodegradable waste). Moreover, heavy investment in fossil fuel infrastructure and the importance of the sector for trade and the economy also poses long-term challenges to phasing out highly-polluting, resource-intensive industries like oil and natural gas.

Estonia faces very similar challenges to Lithuania, mainly at the policy and governance level. From a policy perspective, much like Lithuania and the Czech Republic, integrating the country's different raw material plans and strategies and developing policy for such a cross-sectoral, horizontal topic as the CE proves a major challenge for policymakers. Directly related to this, and despite recent improvements, broad, active and effective stakeholder engagement remains weak. This lack of policy coordination and integration and proactive stakeholder engagement hampers the development of a unified, coherent, and coordinated strategic approach to the CE agenda.[198] Additionally, despite an enabling digital environment and robust startup and innovation culture, low R&D intensity and little diversification from large-scale industrial actors limit the emergence of support opportunities derived

[196] European Commission. (2019). Environmental Implementation Review. Lithuania country report. Retrieved from: EC website
[197] Rödl & Partner. (2021). Newsletter Lithuania 2021. Retrieved from: Roedl website
[198] European Environment Agency (EEA). (2019). Resource efficiency and the circular economy in Europe 2019. Retrieved from: EEA website

from KETs and economic enablers (primarily ICT focused).[199] Dissemination of technologies is essential since big businesses play a crucial role in driving innovation-led economic development and diffusing new technologies through early market adoption.

The Czech Republic faces political, cultural, technological, and market challenges. On a political level, resistance to change, the lack of leadership at the highest levels, and fixation with business-as-usual thinking are crucial barriers hindering the advancement of circularity.[200] The results are insufficient ambition, misalignments and bottlenecks and an overall lack of policy integration and coordination.[201] Another fundamental obstacle relates to demand-side barriers: a low social appetite for and interest in circularity, which in turn results in a lack of confidence and risk-taking in industrial companies for more sustainable operations and business models.[202] Similarly, there is also a lack of venture capital to finance new technologies as eco-innovation areas tend to be disregarded by investors.[203] There are also several shared challenges with Lithuania. For example, factors derived from the structure of the labour market and the availability of skills and expertise make it difficult to fill research placements.[204] Similarly, cooperation between industrial businesses and research institutions, although increasing, remains rather low.[205] Furthermore, an outdated and obstructive regulatory framework serving to preserve the existing status quo impedes effective change to occur in critical areas like waste management, where landfilling, hierarchical waste structures, and artificially high secondary raw materials remain key obstacles.[206,207]

Barriers faced by the Netherlands are shared with other countries but also differ substantially. While the country is ahead of the curve from the policy and governance perspective, cultural and market challenges are once again central. For instance, relatively low consumer interest and awareness also impede many Dutch businesses to develop circular business models and secure more circular revenue streams.[208] Likewise, the fact that the linear economy is well-established in company cultures and entrenched in system operations also hampers business transformation.[209] This reveals how a society-wide, systemic transformation is required for the CE transition to advance effectively. Moreover, high upfront acquisition costs and lack of funding for new technologies, and low prices for virgin materials are the most pressing market barriers.[210,211] Additionally, despite doing well in terms

[199] Ecopreneur. (2019). Circular economy update. Retrieved from: European Circular Economy Stakeholder Platform
[200] INCIEN. (2020). Mission & vision statement 2021-2025. Retrieved from: INCIEN website
[201] Eco-Innovation Observatory. (n.d.). Czech Republic country profile 2018-2019. Retrieved from: EC website
[202] Direct People & INCIEN. (2018). Circular Czechia. Retrieved from: Direct people website
[203] Ecopreneur. (2019). Circular economy update. Retrieved from: European Circular Economy Stakeholder Platform
[204] Ecopreneur. (2019). Circular economy update. Retrieved from: European Circular Economy Stakeholder Platform
[205] European Commission. (2019). Environmental Implementation Review. Czech Republic country report. Retrieved from: EC website
[206] Direct People & INCIEN. (2018). Circular Czechia. Retrieved from: Direct people website
[207] Eco-Innovation Observatory. (n.d.). Czech Republic country profile 2018-2019. Retrieved from: EC website
[208] Kirchherr, J. et al. (2017). Breaking the barriers to the circular economy. Retrieved from: Utrecht University website
[209] Ecopreneur.eu (2019). Circular economy update. Retrieved from: European Circular Economy Stakeholder Platform
[210] Kirchherr, J. et al. (2017). Breaking the barriers to the circular economy. Retrieved from: Utrecht University
[211] Eco-Innovation Observatory. (n.d.). Netherlands country profile 2018-2019. Retrieved from: EC website

of innovation and entrepreneurship, the low take-up of ecolabel licences and the sparing use of eco-management and audit schemes remain significant barriers to innovation. In this regard, there is also a need to focus on the transition's social dimension and for a broader appreciation of the necessity to promote different forms of innovation beyond technological, such as financial, organisational, and social.[212] Lastly, although work is being done in this regard, a distinctive regulatory barrier is related to the availability of indicators to measure targets and difficulties for monitoring the CE agenda's implementation.[213]

Enablers

Enablers promoting the circular economy in industry are manifold. Firstly, the circular economy is a collaborative economic model: only by cooperating in a mutually beneficial way can, for example, industrial symbiosis be developed. In this sense, stakeholder engagement and collaboration networks are vital in promoting open communication and know-how exchange between core change agents, such as academia and companies as well as consumer organisations and municipalities. Secondly, an overarching driving force for all countries is the existential threat posed by environmental pollution and climate change and the enabling European policy landscape. Political commitment and leadership at the European and, in some cases, national level translate into enabling policy and regulatory frameworks. For example, a good policy mix consisting of a national roadmap with clear goals and targets combined with regulatory reform can be a core enabler for advancing the circular industrial transition. Similarly, the strive for a reduced import bill and, in some cases, geopolitics can also be a driving force for policies that support increased resource efficiency in industrial production processes. Thirdly, cultural and social factors and trends are also fundamental, albeit often overlooked, enablers of the transition. For example, demand-side factors such as environmental consciousness and consumer choices together with grassroots support create decisive momentum towards more circular and sustainable consumption patterns, positively influencing industrial production processes. Fourthly, developing breakthrough innovations aligning skills innovation and skills strategies with CE are also crucial enablers. However, to enable an industrial transition to circularity, it is also essential to transcend purely technological innovations and consider other social and organisational innovations that, for example, spur new business models.

A brief explanation of the enablers categorisation made goes as follows:

Collaboration encompasses activities related to stakeholder engagement, the establishment of longer-term relationships and partnerships, and companies engaging in vertical and horizontal collaboration at the sectoral, local and regional levels to promote, for example, industrial symbiosis by jointly developing infrastructure and exchanging knowledge.

[212] European Commission. (2019). Environmental Implementation Review. Country Report the Netherlands. Retrieved from: European Commission

[213] European Environment Agency. (2019). Resource efficiency and the circular economy in Europe 2019. Retrieved from: European Circular Economy Stakeholder Platform website

Policy and regulation concern the EU-wide and national policy landscape, ranging from legislative initiatives to regulatory reforms and financing instruments. Leadership and commitment at the highest political level is also an important enabler.

Cultural enablers encompass education, awareness and communication related to sustainability and environmental issues, both within companies and society. They are fundamental to stimulate demand for sustainable products and services and thus support the development of circular, low-carbon industrial processes and alternative business models.

Technology and innovation encompass different activities such as funding and investment in R&D, patents and commercially viable cutting-edge technologies, and increasing the availability of skills and technical expertise are crucial enablers for circularity.

	Collaboration	Policy & Regulation		Cultural	Technology & Innovation
	Effective stakeholder engagement, support networks	European policy and regulatory environment	National policy and regulatory environment	Education, awareness & communication	Funding and investment in new technologies, Eco-innovation, R&D
Lithuania					
Estonia					
Czech Republic					
Netherlands					

Table 7: Comparative heatmap of circular economy enablers in *selected EU countries.*

Core enablers Intermediate enablers Minor enablers

In the first place, because there are EU-wide shared political and economic factors, it is relevant to identify overarching enablers for circularity at the European level. As a highly-industrialised and major trading block but resource-poor world region, resource efficiency is one of the core political and economic factors driving the implementation of circularity within the EU. To this end, EU-wide funding mechanisms, legislative initiatives, policy support and regulatory reforms have aimed to pursue the circular transformation of industrial processes. Recent examples include the 2018 introduction of general minimum requirements on EPR[214], the recent revision of the European taxonomy for sustainable investments and the *European Circular Economy Stakeholder Platform,* which effectively fosters intra-EU stakeholder engagement by facilitating the exchange of best practices, expertise, and information. **From a European perspective, the main enablers of the circular economy are new**

[214] Directive (EU) 2018/85. Retrieved from: EUR-Lex website

legislative initiatives and regulatory frameworks, economic opportunities, education and innovation factors. Firstly, an overarching driver for all countries is the newly established and expanding European policy framework supporting the CE transition, mainly the 2015 CE Action Plan[215] and the European Green Deal[216]. Secondly, economic enablers are also crucial to resource-scarce EU: price fluctuations and growing resource use are often highlighted as relevant driving forces for more sustainable economic models. EU Programmes such as *Horizon 2020*[217] and *Industry 2020 in the Circular Economy* have provided funding to help businesses across the EU to bridge the resource scarcity gap and become more resilient by becoming more sustainable. Several other initiatives such as *Factories of the Future*, *Sustainable Process Industries*, and *Bio-based Industries* have been launched at an EU level to support the technological development and deployment of cutting-edge manufacturing solutions across a wide range of sectors. A new funding round for the Horizon Europe innovation programme for 2021-2027 has an available budget of 95.5 billion euros, and the LIFE Programme for 2021-2027 has made available 5.43 billion EUR. Open calls under the sub-programmes of 'Circular economy and quality of life sub-programme' or 'Clean Energy Transition' are relevant to this landscape. Thirdly, EU education and innovation policies are two crucial horizontal enablers for circularity. Raising social awareness and generating the necessary skill base through education and training are underlying foundations to foster adequate R&D and spur (eco-)innovation.

From a broad perspective, progress directly linked to circularity shows a positive performance in two areas. Firstly, waste disposal per citizen compared to the EU average is relatively low and the deposit-refund system for beverage packaging has been an impressive success, illustrating the high potential for further effective action. Secondly, despite ranking well below EU average, material resource productivity has substantially increased from 2011, showing a relative decoupling of economic growth from resource use.[218]

Collaboration is where Lithuania remains weakest. As explained in the previous section, broad proactive stakeholder engagement and a whole-of-government approach are lacking, interinstitutional cooperation is weak, and competition prevails over cooperation among key change agents, such as SMEs. However, there is also a growing alignment between policy priorities and the needs of the scientific and business community. There also appears to be momentum building among the business community, particularly among large companies, regarding the direct and co-benefits of collaboratively transitioning to a CE model (i.e. increased competitiveness). Collaboration is vital: Given the industrial structure of Lithuania, full-closed loop value chains are complicated but there is big potential to be exploited at the micro and meso level and for industrial symbiosis, especially in industrial parks.

As key levers for change, policy and regulation show diverse results between the European and the national level. On the one hand, EU legislative initiatives and funding mechanisms are decisive factors

[215] European Commission. (2015). Closing the loop: an EU action plan for the circular economy. Retrieved from: EC website
[216] European Commission. (2020). Circular Economy Action Plan. Retrieved from: EC website
[217] European Commission. (n.d.). Lithuania Horizon 2020 country profile. Retrieved from: EC website
[218] Eurostat. (2019). Resource productivity. Retrieved from: Eurostat

stimulating circularity in Lithuania**.** Firstly, the national transposition of amendments to EU's Waste Legislation, the setting of clear waste reduction and treatment targets, and other EU-wide initiatives, such as GPP, have initiated modifications in national legislation and the mobilisation of public resources. For instance, the Lithuanian Innovation Centre (LIC), Kaunas University of Technology (KTU) and other partners have come together to boost eco-innovation and circular public procurement. The successful implementation of the deposit-refund system also exemplifies well how EU legislation, in this case mandatory recycling targets, can stimulate change and mobilise action at the national level. Secondly, financial instruments such as European Regional Development Fund (ERDF) and the ESF from the EU's Cohesion policy, which directly supports Lithuania's industrial transition by attempting to address the structural challenges linked to energy, resources and skills, have been successfully used to support energy efficiency investments in buildings.[219] Additionally, measures like Eco-innovation LT and Eco-innovation LT+ funded by the EU structural funding period 2014-2020 have effectively supported the development of eco-innovation, for example, related to developing/using plastic and wood as secondary materials.[220] On the other hand, the lack of a coherent, national strategic CE roadmap, political leadership and commitment, and availability of targets and indicators hinders the advancement of circularity. However, there are still positive driving forces influencing CE policymaking. For example, a mix of economic interests and geopolitics also drives Lithuania's strive for resource efficiency. Firstly, aiming to improve energy security and reduce import bills, renovation plans to increase the energy efficiency of multi-apartment buildings have helped reduce total energy consumption.[221] Secondly, recent investments in new infrastructure have allowed Lithuania to gain flexibility and autonomy, improve its energy supply security, and become a regional energy hub.[222] In this sense, thanks to infrastructure development to support the synchronisation and integration of electricity networks with other neighbouring EU countries, together with plans to start developing its substantial off-shore wind energy potential in the Baltic Sea, Lithuania is well-positioned to benefit from renewable electricity trade, speeding up the electrification of the economy and reducing fossil fuel consumption.[223]

Despite important challenges, cultural enablers reveal positive signs. Firstly, a growing interest in academia regarding circularity shows promising long-term results and the high potential for eco-innovation to pick up speed.[224] However, for success to materialise, structural obstacles must be addressed (i.e. lack of cooperation between the scientific and business communities). Secondly, there are also positive developments regarding the promotion of the CE by the traditional and social media and grassroots organisations, which can positively influence consumer behaviour and personal habits by making circularity mainstream. Although, it is important to highlight that this is mainly an urban

[219] European Court of Auditors. (2020). Energy efficiency in buildings. Retrieved from: ECA website

[220] Eco-Innovation Observatory. (n.d.). Lithuania country profile 2018-2019. Retrieved from: EC website

[221] European Commission. (2020). Policy fact sheet Lithuania: Multi-apartment renovation programme. Retrieved from: BuildUp website

[222] Bakas, V. (2019). Lithuania's strive for energy security. Retrieved from: University of Turku website

[223] Rödl & Partner. (2020). Lithuania and the Baltic Sea region turn to offshore wind energy. Retrieved from: Roedl website

[224] Eco-Innovation Observatory. (n.d.). Lithuania country profile 2018-2019. Retrieved from: EC website

phenomenon, since awareness and interest regarding sustainability and circularity outside the main cities is still lacking.

Investment in technology and innovation are supporting circularity to kick in. Despite no strict connection with CE, S3 has a focus on new technologies that can facilitate the implementation of circularity. The most relevant being 1) the use of renewable energy sources, 2) agricultural waste resource use, and 2) for flexible manufacturing systems. ICT, which is one of the priority areas, is more horizontal and can be applied to the automation and optimization of a wide range of industrial processes. However, sectoral strategies are not yet there for the different S3 areas of focus. Additionally, the growing alignment between policy priorities and the needs of the scientific and business community, also supports the adoption of incremental and radical technologies. Regarding innovation infrastructure, DIHs have successfully teamed up to make alliances and integrate into DG Connect[225]. But DIHs differ substantially in terms of their maturity, and a lack of proper and continued funding prevents the attraction of more researchers.

In the Netherlands, a horizontal policy mix and a government-wide approach have been fundamental enablers supporting the CE transition. Political commitment and legislative stimuli are key in this sense. The 2015 *Van Afval Naar Grondstof* (From Waste To Resource) plan set ambitious targets and included specific measures to remove barriers for entrepreneurs and support for frontrunners.[226] Building upon this, the 2016 *A circular economy in the Netherlands by 2050* roadmap laid out a clear, bold national vision, further targets, and placed the circular economy at the forefront of the national political and economic agenda. Furthermore, sectoral transition agendas, plans, and formative strategies have been developed to support the national strategic roadmap. Public and private sectors are actively involved in stakeholder engagement on a sectoral basis. However, despite being a frontrunner and pace-setter country, the European Commission recommends the Netherlands establish a long-term budget for the implementation of the CE agenda to be sustained with domestic resources, further promoting cross-sectoral collaboration, and creating new circular value chains.[227]

A strong and inclusive community of support organisations and public-private initiatives is vital. In this sense, the coalition of organisations *Nederland Circulair!*[228] together with and private-public platform *Holland Circular Hotspot*[229] play a key role in promoting and accelerating the transition by serving as cross-cutting multi-stakeholder engagement platforms for continuous awareness-raising, knowledge accumulation, and experience sharing.

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[225] European Commission. (2016). Strategic Plan 2016-2020. Retrieved from: EC website

[226] From Waste to Resource. (2015). Retrieved from: Government of the Netherlands website

[227] Marino, A & Parios, P. (2020). Comparing European countries' performances in the transition towards the Circular Economy. doi:10.1016/j.scitotenv.2020.138142

[228] Nederland Circulair! (n.d). Retrieved from: Nederland Circulair! website

[229] Holland Circular Hotspot. (n.d.). Retrieved from: Holland Circular Hotspot website

Economic opportunities from increased resource productivity and efficiency have also been significant enablers. Firstly, similar to Lithuania and the Czech Republic, the Netherlands is a heavy importer of raw materials and energy products, thus the economic benefits of mitigating dependency on external resources via increased resource efficiency and reduced resource consumption, are relevant enablers. For example, bio-waste and recycling, with increased recovery rate and material value, represents substantial economic opportunities.[230] Secondly, given its strong entrepreneurial capacity, the Netherlands is well-positioned also to take advantage of innovation opportunities and attract new business opportunities while enhancing its international competitiveness.[231] In this sense, public capital made available to finance high investment costs has played a pivotal role.[232]

EU policy and funding are a major driver for circularity in the Czech Republic. As have Lithuania and Estonia, the country has received substantial EU funding and has mainly concentrated on improving environmentally friendly innovative technologies. The country is also enacting proper legislation, albeit slowly, to implement EU regulations on waste management and plastics. For example, several targeted initiatives have been undertaken, such as the National Waste Management Plan 2015–2024, in which the circular economy has had a leading role in long term planning (Circular Czechia 2040).[233] At the same time, however, the significant number of landfills remains one of the main problems in municipal waste management. The European Commission has recommended that the public and private sector improve 3R actions and ensure prevention practices in waste management.[234]

Economic incentives are also a significant driving force. Given its broad industrial base, highly dependent on foreign resources, a central driver relates to the need to secure raw materials for the Czech economy, promote its competitiveness, and create new jobs.[235] To this end, several programmes by the Ministry of Industry and Trade to bring together industrial businesses and research institutions promote resource efficiency and are good examples of effectively encouraging and guiding practical collaboration between academia and industry.

Bottom-up initiatives are creating social momentum. For example, the Czech Circular Hotspot, a partnership platform between NGOs, academia, and businesses, and the Czech Institute of Circular Economy (INCIEN)[236] play a central role in promoting circularity and sustainability as core social values, creating upward pressure for change, and adding structure and cohesiveness to the transition.

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[230] Netherlands Organisation for Applied Scientific Research (TNO). (2014). Opportunities for a Circular Economy in the Netherlands. Retrieved from: Dafoka website

[231] Eco-Innovation Observatory. (n.d.). Netherlands country profile 2018-2019. Retrieved from: EC website

[232] Kirchherr, J. et al. (2017). Breaking the Barriers to the Circular Economy. Retrieved from: Utrecht University website

[233] Marino, A & Parios, P. (2020). Comparing European countries' performances in the transition towards the Circular Economy. doi:10.1016/j.scitotenv.2020.138142

[234] European Commission. (2019). Environmental Implementation Review. Czech Republic country report. Retrieved from: EC website

[235] Eco-Innovation Observatory. (n.d.). Czech Republic country profile 2018-2019. Retrieved from: EC website

[236] INCIEN. (2020). Mission & vision statement 2021-2025. Retrieved from: INCIEN website

However, governance is very fractured as the transition process is almost entirely bottom-up driven, very specific-focused, and lacks a systematic approach and complementary top-down support and coordination.

Estonia's main enablers relate to a favourable economic environment and the CE gaining prominence. Firstly, favourable macroeconomic conditions, rich human capital resources and highly developed technological base conditions present the Northernmost Baltic state with opportunities to (eco-)innovate and attract new business, entrepreneurs, and investors.[237] Secondly, the country has promoted many actions to reuse material consumption and has an excellent deposit-refund system for beverage packaging.[238] However, Estonia also has areas of improvement related to low resource efficiency, low engagement of national SMEs in waste reduction practices and an inefficient municipal waste and packaging recycling (3Rs) system.[239] Yet, Estonia is the first country in which a University (TKK) established an educational institution, the Institute of Circular Economy and Technology, to create and develop skills to sustain and accelerate the transition to circularity. Furthermore, the country is steadily developing effective national networks to engage stakeholders, share information, and promote constructive dialogues to create a national CE strategy, albeit overall efforts remain low and there is ample room for improvement in this regard.

2.2 Material flow analysis

2.2a Measuring the circularity of Lithuania

Measurements are critical to understanding the world around us. As it becomes more urgent to adapt our economic system to be more circular, we need to provide a tactical approach to measuring the intricacies of advancing the transition. This section explains how Lithuania's circularity was assessed using the Circularity Metric by Circle Economy and illustrates the country's material footprint in order to provide insight into the significant material flows that contribute to Lithuania's material metabolism. Using these insights, we aim to aid Lithuania's key decision makers in setting priorities for how the economy and industry can move towards increased circularity. We do so, by locating circular opportunities and priorities in the material flows and their role for the national material metabolism. By measuring circularity in this way, businesses and governments can track their circular performance over time, put trends into context and engage in uniform goal-setting to guide future action in the most impactful way.

[237] Eco-Innovation Observatory. (n.d.). Estonia country profile 2018-2019. Retrieved from: EC website

[238] Marino, A & Parios, P. (2020). Comparing European countries' performances in the transition towards the Circular Economy. doi:10.1016/j.scitotenv.2020.138142

[239] European Commission. (2019). Environmental Implementation Review. Estonia country report. Retrieved from: EC website

The Circularity Metric

In order to capture the circularity of an economy in a single metric, we need to reduce complexity somewhat. Our starting point for the process is to get a better understanding of Lithuania's material metabolism: measuring how resources flow through the economy and remain in long-term use. This approach builds on and is inspired by the work of Haas et al (2015)[240] and follows the approach applied in Circle Economy's other national Circularity Gap Reports[241]. Taking an 'x-ray' of the economy's resource and material use, we consider six fundamental dynamics of what the circular economy transition aims to establish and how it can do so. This translates into two objectives and four strategies, which we base on the work of Bocken et al. (2016).[242,243]

The core objectives are:

- **Objective one:** Resource extraction from the lithosphere is minimised and biomass production and extraction is regenerative;
- **Objective two:** The dispersion and loss of materials is minimised, meaning all technical materials have high recovery opportunities, ideally without degradation and quality loss; emissions to air and dispersion to water or land is prevented; and biomass is optimally cascaded.

The four strategies we can use to achieve these objectives are:

- **Narrow flows—Use less**: The amount of material used or greenhouse gases (GHGs) emitted in the making of a product or in the delivery of a service are decreased. This is through circular design or increasing the usage rates of materials and products. In practice: Sharing and rental models, material 2lightweighting, multifunctional products or buildings, energy efficiency, digitisation.
- **Slow flows—Use longer**: Resource use is optimised as the functional lifetime of goods is extended. Durable design, materials and service loops that extend life, such as repair and remanufacturing, both contribute to slowing rates of extraction and use. In practice: Durable material use, modular design, design for disassembly, repair, remanufacturing, refurbishing, renovation, remodelling.
- **Regenerate flows—Make clean**: Fossil fuels, pollutants and toxic materials are replaced with regenerative sources, thereby increasing and maintaining value in natural ecosystems. In practice: Regenerative material use, renewable energy, regenerative agriculture.
- **Cycle flows—Use again**: The reuse of materials or products at end-of-life is optimised, facilitating a circular flow of resources. This is enhanced with improved collection and reprocessing of materials and optimal cascading by creating value in each stage of reuse. In

[240] Haas, W., et al. (2015). How circular is the global economy? An assessment of material flows, waste production, and recycling in the European Union and the world in 2005. doi:10.1111/jiec.12244

[241] Circle Economy. (2019). The Circularity Gap Report: Austria. Retrieved from: Circle Economy Website

[242] Bocken, N., et al. (2016). Product design and business model strategies for a circular economy. doi:10.1080/21681015.2016.1172124

[243] Circular Strategies. (n.d.). Supporting innovation for a circular economy. Retrieved from Circular Strategies Website

practice: Design for recyclability (both technical and biological), design for disassembly and recycling into raw materials and cycling of nutrients.

If we effectively deploy strategies focused on **narrowing**, **slowing, cycling** and **regenerating** the flow of materials, we will ultimately require fewer materials to provide for similar needs. Because of this, fewer materials will be used by the economy, they will have longer lifespans and can be reused more effectively and with less harm caused to the environment. For our (consumption based) Circularity Metric to capture this crucial process, we measure the share of cycled materials as part of the total material inputs into a global economy. As such, it illustrates the current progress towards achieving the circular economy's ultimate goal of reducing the material footprint and designing out waste through the four listed strategies.

How does the metric reflect these objectives?

The Circularity Metric we report on is an 'input-focused' metric. Communicated as a percentage, it is a relative indicator of how well global or national economies manage to sustain societal needs and wants with materials that are already in use. Crucially, this indicator consists of two components, the volume of secondary material inputs in the numerator — and the total material input for consumption in the denominator. And while the metric is therefore most prone to change due to a change in the volume of secondary material inputs, it also changes based on a change in overall material footprint. To account for this duality, we report on both indicators in monitoring progress on the circular economy - material cycling in relative terms and total material footprint in absolute terms.

Relating this back to the four strategies that were introduced, the circularity indicator is most sensitive to cycling and narrowing interventions and only indirectly accounts for a slowing or regenerating of flows. These would materialise in a decrease of overall material consumption or footprint as the need for replacement decreases as products last longer and regenerative resources usually have lower material footprints. As the indicator provides a snapshot of current material flows, the effects of extending product life times will only show up in the metric several years later when product replacement has successfully been stalled or made unnecessary. As an accurate account of the lifetime duration of individual products and materials and the extension thereof is rarely kept, it is inherently difficult to measure the effect of these strategies.

Measuring national circularity: A consumption and production perspective

Applying the Circularity Metric to the global economy is relatively simple, largely because there are no exchanges of materials in and outside of planet earth. For countries, however, the dynamics of trade introduce complexities for which we must adapt our metric, resulting in certain methodological choices.[244] In assessing a country or region, we can either take a production or consumption perspective. In a production perspective, we consider all the materials involved in any sort of

[244] Centraal Bureau voor de Statistiek (CBS). (2020). Notitie circulair materiaalgebruik in Nederland [Press release]. Retrieved from CBS Website

processing of production activity, regardless of whether they are exported or consumed domestically. In a consumption perspective, we consider only the materials that are consumed domestically. Whether we apply the metric based on a consumption or production perspective will yield different results as we report on section 2.2b.

As is typical for highly industrialised, service oriented economies, the Lithuanian economy is a net importer of resources, meaning that more resources are imported than exported. This also underlines the geopolitical relevance of a circular economy. Lithuania is critically dependent on imports of key raw materials, from rare earth materials needed for key technologies to the phosphate rock used in fertiliser production.

In this study, we therefore take a consumption perspective in a bid to generate actionable insights for production and consumption on the ground. This has also been the approach in previous circularity gap report studies. Most production, domestic and abroad, is ultimately driven by the demand of consumers for a certain product or service. In an increasingly globalized world, the chain that connects production to consumption becomes more entangled across regions. Demand-based indicators—applied in this analysis—allow for a re-allocation of environmental stressors from producers to final consumers in Lithuania. In terms of material footprinting under a consumption based approach, that means we account for all the products and materials that went into meeting final demand in Lithuania. At the same time, we exclude those materials that merely pass through the economy but are consumed elsewhere.

This approach follows the perspective that in order to achieve worldwide circularity, there is an immense need for changes in consumption, and demand in those countries where the majority of resources are consumed. In terms of opportunities for the Lithuanian industry, this means ensuring that not only domestic operations and production, but also global value chains need to be encouraged to apply circular design and achieve higher levels of resource efficiency. This approach therefore ensures transparency for countries with high import levels and also supports policies aimed at reducing or shifting demand, helping consumers understand the material implications of their choices, or at ensuring that costs of, and responsibilities for, resource depletion and material scarcity are allocated to entities and regions based on their roles in driving production processes through consumption.

This consumption based approach was chosen as the main indicator to report on current circularity in Lithuania, in line with previous work of the circularity gap reporting initiative. However, the opportunities highlighted throughout this report aim to span the full spectrum of circular economy interventions, placing the industrial transformations of key producing sectors—independent of whether they cater to domestic consumption or exports—at the centre. Consequently, there is merit in keeping record of production based metrics as well, which provide further insight into extractive industries and throughput of primary materials. Therefore, a production based metric is reported as well (see section 2.2b). *(Disclaimer: When referencing 'the Circularity Metric' without specifying consumption or production-based in the rest of the report, we refer to a consumption perspective)*.

This production based metric indicates the share of secondary material inputs out of all raw material inputs - independent of their use in domestic consumption or exports. Similarly a production footprint considers the raw material equivalent of all material inputs without deducting the footprint of exports.

Measuring national circularity: Accounting for trade

When aiming to mirror the full material footprint of consumption, we must apply a nuanced lens to direct imports—meaning we report on the full material footprints of the products that are consumed in Lithuania. To account for the material footprint of imported raw materials is straightforward, but this is not the case with semi-finished and finished goods. A motor vehicle, for example, may weigh 1 tonne when imported, but all the materials used to produce and transport it across global value chains can weigh as much as 3.4 tonnes. To represent actual material footprints in imports and exports, we apply so-called raw material equivalents (RME) in this study. Following a key assumption underlying the allocation of footprints in Input-Output analysis, the RME values reported for imports only account for the footprint of those materials that are actually consumed in Lithuania. Consider, for example, fossil fuel trading in Lithuania: Following a consumption based allocation, the large volumes of crude petroleum that are imported to Lithuania, refined and then exported again do not weigh into the RME of imports nor the RME of exports. Instead, in the material accounts, they bypass Lithuania and are allocated directly to the country of final consumption. This principle ensures that there is no double-counting of trading flows at the global level.

Two essential assumptions

Finally, the Circularity Metric considers all secondary materials as adding to a country's level of circularity. These secondary materials can be part of those cycled within the country, as well those that are imported as secondary materials embedded in traded products. However, estimating the shares of traded secondary materials is a difficult undertaking due to a lack of data on secondary material imports specifically. So, we introduce an important **first assumption**: in order to estimate the volume of secondary materials imported, our analysis relies on the results of our analysis on the global level—the average Global Circularity Indicator (GCI)—calculated per resource group—to the net direct imports of the country (aggregated by resource group). This ultimately yields the following secondary material shares in imports:

Resource group	Share of secondary materials in imports[245]
Biomass	8.9%
Metal Ores	9.0%
Non-Metallic Minerals	13.8%

[245] This reflects an assumption of secondary materials based on global circularity as reported in the Circularity Gap Report: De Wit, M., J. Hoogzaad, and C. Von Daniels. "The circularity gap report 2020." Ruparo: Amsterdam, The Netherlands (2020).

Fossil Fuels	0.8%

Table 8: Share of secondary materials in imports, based on assumption 1 (above)

We assume that this is a good proxy for the estimation of the total amount of secondary materials in the system. The underlying assumption is that—although varying in terms of volume—imports of every country have the same average share of secondary materials per resource group.

To understand the amount of secondary materials that are consumed domestically, rather than exported, we make our **second assumption**: that the share of secondary materials in the total consumption of raw materials is equal to the share of imported and domestically cycled secondary materials in the total input of raw materials.[246]

These two assumptions ultimately determine the numerator of the circularity metric - the volume of cycled materials in consumption. Based on domestic cycling data, the assumption that the share of secondary materials in imports reflects the global averages, and the assumption of secondary material exports, we can judge the total amount of secondary materials entering the economy.

Practical challenges of a single circularity metric

- **There is more to circularity than cycling.** A circular economy strives to retain the value and complexity of products for as long as possible, with as little degradation as possible. The cycling of resources measured in the circularity metric is only one component of circularity. The relative Circularity Metric does not, however, *explicitly* consider other strategies that are core to building a circular economy such as asset sharing, reuse, lifetime extension or remanufacturing. By reducing the need for new products, they reduce overall material footprint and waste that is available for cycling. So, what is clearly a benefit for the circular economy, may not always show up as such in the metric. This is why we emphasise the importance of reporting on both relative circularity and absolute material footprint.
- **Lack of consistency in data quality.** Whilst data on material extraction and use are relatively robust, data on waste, by-product generation and treatment as well as the subsequent secondary material production and their (re)use is weak, thereby presenting challenges in quantifying secondary material flows. The weak data is in part due to the complexity of waste: it's heterogeneous, it is handled outside of sectors that produced it, it is geographically spread out and materials come in different qualities. In Lithuania, waste generation and treatment data is comparably strong, but data on application of secondary materials is missing. In addition, waste statistics currently do not account for by-products that are produced and reused. According to the EU waste framework directive, by-products are classified as a

[246] This assumption is applied at the level of single resource group (biomass, metals, minerals and fossil fuels), that is: If the share of secondary biomass, say recycled paper, in the total input of biomass is 1%, then also the share of consumed recycled paper in the total consumption of biomass will be 1%.

"substance or object resulting from a production process the primary aim of which is not the production of that item." [247]

- **Quality loss and material degradation.** The metric focuses on the end-of-use cycling of materials that re-enter the economic system, but does not consider in what composition, or to what level of quality. As such, any quality loss and degradation in processing goes unconsidered. In this way, a plastic bottle made from PET (polyethylene terephthalate) may re-enter the economy as a secondary material—recycled PET (rPET). Its quality will determine whether it is to be utilized for building park benches, for example, or if it is re-introduced to manufacture food-grade plastic products. This variance would not be documented in the metric but has strong implications regarding material degradation.

For a more exhaustive look into the methodology behind the Circularity Gap, you can visit our website or refer to appendix C.

2.2b Lithuania's Circularity Gap

Lithuania is 3.3% circular, which leaves a Circularity Gap of more than 96% and it's national consumption in 2017 has a Raw Material Consumption (RMC, also known as consumption-material footprint) that amounts to **83.9 million tonnes**[248]. This footprint of consumption is calculated by summing up the footprints of imports and domestic extraction, considering their RME, and then deducting the volume of exports (also considering their RME). The Circularity Metric is calculated by dividing the amount of secondary materials consumed (2.9 million tonnes) by the total material consumption, determined as RMC plus the secondary material consumption (86.9 million tonnes). When applying a production focus this changes slightly. Applying a production based circularity metric, we reach a rate of 3.5% and a Raw Material Input (RMI, also known as production-based material footprint) of 103.7 million tonnes.

The following section will further illustrate the investigation into Lithuania's resource metabolism: We depict how materials are sourced and traded, how they are used, and how the material flows ultimately serve societal wants and needs, such as food and beverages or housing in Lithuania or how they feed into economies abroad through exports. It also assesses how raw materials are processed and assembled by Lithuanian industries to become the products that address local needs in Lithuania. Further, by visualising what happens at end-of-use, this section sheds light on the accumulation of materials in products, goods, the environment and waste volumes. As figure 3 reveals, we bring these different elements into context and explore how the Lithuanian material metabolism is set up and which resource-intensive activities and consumption domains weigh heaviest. These observations provide a starting point, to better understand where sectors and supply chains should focus their strategies as they move toward a circular economy.

[247] European Commission. (n.d.). Waste Framework Directive Retrieved from: EC website
[248] Circle Economy Analysis, detailed calculation and sources in Appendix C.

The material footprint of satisfying societal needs in Lithuania

Following the described focus on materials used in domestic consumption, we proceeded the analysis by allocating the extraction and processing of materials and turning them into final products to the different societal needs and wants they ultimately serve, ranging from essential needs such as nutrition, housing and healthcare to wants such as mobility, communication and using different types of services, manufactured goods and consumables. These are described below:

Seven societal needs and wants

Societies need to not only survive, but thrive, and resources are needed to fuel these societal needs. Here we describe the seven key societal needs and wants and which products and services they include, as well as the volume of materials it takes to fulfil them in Lithuania. Since various products can be allocated differently, here we make our allocation choices explicit. For example, "radio, television and communication equipment" can be classified either as part of the societal need "communication", or as "manufactured goods and consumables". We decided to subsume it under "communication".

A more detailed breakdown of the key resource groups falling under each of these societal needs is provided in table 9.

Housing

The need that represents the largest resource footprint in Lithuania, with **35.9 million tonnes or 41% of the total consumption footprint**, is for all sectors relating to Lithuania's main infrastructure, the built environment relating to construction of houses, offices, roads and other infrastructure. This need typically ranks among the highest of a country due to the weight and volume of mineral resources that are dominant building materials, which is no different for Lithuania, where about 75% of mass in the housing need relates to minerals. In addition, it includes the footprint of electricity and heat utilities (excl. water).

Nutrition

The second biggest category of needs and wants in terms of resource consumption is nutrition. It includes food products such as crops, dairy, meat and fish as well as the inputs into agriculture (excluding water) and livestock farming. In Lithuania it's total footprint amounts to **18.7 million tonnes, 22% of total consumption,** per year. Food products have short life cycles in our economy, being consumed quickly after production.

Manufactured Goods and Consumables

Coming in third, manufactured goods and consumables are a diverse and complex group of products—such as refrigerators, clothing, cleaning agents, personal-care products and paints—that generally have short to medium lifetimes in society. Textiles including clothing also consume many different kinds of resources such as cotton, synthetic materials like polyester, dye pigments, and chemicals. This category also includes the diverse types of packaging these products usually come in. In total, this category accounts for **10.3 million tonnes (12%)** worth of resources.

Services

The delivery of services to society ranges from education and public sector activities, to commercial services like banking and insurance. The related material footprint consumes **9.8 million tonnes**

(12%) in Lithuania in total and typically involves the use of professional equipment, office furniture, computers and other infrastructure.

Mobility

A considerable resource footprint is taken up by the need for mobility. Even though, at **7.8 million tonnes (8%)** this seems comparably little, this sector plays a crucial enabling role for the Lithuanian economy. This also relates to the approach to allocation of material flows to sectors when using Input-Output analysis. Even though technically a part of mobility, cargo shipping, for instance, is mostly allocated to the products shipped (Manufactured goods and consumables) rather than to mobility, unless the service is purchased directly by households. In particular, two resource types are covered by this sector: the materials used to build transport technologies and vehicles like cars, trains, ferries, ships and airplanes; plus, predominantly, the fossil fuels used to power them.

Healthcare

With an expanding, aging and, on average, more prosperous population, healthcare services are increasing in Lithuania. Buildings aside, typical resource groups include use of capital equipment such as X-ray machines, pharmaceuticals, hospital outfittings (beds), disposables and homecare equipment. This accounts for **2.7 million tonnes (3%)** in Lithuania.

Communication

Communication is becoming an evermore important aspect of today's society, provided by a mix of equipment and technology ranging from personal mobile devices to data centres. Increased connectivity is also an enabler of the circular economy, where digitisation can make physical products obsolete, or enable far better use of existing assets, including consumables, building stock or infrastructure. Resource use in this group is less intense, standing at **1.6 million tonnes or 2% of the total consumption footprint.**

Societal need	Share of total footprint	Share of raw material category in need footprint	
Communication	2%	minerals	56%
		biomass	11%
		metal	14%
		fossil	19%
Healthcare	3%	minerals	28%
		biomass	18%
		metal	3%
		fossil	52%
Housing	41%	minerals	52%
		biomass	3%
		metal	2%
		fossil	43%
Manufactured goods and consumables	12%	minerals	48%
		biomass	22%
		metal	6%
		fossil	24%
Mobility	9%	minerals	23%
		biomass	7%
		metal	4%
		fossil	66%
Nutrition	22%	minerals	16%
		biomass	68%
		metal	1%

		fossil	14%
Services	11%	minerals	42%
		biomass	20%
		metal	2%
		fossil	36%

Table 9: A breakdown of the seven societal needs and wants into material categories.

To unravel how Lithuania's Circularity Metric came to be at a relatively low 3.3% and how it's national material footprint in 2017 stands at **83.9 million[249] tonnes**, a closer look at the country's material metabolism is needed. Figure 3 is a conceptual visual of the material metabolism of Lithuania. It illustrates the material metabolism of Lithuania; linking how four resource groups (minerals, metal ores, fossil fuels and biomass) satisfy the seven key societal needs and wants shown on page 10. From left to right, the figure will show the domestic extraction of resources (**Take**) which amounts to **49.2 million tonnes**. This flow is dominated by non-metallic minerals and biomass, relating mostly to the country's strong construction sector, including quarrying of limestone and natural stone and production within Lithuania's agricultural sectors, in particular cattle and dairy farming. However, in a national context, domestic extraction represents only one of the inputs to the economy, which also include direct imports of products, **30.5 million tonnes** and secondary materials, **1.8 million tonnes**. The reported imports mirror the country's close relationship with fossil resources with around half of imports relating to fossil resources coming from outside the country, in particular from Poland and Russia. This relates predominantly to crude petroleum, refined petroleum and petroleum gas. The remainder of imports is largely made up of biomass and non-metallic minerals. According to the Observatory of Economic Complexity, the high share of fossil fuels and electricity in imports is followed by diverse machinery and equipment, vehicles and equipment and chemical products such as pharmaceuticals, which are the key import groups in monetary terms.[250] Re-exports—products that are imported and without any processing are exported again—do not make up a significant part of Lithuanian imports (except in smaller sectors like, for instance textiles) and therefore are not explicitly quantified in this study.

When considering not just the direct imports, but also the RME, as previously introduced on page 6, we see that Lithuania imports **54.5 million tonnes** of RME. On a more granular level, the footprint of imports increases significantly overall, to nearly twice the volume of direct imports. This includes significant waste and other material use incurred abroad—in particular for fossil fuels and their extraction as well as non-metallic minerals.

The raw materials typically undergo processing (**Process**), for example in the production of metals from ores, cement from limestone, or refined sugar from beets. The total amount of processed materials, which on top of raw material inputs also includes local and imported secondary materials,

[249] Circle Economy Analysis, detailed calculation and sources in Appendix C.

[250] Observatory of Economic Complexity (OEC). (2020). Lithuania country profile. Retrieved from: OEC website

amounts to **86.9 million tonnes**. Subsequently, these refined materials can be used for the manufacturing (**Produce**) and assembly of products like automobiles from metals, plastics and glass, or the construction of roads and houses. These finished products can, in turn, be distributed and delivered to provide services (**Provide**) and access to products that can satisfy societal needs and wants locally or be exported. In 2017, Lithuania exported some **28.3 million tonnes** of final products with an associated RME of **19.8 million tonnes**. According to our estimates, as per the second key assumption made on secondary material volumes, a total of **0.9 million tonnes** of secondary materials were exported in the same year. Correspondingly, the total material consumption amounts to **86.9 million tonnes**, of which **2.9 million tonnes** were either secondary materials available from domestic recycling (2.0 million tonnes) and imported secondary materials (0.9 million tonnes) or, to a very small extent, directly reused waste.

This consumption footprint amounts to nearly **30 tonnes per capita**—more than twice that of, for instance, the Netherlands, yet still significantly less than Norway, with a footprint of 44 tonnes per capita. Based on this per capita consumption footprint, Lithuania would rank sixth for the countries analysed[251]—in between Malta and Canada. Lithuania's high material footprint is linked to a few aspects of its economic metabolism, primarily the high footprint of imported fossil fuels and construction materials. In terms of the material categories that are reflected in the consumption footprint, nonmetallic minerals as used in construction materials and fertilisers lead the list with **33 million tonnes,** which is common due to the heavy materials this category encompasses. Conversely, the country's consumption of fossil resources is comparably high with about **30 million tonnes**, most prominently, gas, coal and petroleum used in electricity generation, heating and cooling and, to a smaller extent, transportation. The remainder of material consumption is made up of biomass **(18.5 million tonnes)** and to the smallest extent metal ores **(2.4 million tonnes)**.

Raw material category	Domestic Extraction	Imports (RME)	Exports (RME)	Raw material consumption
Non-metallic minerals	26.6 Mt	14.5 Mt	8.0 Mt	33 Mt
Fossil resources	0.5 Mt	29.9 Mt	0.44 Mt	30 Mt
Biomass	22.1 Mt	7.7 Mt	11.3 Mt	18.5 Mt
Metal ores	0 Mt	2.4 Mt	0 Mt	2.4 Mt
Secondary materials				2.9 Mt

Table 10: Consumption footprint and trade balance by raw material category. (Source: Circle Economy Analysis, detailed calculation and sources in Appendix C)

[251] In comparison to the 43 + 5 Rest of the World regions analysed under SNAC Exiobase.

Essential to identifying and addressing opportunities for a more circular economy is what happens to products and materials after their functional use in our economy (**End-of-use**). This is mostly related to the **83.9 million tonnes** of Raw Material Consumption. In Lithuania, the total amount of waste generated amounted to around **8.9 million tonnes, of which 4.6 million tonnes[252] are treated domestically.** Of these 4.6 million tonnes, **2.8** came from Products That Last and **1.8 million tonnes** from Products That Flow. Products that flow are those products that are made and become waste within the reporting period of a year. Products that last, in turn, are products that are added to socioeconomic stock, or, in this case, disposed of from stock. Wastes from stock depletion, for instance demolition of houses or end of life vehicle management, would be featured here.

Of the total **4.6 million tonnes** of waste being treated, **2.0 million tonnes**, that is 43%, are either recycled, backfilled or reused for energy purposes, whereas the other **2.6 million tonnes** are mostly lost to landfills. A minor amount also ends up incinerated without energy recovery or disposed of otherwise. Specifically, the distribution of different waste recovery routes can be seen in the table below.

Waste Management Route	Volume (tonnes)	Percentage
Disposal - landfill (D1, D5, D12)	2,608,050	56.4%
Disposal - incineration (D10)	2,099	0.0004%
Disposal - other (D2-D4, D6-D7)	12,003	0.3%
Recovery - energy recovery (R1)	292,878	6.3%
Recovery - recycling	1,577,788	34.1%
Recovery - backfilling	129,493	2.8%

Table 11: Waste disposal and recovery volumes. (Source: Eurostat, 2018)

[252] Eurostat. (2018).

Remarkably, about 85% of the landfilled waste[253] is made up of other mineral waste which is predominantly concerned with phosphogypsum waste, a waste output of fertiliser production for which recycling applications exist in construction and agriculture (see chapter 6 for additional information).

Next to the small flows included in the other two disposal routes, Lithuania's waste ends up largely recovered. At the bottom of the waste hierarchy, energy recovery from waste is particularly relevant for mixed sorting sludges and wastes, wood waste and textile waste. At the next higher level - backfilling—we spot primarily construction and demolition waste. Lastly, within recycling, Lithuania's strong recycling infrastructure becomes apparent. Even though at different rates, recycling is achieved across material flows, spanning chemical wastes, metal wastes, agricultural and wood based wastes, textiles waste and construction and demolition waste. Most significant in terms of mass volumes among these are construction and demolition waste, sorting residues and vegetal waste.

The municipal waste generation in Lithuania amounts to 1.31 million tonnes, equivalent to 24% of total waste generation. At 472 kg per capita in 2018, this is already lower than the EU average of 502 kg per capita. Although still depositing the majority of its MSW in landfill, during the decade between 2004-2014 Lithuania went from sending 92% of its MSW to landfill, to 59%. Further, guided under the National Waste Management Plan during the period between 2014-2020, 10 mechanical and biomechanical waste treatment facilities were introduced, which further reduced the amount of municipal waste, disposed of in landfills significantly from 54 % in 2015 to 23.48 percent in 2019.[254] The main output of these facilities is technical compost to be applied in landfills as cover and stabiliser.

Aside from materials going to waste, **32.5 million tonnes** are added to stock (Net Stock Additions) in the form of capital investments such as buildings and infrastructure, machinery and equipment. Viewed in relation to the overall material footprint, at 37.% of consumption, net stock additions are similar to the Netherlands (38%) or Norway (51%)[255]. It is noteworthy to caveat this data as stock additions may be somewhat overestimated as a result of mass balancing. Linked to the population decline that Lithuania has experienced in recent years, the need for new building stocks may in fact be somewhat lower.

Another **8.3 million tonnes** are released into the environment as emissions (to air) mostly relating to fossil fuel combustion. The remaining **2.2 million tonnes**[256] are dispersed into the environment as a deliberate, or unavoidable consequence of product use. This includes fertilisers and manure spread on fields, or salt, sand and other thawing materials spread on roads and the erosion of metals. Finally, **35 million tonnes** is made up of all emissions, materials and waste either generated or dispersed in importing regions as a result of Lithuanian final demand.

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[253] Other mismatches for subtotals are due to 1.) aggregation (we provide our aggregation in the methodology document) and 2.) our use of more detailed category tables: Statistics Norway

[254] Ministry of Environment of Lithuania. (2021). State waste prevention and management plan for 2021-2027. Retrieved from: Seimas website

[255] Circle Economy analysis (based on Exiobase V3.7).

[256] Eurostat. (2017). env_ac_MFA.

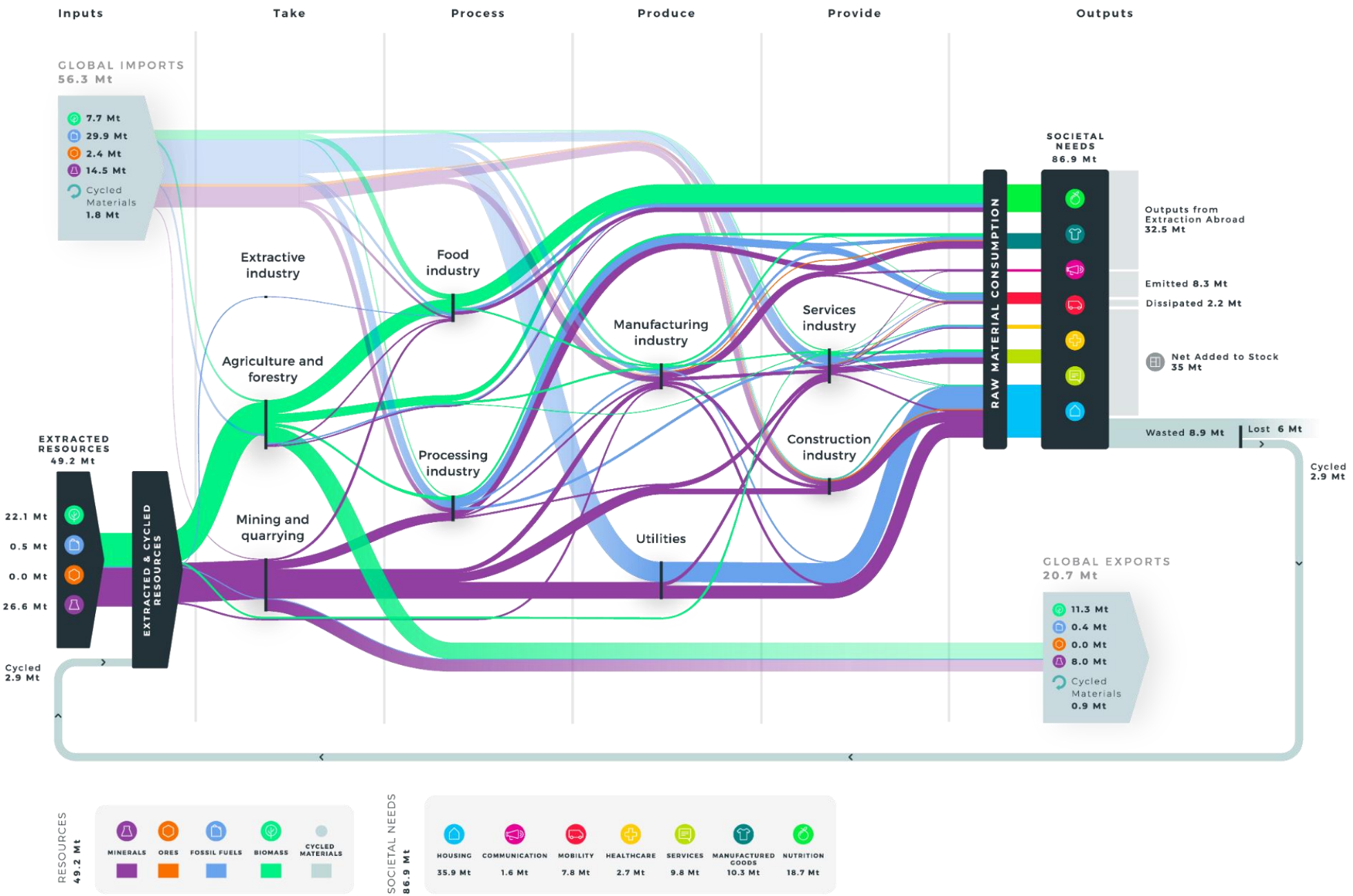


Figure 3: An X-ray of Lithuania's economy.

2.2c Lithuania's Circularity Metric in context

Lithuania's Circularity Metric is well below the global average of 8.6% at **3.3%**—for a country that has been celebrated as one of Europe's recycling champions this may come as quite a surprise. The reason for this is largely due to an economic metabolism that is characterised by high levels of consumption. In fact, viewed in terms of material consumption per year, Lithuanians consume about 30 tonnes of materials per capita and produce about 2.1 tonnes of waste per capita (also including industrial waste).

Lithuania is famed for leading on recycling of plastic packaging, with a recycling rate of 69% in 2018[257]. Yet, further exploration of the local collection and recycling infrastructure in Lithuania shows that reality may not be as advanced as the statistic suggests. In fact, part of this statistic relates to plastic waste fractions that are imported from countries with significantly higher purity of fractions achieved. Meanwhile, waste collection schemes and requirements for recyclability of for instance packaging lack alignment, which later on impedes the volumes of materials actually recovered as well as the quality of secondary materials to be fed back into the market.

Further, plastics only make up a small fraction of waste volumes in Lithuania. In fact, the dominant waste stream relates to other mineral waste and is largely connected to phosphogypsum, a waste-product of fertiliser production, which is landfilled in a specifically engineered landfill. Approaches to recycling and reusing this material exist and are already applied in other countries, such as the United States. To this end, significant opportunities emerge to bolster Lithuania's circularity through the diversion of phosphogypsum waste—which represents almost half of the country's total waste generation.

As is characteristic of most industrialised, largely service oriented economies, the low metric is also the result of many processed or final products reaching the country instead of only raw materials which causes a significantly higher material footprint. In other words, the weight of raw materials used to produce products abroad will always exceed the weight of the finished product, wherever it is imported, sold, and eventually disposed of. Our analysis indicates that an increase in Lithuania's already-high rate of recovery from 43% to a utopian 100% would significantly boost the consumption based circularity indicator to 5.8%, which is still below the global average.

Based on this definition of the Circularity Metric, the opportunities for Lithuanian industry to improve the circularity index can be categorised in two ways: The first is to reduce the overall footprint of consumption as reflected in the denominator of the index, for instance, through dematerialisation of needs and wants, extending the lifetime of products and materials that are already in use and increasing the resource efficiency in new products. The second is to increase the share of secondary material inputs, enabled by improved recovery and cycling of materials as well as a strengthened demand for secondary materials. The important part is the duality of the two: Increased cycling alone

[257] Eurostat. (2018).

contributes little if the rest of the consumption footprint stays untouched: for Lithuania's Circularity Metric to increase further, the consumption of materials needs to drastically decrease.

2.2d Inside Lithuania's Circularity Gap

Having contextualised the Circularity Metric and the guiding logic for its improvement, we now move on to further distinguish between different components of what we refer to as the 'circularity gap'. The circularity gap broadly captures those parts of the material footprint that are not fed from secondary materials. Following the framework put forth by Mayer et al. (2019)[258], we uncover that the circularity gap generally consists of three key components: Biomass materials that are available for ecological cycling, non-circular materials as well as non-renewable materials that could be available from cycled sources. 'Closing the gap' means something else for each of them.

Firstly, biomass can be considered circular if it re-enters nutrients cycles and ecosystems and thereby contributes to new plant growth, allowing the ecosystem biocapacity to remain the same; but this is not often the reality. Therefore, to be considered circular, primary biomass must at the very least guarantee full nutrient cycling and be carbon neutral. At present, this is difficult to estimate for Lithuania as data on primary biomass production is incomplete and neither carbon neutrality nor nutrient cycling can be guaranteed. Therefore, out of precaution the 22% of the material footprint that relates to biomass with ecological cycling potential is currently excluded from the circularity indicator. Where data on recycling of bio-based waste is available, this is accounted for in the cycled materials indicator already. In the case of Lithuania this is relevant for paper and cardboard, vegetal wastes and wood wastes. A significantly larger material flow, however, relates to agricultural by-products that are not accounted for in waste statistics. According to national Lithuanian statistics, around 3.5 million tonnes of straw and 3.9 million tonnes of manure, representing the largest by product flows, were produced and subsequently in 2018.[259] These are predominantly (around 75%) recycled ecologically by application to local soils, but given that the two criteria on carbon neutrality and nutrient cycling cannot be conclusively answered, these are not (yet) accounted for in the circularity metric.[260] This also shows that alignment is needed in waste accounting across Europe to produce results that can be compared better. Straw and manure that are primarily reported as by-products in Lithuania, for instance, are predominantly reported as a waste in the Netherlands and therefore better accounted for in the Circularity metric.[261,262]

Secondly, the non-circular materials component of the 'circularity gap' - refers to all the fossil resources that are combusted to produce energy of some sort and therefore are by definition not

[258] Mayer, A. et al. (2019). Measuring progress towards a circular economy: a monitoring framework for economy-wide material loop closing in the EU28. doi:10.1111/jiec.12809

[259] Official Statistics Portal of Lithuania. (2018). Waste generation in agriculture, forestry and fishery. Retrieved from: OSP website

[260] Idem.

[261] Eurostat. (2018). Generation of waste by waste category, hazardousness and NACE Rev. 2 activity. Retrieved from: Statistics Norway

[262] Circle Economy. (2020). The Circularity Gap Report: the Netherlands. Retrieved from: Circle Economy website

circular. These make up about 32% of the material footprint and thus are the second largest fraction within the circularity gap. This further underlines why leading the charge on a decarbonised energy supply not only benefits Lithuania's emissions, but also circularity.

Thirdly, non-renewable resources include all those fossil, metal and mineral resources that currently come from virgin sources but are not used for combustion in energy production. Combined, these make up the majority, about 44% of the material footprint. This fraction of the circularity gap shows that substantial gains in circularity can be achieved in reductions of the footprint of minerals and metals as well as increasing their cycling. For Lithuania, this also starts with addressing the Phosphogypsum problem head on.

Another dynamic that needs to be accounted for is that of stock building, so those materials that stay in the economy much longer than the material flow accounting period of one year. These primarily include products that are meant to last, such as buildings, infrastructure and heavy machinery. Considering that the Circularity metric is an input oriented indicator, being an output stream, the element of stock building is not accounted for directly in the metric. However, especially within the last fraction of non-renewable resources, materials that are added to stock form a significant share. In Lithuania, the net additions to stock measure up to 8.9 million tonnes in 2016[263]. The opportunity for increased circularity for this part of the gap lies most of all in resource efficiency and circular design, ultimately shrinking the footprint of stocks and enabling future reuse of resources as inputs.

Finally, this segmentation of the 'circularity gap' also illustrates the complexities behind a goal of reaching a full 100% of circularity, and why it may not be attainable or desirable for Lithuania at present. The objectives of driving net additions to stock, consumption of non-renewable materials and fossil fuels for energy use down further from the current level and ensuring ecological cycling of biomass are valid and should be pursued ambitiously. Yet, the question remains, if this can and should be brought to zero immediately. This becomes apparent in the context of the decarbonisation of Lithuania's industrial sector and infrastructure, which will at least temporarily, require further stock building.

2.2e Priorities in the Lithuanian material metabolism

Identifying demonstration sectors in the Lithuanian economy

In exploring opportunities for increasing circularity through further use of secondary materials and, primarily, a reduction of the consumption footprint, the next step of the analysis performed has been to prioritise key leverage points for circular economy initiatives within Lithuania's key industries and

[263] Circle Economy Analysis, based on Gross Fixed Capital Formation. For further details see appendix C.

consumption domains. By focusing on a few key sectors, we can dive deep and apply a diagnostic lens to identify where we can best apply interventions to increase the circularity of Lithuania. In making our decision, we zoomed into the material flows associated with different areas and gather data on how the sectors score on their material consumption and waste generation (Mass), GHG emissions[264] (Carbon) and economic relevance as represented in financial value creation[265] (Value); the Mass, Carbon and Value (MCV) nexus. The results of this are summarised in figure 4. In addition, stakeholder consultations including local experts from Kaunas University of Technology (KTU) and Ekokonsultacijos, the Lithuanian Agency for Science, Innovation and Technology (MITA) and the Ministry of the Economy and Innovation of Lithuania (EIMIN)—in alignment with the programmes from other key Ministries—were held to ensure relevance of the demonstration sectors.

The demonstration sectors are (1) agriculture and food[266], (2) construction[267], (3) chemicals and plastics[268] (4) furniture and wood products[269] and (5) textiles[270]. On top of the demonstration sectors, two additional sectors have been added into the following analysis because of their environmental footprint and economic relevance for Lithuania: (6) electricity and heat production[271] and (7) mobility and transport[272]. In the following chapter, the scope of the opportunity analysis will focus on identifying circular opportunities for the selected demonstration sectors. It is also worth noting that in our use of the term sector, we move beyond strict definitions and encompass a range of related industries under one umbrella 'sector'. The repair and recycling sectors span across the other sectors and therefore do not score on the MCV nexus. Below we provide further information into the MCV assessment and provide additional information to substantiate the rationale behind their priority role in the circular transition of Lithuania. Further information on the specific opportunities and initiatives to take circularity forward in these sectors will be provided in Opportunity analysis (chapter 6).

[264] Measured as Greenhouse gas emissions in CO2 equivalents.
[265] Measured as Gross Value Added per sector.
[266] Including NACE Rev 2 sectors: 01.1-2 (excl. 01.16); 01.4; 03.1-2; 10.1-5; 10.5; 10.7-8; 11.0; 56.1
[267] Including NACE Rev 2 sectors: 08.1; 41.1-2; 42.1-9; 43.1-9; ; 23.3; 23.5; 23.6; 23.9
[268] Including NACE Rev 2 sectors: 8.91; 20.15-16; 20.5; 22.1-2;
[269] Including NACE Rev 2 sectors: 02.1-3; 16.1-2; 31.0
[270] Including NACE Rev 2 sectors: 01.16; 13.1-9; 14.1-3; 15;
[271] Including NACE Rev 2 sectors: 35.1 - 35.3; 05.1-2; 06.1-2; 19.1-2
[272] Including NACE Rev 2 sectors: 29.1-3; 30.1-9; 45.1-4; 47.3; 51.1; 49.1; 49-3; 50.1; 50.3

Figure 4: MCV nexus of prioritised sectors.

Leading across both material consumption and GHG emissions is the generation, transmission and distribution of **energy both for electricity and heat** including the refinery of petroleum materials and the supply of steam and hot water. About 32%, nearly a third of material consumption relates to this as is reflected in the high share of fossil fuels in the consumption footprint.[273] This underlines the enormous potential for increasing circularity within a deep decarbonisation of energy supply in Lithuania. Due to the combustive consumption of fuels, waste volumes for this sector make up a marginal (<0.5%) fraction of total waste volumes. In terms of GHG emissions, the share taken up by the sector is even higher than the material footprint. At 38% of industrial emissions, this is by far the most significant contributor. This relates primarily to the production of electricity from natural gas as well as, to a smaller extent, the use of petroleum and coal in industrial heating. Within residential heating, the majority of fuels already relates to bio-based alternatives[274]. Weighing heavily into the material footprint of this sector is also the dependence on imports, meaning that the footprint also includes materials processed and wasted abroad. Consequently, this allows for significant footprint reductions by shifting to sources with lower associated footprints. Ideally this would be domestically produced, renewable energy as is reflected in Lithuania's ambitious plans to decarbonise its energy supply[275]. In contrast to its heavy material and climate impact, this sector only contributes around 2.5% of Gross Value Added (GVA).

Agriculture and food production, in comparison, rank second in terms of material footprint taking up about 22% of annual material consumption, largely biomass, 18% of GHG emissions and 11% of GVA. This fits in well with the prominent role that agriculture and food processing take in the Lithuanian economy, primarily focused around the farming and processing of dairy, meat and grain crops.[276] Along with processing, agriculture forms a characteristic element of Lithuania's economy and landscape, with the leading branches of agriculture being the cultivation of vegetables and fruits as well as animal husbandry of cattle for meat and dairy production. Agricultural waste streams including vegetal waste and manure make up a significant waste stream, but already end up predominantly recycled. In the Lithuanian context organic waste fractions in mixed municipal waste and sludges are sorted and legally required to be recovered in mechanical biological treatment (MBT) plants. Recovered materials are then used for technical purposes in landfills such as redevelopment, restoration and backfilling. For an increase in circularity of this sector, the key is to ensure that ecological cycling can be guaranteed, meaning ecosystems need to be maintained sustainably and nutrients cycled. This is particularly important for the large volume of agricultural by-products that are already being valorised through local reapplication to land.

The third sector to feature prominently across material consumption, GHG emissions and GVA is that of **construction and construction materials**. It contributes about 12% of total annual material

[273] Exiobase Version 3.7. Data based on conversion of monetary transactions in 2016

[274] Lithuania's National Inventory Report. (2020). Greenhouse Gas emissions 1990-2018.

[275] Government of Lithuania. (n.d.). National Energy and Climate Action Plan of the Republic of Lithuania for 2021-2030. Retrieved from: EC website

[276] Melnikienė, R. et al. (2019). Agricultural and Food Sector in Lithuania 2018. Retrieved from: Lithuanian Institute of Agrarian Economics

consumption and ranks somewhat lower, 8%, in terms of industrial GHG emissions. Next to the service sector which makes up the majority of gross value added in Lithuania, Construction and the built environment make up a significant 14% of GVA. Waste from construction and demolition sites makes up a significant waste stream of 798 thousand tonnes[277], much of which is already undergoing some form of reuse and recycling—often, however, in low quality applications such as granulate or backfilling. The majority of materials used in this sector are locked into stock for periods of 30 years or more. Therefore, ensuring that structures are designed bearing in mind that materials are to be recovered from stock in the future will be a key task of future construction. In addition, significant gains are to be achieved in overall resource efficiency gains in the delivery and use of built structures thus reducing the overall footprint of the sector.

In fourth place, sectors surrounding **mobility and transport** of people and cargo (partially) are considered. In terms of annual material consumption it contributes 9%, and 2% of annual GHG emissions. In reality, however, the impact potential of this sector may rank even somewhat higher. Given the focus on consumption in our material accounting, transport is not always allocated to the designated transport sector, but instead one of the other sectors that the transport caters to. More specifically, freight transport services are normally allocated to those sectors that commission the shipping. In addition, emission figures in the MCV nexus are reported on industrial emissions, thereby excluding all household related individual passenger transport related emissions, which are otherwise the most significant source of emissions. in Lithuania's *National Energy and Climate Action Plan for 2021-2030*, for example, it is reported that fuel combustion for transport contributed 5,795 kilo tonnes of CO_2 equivalents, equal to more than a quarter of total emissions (excl. Land use, land-use change and forestry) reported[278]. Finally, the sector contributes a considerable share of GVA at 13% and due to its crucial role in society merits inclusion in any CE strategy. In terms of priorities for Lithuanian industries and consumption, a rapid decarbonisation of the transport sector is imperative to closing the circularity and emissions gap. Further savings can be achieved in a reduction of the non-energy related material footprint through reduced vehicle ownership, longer vehicle life times and lighter, more resource efficient design.

Next, the production and use of **chemical products and plastics** are highlighted due to their contribution of 6% of annual material consumption, 4% of carbon emissions and 3% of GVA. Crucially, this sector includes the manufacture of **plastics and other synthetic packaging materials** used across industries, which make up around 1.03 million tonnes of material consumption[279]. Plastics have been at the centre of considerable debate in the circular economy. Their versatility and relatively low price have won them application in virtually all value chains of the Lithuanian economy. At the same time, environmental impacts centred around pollution, emissions and waste generation urge to reduce plastic consumption and prioritise alternatives. In terms of their recycling, statistics suggest Lithuania is leader in the field. Yet, further contextualisation shows that the country still has a long way to go in

[277] Eurostat. (2018). Retrieved from: Eurostat

[278] Government of Lithuania. (n.d.). National Energy and Climate Action Plan of the Republic of Lithuania for 2021-2030. Retrieved from: EC website

[279] Material footprint relating to NACE Rev 2 sectors: 20.16; 20.2

aligning collection schemes and improving recyclability of plastic products, particularly packaging materials.[280] Further transparency into the exact volumes and types of waste streams going into recycling as well as different output qualities of recycled plastics is needed to provide better insights based on which to improve the applicability of secondary plastics. The chemical industry in Lithuania further produces inputs to other chemical products and also encompasses the production of fertilisers, which entails the accumulation of **phosphogypsum waste**, which makes up nearly half of all waste produced in Lithuania and currently ends up in a specifically engineered landfill. It therefore represents a key leverage point for increased circularity. Besides phosphogypsum, other chemical wastes flows are marginal in comparison and are largely recovered through recycling, or to a smaller extent through energy recovery.

Summarised under one more diverse group, we combine sectors associated with the production and use of **furniture and wood products**. With a share of 1.5% in material consumption, 1.2% in GHG emissions and 5.2% in GVA. Even though in comparison, these sectors rank relatively low, they form key pillars of the country's manufacturing industry for exports and therefore play an essential role in the industrial transformation thereof. In line with the relatively small share in footprint, Lithuanian industries produce nearly 90 kilotonnes of wood waste, the majority of which relates to the mentioned sectors. In terms of waste treatment, this sector sets a positive example, with recycling rates of ca. 70% and recovery rates (incl. waste-to-energy) of more than 95%[281].

Finally, **textiles and clothing** represent another key industry of the Lithuanian Economy with a long standing tradition in cotton, wool, flax yarn and fabric production, as well as garment and textile product manufacturing. Contributing 2.4% in material consumption, 2.2% in GHG emissions and 1.8% of GVA, it ranks the smallest out of the priority sectors. The sector includes the manufacturing of apparel and other textile products, the production of plant-based fibers and wool as well as fur and leather goods production. Textile wastes actually make up a tiny fraction of the overall waste flows in Lithuania measuring up at 9 kilotonnes or at 0.15% of total waste (both municipal and industrial waste). In 2018, recycling rates for these textile wastes have been relatively low at slightly over 20%[282]. Nonetheless, it is noteworthy that the industry is also involved in the import, processing and trade of used textiles. According to a recent study, Lithuania is among the top 5 destinations for exports of used textile from the Nordic countries and 29% of total household consumption of textiles relates to second hand garments[283]. However, studies also show that collection rates for textile waste are low (11%) and infrastructure is lacking to collect, sort and recycle textiles.[284] This also holds for industrial textile wastes and scraps, which are largely exported or, to a smaller extent, landfilled in Lithuania.[285]

[280] Insight from stakeholder consultation.

[281] Eurostat. (2018). Retrieved from: Eurostat

[282] Eurostat. (2018). Retrieved from: Eurostat

[283] Watson, D. et al. 2020. Post-consumer textile circularity in the Baltic countries: Current status and recommendations for the future. Nordic council of Ministers. doi:10.6027/temanord2020-526

[284] Idem.

[285] Rapsikevičienė, J., Gurauskienė, I., & Jučienė, A. (2019). Model of industrial textile waste management. Environmental Research, Engineering and Management, 75(1), 43-55.

In spite of the lacking infrastructure initiatives exist to advance recycling of pre- and post consumer textile waste, such as the companies Neaustima[286] or Antriteksa[287] that differentiate themselves on the market as producers of recycled yarns and products. In addition, Lithuania prides itself with operating a sizable second hand market platform, Vinted, whose reach extends well beyond the border of Lithuania and won it a billion Euro valuation in 2019.[288]

[286] Neaustima. (2021). Retrieved from: https://neaustima.lt/en/recycled-fibers/

[287] Antriteksa. (2021). Retrieved from: http://www.antriteksa.com/aboutus

[288] EU Start-ups. (2019). Lithuania crowns first tech unicorn vinted second hand fashion market place. (2019). Retrieved from: EU-startups

3. SWOT Analysis

A SWOT analysis is a useful tool to summarise findings from research and prepare recommendations for actions to be taken to make the most out of developments. A SWOT analysis regards internal and external factors that are either helpful or harmful:

	Helpful	Harmful
Internal origin	Strength	Weakness
External origin	Opportunity	Threat

In the context of this study we make a distinction between Opportunities as used in a SWOT analysis, and Circular Opportunities for the industries of Lithuania. For circular opportunities we retain the following definition:

> Circular opportunity: An *intervention* with regard to a *material* in a certain *sector* to increase circularity. For example; saving textiles by adapting designs in the furniture industry.

This SWOT analysis as a whole reports on the fitness of the Lituanian economy and especially the industrial ecosystem to absorb the circular economy. In the Opportunity Analysis (chapter 5), we analyse in more detail the circular opportunities themselves and how they fit into the Lithuanian context.

3.1 Strengths

On the macro level

We have identified growing awareness among government, businesses and civil society in the literature, survey and interviews. There is evidence of growing investments by SMEs, particularly in material efficiency - as was indicated by the survey. For example, in the furniture industry we have seen uptake of digital design methods to reduce material consumption and waste generation. Lithuanian businesses also increasingly participate in (EU and international) R&D projects and initiatives, for example the Eco-Innovation LT and LT+ programmes in 2014-2020. Increasing attention from academia is also present as well as a modest but growing number of collaborations between companies among themselves as well as with knowledge institutions: Evidence was found in the plastics and packaging sector, where a preform manufacturer is testing chemically-recycled PET that in turn was developed by another business in collaboration with knowledge institutions.

Lithuanian policy is also increasingly aligned with the CE concept. Successful examples are the deposit-refund scheme for plastic bottles, and other Extended Producer Responsibility schemes for products ranging from batteries to electronics, automobile engines and tires. Although their impacts vary, results are increasingly monitored using circular economy indicators, such as recycling rates, recovery rates and application of recycled materials in new products. Evidence also suggests that policy is increasingly focusing on higher regions of the circular economy, embracing eco innovation, green public procurement for government spending and circular entrepreneurship. Also on the financial side there are dim yet promising signs of increasing effectiveness of pollution taxation, as described in the policy analysis. Some experts note that financial measures directed towards SMEs specifically could be improved.

The industrial and innovation infrastructure is fit to absorb some promising aspects of a circular economy of Lithuania. The country hosts decent rail, sea and road infrastructure and an established petrochemical and packaging industry. Owing to the large role that SMEs and family companies play in the Lituanian economy, we expect that their agility can be a fruitful ground to absorb (hardware) technical innovations if their development is stimulated with well-directed investments. Examples of innovations that might be worth pursuing are sensing equipment for sorting waste streams in textile, robotics to process textile materials and produce furniture with minimal waste, but also installations to chemically recover polymers from plastics. The capacity to absorb (technological) change and changing material flows are especially important because we found good potential for industrial symbiosis, as explained in the Opportunity Analysis (chapter 5). For example, cross-links between agriculture and furniture seem logical to apply crop residues (soy husk, fibres from herbs, grasses straw) whereas the textile industry could supply waste fibres as insulation towards the construction sector. Another important strength is Lithuania's fertile and growing startup ecosystem that also focuses on sustainability and industry 4.0.

Recently, **promising steps have been taken to modernise the (municipal) waste infrastructure**, leading to the abolishment of landfilling for most municipal waste, centralization and professionalisation of remaining landfill sites and an adequate processing infrastructure for plastic packaging.

On the sectoral level

Lithuania's central role in European textile manufacturing and processing for both new and second hand clothes, is a key European strength to foster as the EU desires more of circularity in textiles. The (exporting) textile manufacturing industry already focuses on sustainability and quality as a way to distinguish itself from (central) Asian manufacturers. Additionally, Humana's sorting and processing centre for used textiles from all over Europe is hosted in Lithuania. It is one of the largest in Europe, with expertise in sorting usable from end-of-life clothing as well as expertise in fabric identification. This means Lithuania has the scale and the expertise to capitalize on this stream, which is internationally recognised as a valuable yet problematic material flow, and will be required to be collected as a separate waste stream by 2025 across all EU countries. In addition, the country has a thriving second-hand clothing culture and market, while the marriage of this sector with the digital

innovation ecosystem has led to Vinted, one of Europe's leading second hand clothing consumer platforms. These strengths could position Lithuania to become the textiles re-use hub of Europe.

At 79%, the Lithuanian construction sector boasts a relatively high share of recycling of construction and demolition waste. Adding to this impressive statistic, less than 2% of this waste flow ends up disposed of without any type of recovery (energy recovery or backfilling). It has also known a successful apartment buildings renovation programme - as pointed out by the policy analysis - that could serve as an example for future approaches to reduce energy consumption while being expanded with circular approaches. The local presence of a cement producing facility gives Lithuania some influence by means of national policy on the facility's sustainability: For example, demands could be set for inclusion of fly ash as a substitute for clinker as long as this does not affect the quality required for its application.. In addition, the Lithuanian metabolism exhibits comparably low rates in the build up of socioeconomic stock, at ca. 11% of total consumption footprint compared to ca. 31% in the Netherlands and nearly 51% in Norway.

In the plastics packaging sector we have already pointed out the successful deposit scheme for bottles. Lithuania also hosts an important part of the plastics production and (preform) bottle production industry, over which the government can exert influence to increase sustainability. In addition, there are innovative sustainable market players already applying chemical recycling to PET, such as NEO Group. Eurostat reports a high (though contested) recycling rate of 69% in 2018 for plastics, which puts Lithuania at the top of the ranks in the EU.

For what concerns the food sector, Lithuanians have a strong tradition of buying local food and knowing the origin. The food sector is made up of a large number of SMEs that have the agility to respond to changing (sustainability) demands, though their limited size also means more limited access to capital for change, as a company's borrowing capacity is related to its size. Interestingly, the food sector already has a culture of preventing waste and cascading the remains first as items for human consumption (where safe and allowed), then as cattle feed and subsequently as either compost, incineration fuel or biogas input. This shows in the statistics: Eurostat mentions that vegetal, animal and mixed food waste are recycled for almost 97% - although it gives no indication of whether this includes composting, digestion or use as feedstock.

Finally, the furniture industry is increasingly focusing on material efficiency. Firstly as a means to reduce costs, but also increasingly because of sustainability demands of (foreign) contractors like IKEA. Evidence suggests that industry 4.0 practices are emerging in this sector, also for non-IKEA producers, for example by using integrated design tools that minimise input materials and keep account of residues for future use.

3.2 Weaknesses

On the macro level

In a **macroeconomic** sense, we see signs of a general increase of consumption per capita. As the circular economy has a higher demand for labour than a linear economy, we find it relevant to report an ageing and declining population - though this is not unique to (eastern) European countries. Experts note that sustainability demands for products stem from the younger part of the population and that they do affect the products offered on the market. However, the lower than average EU purchasing power hinders the Lithuanian domestic market to purchase sustainable or circular goods, which often do have a higher price - the so-called Sustainability Premium. Interestingly, because of this lower purchasing power, Lithuania is able to manufacture products for western EU and Scandinavian countries that also drive demand for sustainable production in Lithuania.

Related to the above are the **issues with scale**. Being a small country with a dispersed population, the affordability of (separated) waste collection infrastructure is under pressure in rural areas, though urbanisation is happening in Lithuania, too. For some material streams, either the underdeveloped collection infrastructure and (sometimes as a consequence) the limited scale of secondary resource flows hinders the business case of industries wanting to use these flows. Finally, mentions have been made of materials being collected and prepared for recycling but that they have not been applied in new products afterwards.

The Material Flow Analysis also pointed out that Lithuania is a large importer of resources, even when disregarding the Raw Material Equivalents. Therefore the country depends on extraction processes abroad. Of course not all imports can be avoided or replaced, but it especially fossil fuels used as fuels (not: feedstock) play a large role in the material balance. The recent and ongoing investments in renewable resources should reduce this problem, though it was outside the scope of this study to investigate the EU and Lithuanian energy policy impacts on the material flows.

With regard to **education and training**, a known issue is that engineering professions have remained unpopular. Added to this is the phenomenon of brain drain to western European economies, further reducing Lithuania's capacity to develop or absorb innovations. In addition, the participation in vocational education training (VET) pathways and apprenticeships is relatively low. This is especially troublesome as the development of a circular economy requires changes in industries and practices applied and so in the skills of workers. Finally, interviewees mention that the recent educational reform has led to regional education centres no longer being available for local industries to deliver talent. However, on the other hand the universities and high schools have developed possibilities for industry and other interested parties to get advanced education in their programmes, which might alleviate the problem.

Lithuania still has a way to go to develop its industrial and innovation infrastructure to be able to develop a circular economy. Interviews and literature have indicated a weak culture of patenting and R&D for eco-innovations. Some experts note that costs of patenting and licensing play a role.

Literature and local experts also indicated that (international) cooperation, coordination and collaboration for R&D could be further strengthened but that a platform to do so is lacking. Some sectors (notably plastics and packaging, textiles) do reach out, as is also the case for multinational businesses. Moreover, a low score of place 22 out of 28 for material productivity (value added (EUR) per tonne of material consumed) in the Eco-14 innovation index indicates a weak performance in this aspect. The Eco-Innovation report indicates a low use of secondary materials in the largest industries (Production of Cement, Production of plastics and packaging, production of Furniture), despite high shares of recycling of some material streams. We also encountered that the existing EPR schemes are still to be connected to higher-up realms of the circular economy - for example designing out waste, - as the ultimate goals of EPR schemes should be to fund design changes instead of waste infrastructure.

Overall, the **policy landscape is fragmented, has omissions and often lacks concrete policy targets**. We have encountered a lack of a comprehensive, integral approach on CE involving more than one ministry. Current policies have a strong focus on energy and resource efficiency as well as waste management, but they are addressing higher CE options (such as designing out waste, adapting processes and addressing consumer behaviour) to a far lesser extent or, when they do, there are targets but no indicators to measure progress.

Although awareness is increasing, a more active governmental role in leading the way for a CE is required. The government can develop the demand for sustainable products by developing and communicating public procurement targets to stimulate the Circular Economy. Also by increased dissemination of topics, practices, and awareness raising among business and society involving sustainable consumption can a Circular Economy be stimulated.

with regard to financial incentives, Lithuania is reported to have ineffective pollution taxation and low income from environmental taxes (though increasing effectiveness is reported). There is a lack of clear and effective fiscal incentives and supportive policy measures, and differentiation to business size, which hinder the adoption and implementation of, among others, (eco-)innovation initiatives. Moreover, it seems that there is a departmental divide between topics of (circular) economy and the environment, while these two are intrinsically linked. This especially prevents policy coherence and coordination between different institutions and actors. It creates bottlenecks and misalignments, and hampers the harmonisation of efforts, regulations, and definitions, ultimately hindering structural coherence and effectiveness.

On the sectoral level

The domestic textile is the "least circular" of the selected material streams with only 21% recycling, 44% energy recovery and 35% landfilling. Unawareness, unfamiliarity and/or an ineffective infrastructure lead to polluted post-consumer textile on the one hand, and a large quantity of textile still in municipal waste. The latter leads to plain losses, the former leads to a variation in quality of domestic secondary textile. This leads to a large fraction (42%) sent to incineration, while commercial collectors send only 1/3 this amount to incineration. Compounding to this problem is that the

wholesale sector has insufficient focus on locally gathered textiles. It is import oriented as abroad there is an affordable, steady supply of clean material.

Moreover, Lithuania is reported to have a growing textile consumption while at the same time there is lack of documented data on current used textiles flows, the reuse and recycling sector practices, overall industry challenges and future possibilities. Finally, although some workshops produce for foreign brands fostering sustainability in their image, the bulk of production cannot claim the sustainability premium. Their options for sustainability are then (only) focused on textiles packaging instead of product design or process design, because they produce for foreign brands according to their specifications.

With regard to plastics and packaging, a weakness is found in a large variation of the quality of especially postconsumer plastics, although this is problematic globally. This stems in part from the non-uniform policies and practices for collecting plastic waste, which is a local competence. Moreover, as is the case globally again, the highest quality secondary materials are sold to the highest bidder that may not be situated in Lithuania; interviews pointed out that supply and demand ranges for secondary materials from Lithuania stretch as far as a 1000 kilometer radius. One expert also noted that there could be more support for the plastics and packaging industry to attract and absorb innovations.

Regarding Food and Agriculture, the current lack of an (affordable) solution for the phosphogypsum stockpiling as a by-product of phosphate fertiliser production from phosphate rock is a strong weakness. Evidence has also surfaced on packaging practices that could be improved, while waste flows from food processors might be handled in a more circular manner - as described in the opportunity identification section. Furthermore, the low-value added in this export-focused sector means there is little room for additional investments in sustainable production.

The waste collection and processing infrastructure of Lithuania has incurred improvements, but some of them are worrying. A shift from landfills to waste incinerators with heat recovery seems a logical step up, but they compete with buyers of secondary resources and even renewable fuel sources, thereby spoiling their business case. Moreover, the cheap and growing capacity of incinerators in Lithuania is said to hamper development of higher CE options in the country. Some specific points of attention:

- A rather large fraction of **domestic post-consumer textile** is being incinerated in Lithuania, as much as 42%. The mechanism described by interviewees is that the clothing has a good energy content that incinerators are willing to pay for. Moreover, the biological fraction of it may be counted as bio-fuel which could yield extra premiums by means of government subsidies. Having a large buyer able to pay (subsidised) prices reduces the chances of innovative players, with higher costs but more valuable applications of the materials, to be able to afford the source material.

- A similar mechanism has been told to compete with prices of (sustainably grown) fuel wood. Interviewees pointed out that 1) incinerators are paid to receive the waste as fuel, 2) get subsidies on the biological content of the waste as biomass and 3) due to their size they participate in the EU ETS system so that they can also receive credits for negative emissions from short-cycled biomass - an advantage that smaller biofuel installations using sustainably grown wood do not have.
- Biodegradable waste is of particular concern: on the one hand, in rural areas there seems to be no effective policy or monitoring the collection and separation of waste - though this may not be necessary due to at-home composting - but on the other hand we have encountered reports of incineration of valuable streams such as wastewater sludge.
- Interviewees pointed out that most of the wastewater treatment sludge in Lithuania is being incinerated, whereas a more useful application as fertiliser (regulations and material quality allowing) in forestry is possible and shown to be economically feasible.

3.3 Opportunities

On the Macro level

As introduced above, opportunities in the SWOT analysis are seen as beneficial, external developments.

With Lithuania being a net importer and processor of material streams, the country is exposed to global commodity price fluctuations. This, combined with growing resources can be shaped into an argument for more sustainable economic models so these external risks can be reduced. In addition, in 2019 Lithuania saw a 9% reduction in emigration and positive net migration, resulting in the first iscalencrease in the country's population in 28 years. On the one hand, this means that more Lithuanians are available for labour as the circular economy often requires more (hand) work than a linear economy. On the other hand, the addition of more labour force may not be relevant as industry is rapidly digitising, also in Lithuania, where software and robots may replace manual labour. What the actual influence is depends in part on the competences of the persons being available for labour.

European policies are a very important opportunity for Lithuania to foster a circular economy, as they already have done in the topics of diminishing single use plastics, batteries, textiles and more. Evidence was found of a legal framework for enabling social enterprises to gain financial support from the European Social Fund. In addition, there is ample support from the European Commission through policies such as the Circular Economy Action Plan and the 2020 European Green Deal. Interviewees and literature pointed out that European education and innovation policy are two crucial horizontal drivers for circularity. Crucially for Lithuania, the Smart Specialisation Strategy (S3) is a key piece of the innovation and development policy. S3 is fundamental for the further development of the

knowledge intensive sectors of the economy and for the promotion of technology and non-technology driven innovations. It is also instrumental in addressing the structural imbalances of the Lithuanian labour market, especially in the medium and long-term, by contributing to Lithuania's long-term economic development. In this sense, S3 is also crucial in supporting the implementation of EU R&D and innovation strategic directions as well as the new Cohesion Policy 2021-2027. Particularly the latter, which seeks to correct socioeconomic imbalances between countries and regions across the EU, offers a solid mechanism to build synergies between the S3 and the twin green and digital transitions, two of the EU's current political objectives.

Furthermore, several R&D related instruments also remain very important: 'Horizon Europe' projects as well as Public Private Partnerships (PPP) such as 'Factories of the Future' (FoF), 'Sustainable Process Industries through Resource and Energy Efficiency' (SPIRE), and 'Bio-based Industries' (BBI). Finally, the European Structural Funds also provide much of the needed funding for (circular) industrial renewal. Note that this opportunity can also become a threat when it introduces a dependence on the support.

Another concrete opportunity for Lithuania as a supplier to larger foreign brands is to position the Circular Economy and cleaner production as a unique selling point. This was pointed out by interviewees from all the analysed sectors except construction and Plastics. This also means that effective and cheap certification needs to be made available to the many smaller manufacturers that have been hindered to certify themselves due to costs or complexity. Specifically mentioned were FSC labels for forestry or the ability to demonstrate product environmental footprints in furniture. Industry 4.0 or digitalisation approach can certainly aid the transition, both in processes as well as in verification and transparency. Some highlights for specific sectors are:

On the sectoral level

In the textile industry, interviewees mention that demand for sustainable goods is already strong from Western European and Scandinavian countries, most notably on higher value added items such as sports goods or work uniforms and outfits. the experience gained by producing for these brands can be further developed and expanded to lower margin producers as experience reduces the costs.

In the furniture industry, IKEA as a foreign single large buyer and asking party for certification can be seen as a good learning opportunity for increased sustainability and certification experience. Government support to make processes sustainable and getting the required certificates enhances the export position of Lithuania for higher value-added products

In the Food industry the sustainability premium is harder to capitalise on, as the markets are confined to a limited distribution radius because of their perishable nature or their volume and weight. Still the opportunity exists in exports to countries with higher purchasing power, e.g. Finland, Austria and Germany, as was suggested by interviewees. Finding and/or growing a market for certified organic products there might give a boost to the Lithuanian production capacity.

Finally, for the **construction sector**, the material flow analysis shows a clear risk of down-cycling, especially for construction and demolition waste: THis is often used as backfilling for roads, whereas modular construction could allow the reuse of entire parts of buildings.

3.4 Threats

On the macro level

As mentioned above, threats relate to factors of external origin that may harm the ability of Lithuanian industry to transition to circularity.

Generic threats for Lithuania relate to the international nature of commodity markets and competition from non-EU countries. For example, Lituania is well integrated into the global commodity market. Because international commodity markets dictate pricing, there is little room to (nationally) increase prices for sustainability investments: buyers would be tempted to select another global supplier as the not sustainably produced material is the same for a lower price. This is especially true in the case of plastics. This again makes the case for easy and cheap sustainability certification systems. Moreover, as a peripheral EU country, Lithuania experiences competition from non-EU countries in several ways. Firstly, high eco-design standards can increase production costs. In the EU single market this is not a problem, but can limit exports to outside the EU. This matters for region-bound products where manufacturers serve a regional market (wood, food) and to a lesser extent for commodities like plastics. Secondly, regulations, especially labelling requirements, and enforcement from non-EU countries are reported by interviewees to be weaker. Thus, for example, wood products can have ECO labels (FSC) while not being strictly compliant. This undercuts the costs of non-EU competitors and is unfair competition for European producers.

On the sectoral level

For the **furniture sector -** responsible for about 11% of all Lithuanian wood waste - the most important threat relates to the monopsonist situation of the market. Lithuanian producers are almost totally dependent on single foreign buyers (IKEA), which set demands, for example, related to product environmental performance or process tracking using industry 4.0 technologies. While such demands are laudable, they can also lead to a price squeeze, as the monopsonist situation means that the buyer determines the price while they may not be willing to accept the premium for the additional process requirements. In addition, if the requirements charge this can lead to undesirable disinvestments. However, with the right guidance, this threat can also become an opportunity for Lithuanian SMEs if a long-term relationship can be made to further the digitisation of their production processes.

In the **food sector**, the retailers have a large influence in the product composition and price, and thus the product and packaging sustainability levels. Currently, about 70% of production is for exports

under private label. In this sense, although an opportunity to improve circularity, sustainable packaging requirements from the EU may affect the business cases of the food service sector as they may increase the price. Within the single EU market this may not be a problem, but for exports to non-EU countries to which Lithuania is geographically nearby, this may have an impact.

The main threats for the Lithuanian **textile sector** relate to the domestic market structure, regulatory risks, and most of the design firms that hold decision-power sit abroad. lack of. Firstly, while the Lithuanian textile sector exports are oriented towards higher purchasing power countries, interviewees note that the domestic market has a larger share in non-sustainable, cheaper, fast fashion segments, again related to the purchasing power. Thus, domestic producers have a weaker base for highly sustainable products from domestic clients. Secondly, REACH EU regulations incur costs on (chemical) industries that make certain manufacturing practices prohibitively expensive (i.e. dyeing with water). At the same time, other regulations stand in the way of circularity, for example, forbidding using clothes as a source for insulation material in construction. Thirdly, the most significant impact to improve the circularity of clothing lies upstream, in design via waste reduction and material choice. However, it is foreign firms and not Lithuanian companies that determine the designs and therefore local producers have little room for improvement.

In the **plastics sector**, the main threat relates to the considerable variation in secondary material quality across different EU countries. This is largely dependent on the collection and cleaning infrastructure for plastic waste which varies per city or region.

4. Infrastructure analysis

4.1 Context

Lithuania's infrastructure network has experienced substantial change during the past two decades, with the government engaging in various high-level infrastructure development and improvement projects. After regaining independence in 1990, and its accession to NATO and the EU in 2004, its infrastructure network has experienced three different trends: privatisation, modernisation, and further development. For instance, as a result of inherited Soviet-style energy and transport infrastructure, EU-funded projects attempt to rebalance networks and connections from the East to the West and the North and South. This involves especially building more EU-gauge railway infrastructure to serve the north-south Baltic corridor.

4.2 Physical infrastructure

By physical infrastructure we understand the means required for the secure flow of goods, services, and people. This involves roads and highways, airports, railroads, harbours, pipelines, refineries, import/export terminals and so forth. Additionally we consider the nation’s waste infrastructure; the physical installations involved to transport and process waste from source to end-of-life or end-of-waste.

With EU support, the government is engaged in a variety of infrastructure improvement projects, mainly in the energy and transport sectors. Owing to its substantial fossil-fuel infrastructure, extensive pipeline system, oil refinery complex, oil import/export terminals, and LNG regasification plants, Lithuania is a regional energy hub. The nation's largest airport at Vilnius and the seaport of Klaipeda have both undergone expansion and renovation projects, as has the road system.

Kaunas is the most important transport hub with the main road (Via Baltica and other highways) and railroad system (Rail Baltica and rail connection with Central and East Asian countries). Kaunas has the main international cargo airport in the country and a link with the sea via the highway to Klaipėda’s seaport. This coastal city is also a relevant Lithuanian transport hub, connecting sea, land and railway routes (both wide-gauge and EU-gauge) from East to West of the country. Klaipėda also clusters key infrastructures such as the largest seaport, a modern multi-functional oil terminal, and the LNG storage and regasification facilities.

Energy infrastructure

The country’s energy infrastructure is fundamental for its economy and has received substantial expansion, renovation, and adaptation during the last years.

Fossil-fuel infrastructure

Despite being inherited from the Soviet era, the fossil fuel industry represents a big part of the economy. It is fundamental for some highly relevant economic sectors, such as the chemicals industry. Plastics production and exports are also substantial for foreign trade and economic activity. Similarly, to diversify energy supplies from neighbouring Russia, and reduce economic and political challenges, there has been significant investment in new energy infrastructure development, particularly related to natural gas. These long-term investments can also hinder the phasing out of fossil fuels. Therefore, it is relevant to consider Lithuania's fossil fuel infrastructure when analysing its infrastructure capacity for the circular economy. Fossil fuel infrastructure includes the following assets:

- **Mazeikiai refinery complex.**[289] It started operating in 1980 and is the only oil refinery of the three Baltic states. Since the year 2000, it has been comprehensively expanded and upgraded and currently has a capacity of 10 Mts of crude oil per year.
- **Pipeline system**. It consists of 105 km of crude oil pipelines and 760 km of natural gas pipelines from and to Russia. There are also several crude oil pump stations.
- **Oil terminals in Butinge and Klaipėda.**
    - Butinge oil import/export terminal, constructed in 1999 on the Baltic Sea, is the main supplier of crude oil to Mazeikiai refinery and can export up to 14 Mts of crude oil a year.
    - Klaipėda's multi-functional oil terminal[290] is one of the most advanced on the Baltic Sea's eastern coast.
- **LNG infrastructure.** Klaipėda's LNG floating storage and regasification unit terminal[291] started operating in December 2014 and has since allowed for the diversification of natural gas supplies.

Renewable energy infrastructure

- **Hydropower** is a main source of (renewable) energy in Lithuania.[292] Total installed capacity, including pumped storage, of Lithuania's 100 hydropower plants accounted in 2019 for roughly 28% of total installed capacity and 20% of total domestic power generation. However, Kruonis (pumped storage) and Kaunas projects aggregate most of Lithuania's hydropower capacity. There are no more plans to expand hydropower infrastructure due to geographical reasons and environmental concerns.
- **Biomass** is another important source of renewable energy.[293] Per capita, biofuel production is among the highest in the EU and since 2016 the use of biomass in the district heating sector exceeds the share of natural gas. A large fraction of the bio-energy is supplied from an

[289] ORLEN Lietuva. (n.d.). Refinery. Retrieved from. ORLEN Lietuva website
[290] KN. (n.d.). Klaipėda oil terminal. Retrieved from: KN website
[291] KN. (n.d.). Klaipėda LNG terminal. Retrieved from: KN website
[292] International Hydropower Association. (2020). Country profile: Lithuania. Retrieved from: IHA website
[293] Switching from gas to biomass. The success story of Lithuania. Retrieved from: European Bioenergy Day website

abundance of nationally grown fast-growing tree species supplying heat to local district heating grids.

- **Wind power** has expanded considerably in recent years, and its share in Lithuania's electricity mix is now almost equal to that of natural gas (about a third of the total). Onshore installations have steadily increased the share of renewables in power generation since 2010 and are planned to continue increasing. Off-shore wind farms on the Baltic Sea are envisioned, with the first auction expected by 2023.[294],[295]
- **Solar power** production has picked up speed during the last few years albeit at a much smaller scale compared to wind power. However, household solar photovoltaic self-consumption and remote purchasing is gaining ground.[296] The potential for combining floating solar photovoltaic plants with hydropower infrastructure ('floatovoltaics') is also being explored in the Kruonis project. The government plans to keep expanding onshore solar power capacity and build a total of 200MW storage infrastructure.[297]

Transport infrastructure

Transport infrastructure is currently experiencing **various trends and issues**[298], with several high-level projects planned and underway. For example, the North Sea-Baltic Corridor[299] consists of a network of railways, roads, and inland waterways, connecting Finland and the three Baltic States on one side and Poland, Germany, the Netherlands and Belgium on the other. Transport and logistics are of utmost importance; however, they are currently inadequate. This is highly problematic as Lithuania is very dependent on imports, such as electricity, raw materials and industrial components. For instance, Lithuanian businesses are usually subcontracted by other European (multinational) companies, and thus dependent on European logistics and value chains, making the economy fragile and with low resilience. Solid logistics and transport connections to other countries need to be further developed and improved. Hence, plans to implement new and improved links by 2030 between the three Baltics states and Poland, including roads, railways and inland waterways.

With regard to **road transport**, the network of streets and highways has a total length of around 85,000 km. There has been a substantial investment in road transport[300] in the past decade due to the growth in freight transported by road[301] and the road system's overall under-capacity. For instance, Via

[294] Maculevičius, L. (2020). Lithuania and the Baltic Sea region turn to offshore wind energy. Retrieved from: Roedl website
[295] Government of Lithuania. (2020). Baltic Sea offshore wind development tenders. Retrieved from: Seimas website
[296] Ministry of Energy of Lithuania. (2020). A new wave of household use of solar electricity is coming. Retrieved from: ENMIN website
[297] Government of Lithuania. (2021). Economic Recovery and Resilience Measure "New Generation Lithuania". Retrieved from: Ministry of Finance website
[298] European Commission. (2019). Transport in the European Union. Retrieved from: EC website
[299] European Commission. (n.d.). North Sea-Baltic Corridor. Retrieved from: EC website
[300] Statista. (2021). Amount of money invested in road transport infrastructure in Lithuania from 2004 to 2018. Retrieved from: Statista website
[301] Statista. (2021). Amount of freight transported by road in Lithuania from 2006 to 2019. Retrieved from: Statista website

Baltica[302] aims to construct new and expand existing major highways through Lithuania to organise better the EU's land access to the three Baltic States. It is worth noting that Kaunas fulfills a central role in the land-infrastructure too.

Lithuania has untapped potential to improve rail and water transport and logistics. The **railroad system** consists of roughly over 1900 km of operated railways, a substantial part linked to the energy infrastructure. However, the vast majority of which are not electrified (only about 8% were electrified by the end of 2019).[303] As discussed above, an important aspect of EU connectivity is the installation of the EU-gauge railway that mostly serves the north-south corridor. However, important Lithuanian cities - among which the capital - are also served by the narrow gauge system. This falls under the Rail Baltica[304] project that should integrate the Baltic States into the European rail network by 2026. The Russian wide-gauge railway remains intact to be able to sustain trade relations with eastern-european and central-Asian countries, the most prominent of them being Belarus and Russia.

Seaports and waterways are not being fully exploited due to lack of compatibility of transport infrastructure with road transport, hindering efficient interoperability. Concerning **sea transport,** the coastal city of Klaipėda hosts the largest and most important multi-purpose, deep-water ice-free seaport in Lithuania. It is one of the few ice-free ports in northernmost Europe. As for waterways, despite its big potential, investment in **inland waterway transport infrastructure** has been scarce[305], and thus the Lithuanian inland waterway network and fleet remains underdeveloped.

Completing the picture there are three international **airports**, in Vilnius, Palanga (near Klaipėda), and Kaunas, the latter being the biggest one. However, airlines and airports are of low quality and there are not enough connections with European countries.

Telecommunications and digital infrastructure

With regard to **telecommunications and digital infrastructure**, Lithuania possesses a modern and efficient ICT infrastructure. Internet penetration and broadband speed are very high. The fibre optic internet connection infrastructure is very well developed, with one of the EU's highest fibre coverages for rural areas. Additionally, in 2020's Digital Economy and Society Index (DESI)[306] Lithuania ranks well-above the EU average for Digital Public Services and Integration of Digital Technology. Regarding digital infrastructure, the Digitalisation roadmap is a very positive and right step to support local digital infrastructure, but it's just in its early stages. Digitalisation is crucial to enable CE and currently LT is far behind other countries. Similarly, the government is also planning to strengthen digital

[302] The Three Seas Initiative. (2018). Priority interconnection projects. Retrieved from: Three seas website

[303] Government of Lithuania. (2021). Economic Recovery and Resilience Measure "New Generation Lithuania". Retrieved from: Ministry of Finance website

[304] Rail Baltica. (n.d.). Future direct. Retrieved from: Rail Baltica website

[305] Statista. (2021). Investment in inland waterway transport infrastructure in Lithuania 2004-2018. Retrieved from: Statista website

[306] Digital Economy and Society Index. (2020). Lithuania. Retrieved from: EC website

infrastructure and ICT infrastructure with the development of data centres, cybersecurity facilities and cloud storage infrastructure.[307]

Waste management infrastructure

As a whole, waste management infrastructure in Lithuania has considerably expanded but it is still limited. Waste recycling infrastructure is lacking or is underdeveloped, and existing infrastructure must be modernised, upgraded, expanded and adapted. Similarly, despite some progress and promising developments, there is also a lack of collection, treatment, reuse and waste prevention infrastructure. Adequate waste management infrastructure is critical to support and sustain the processing of waste into recovered raw materials and expand the use of high-quality secondary raw materials. Regional waste management centres (RATC) are Lithuania's core waste management infrastructure assets. They are present in all of Lithuania's counties, and consist of: Green waste composting sites, Bulky waste sites, Waste incineration plants, and mechanical biological waste treatment (MBA) plants (see figure 5).

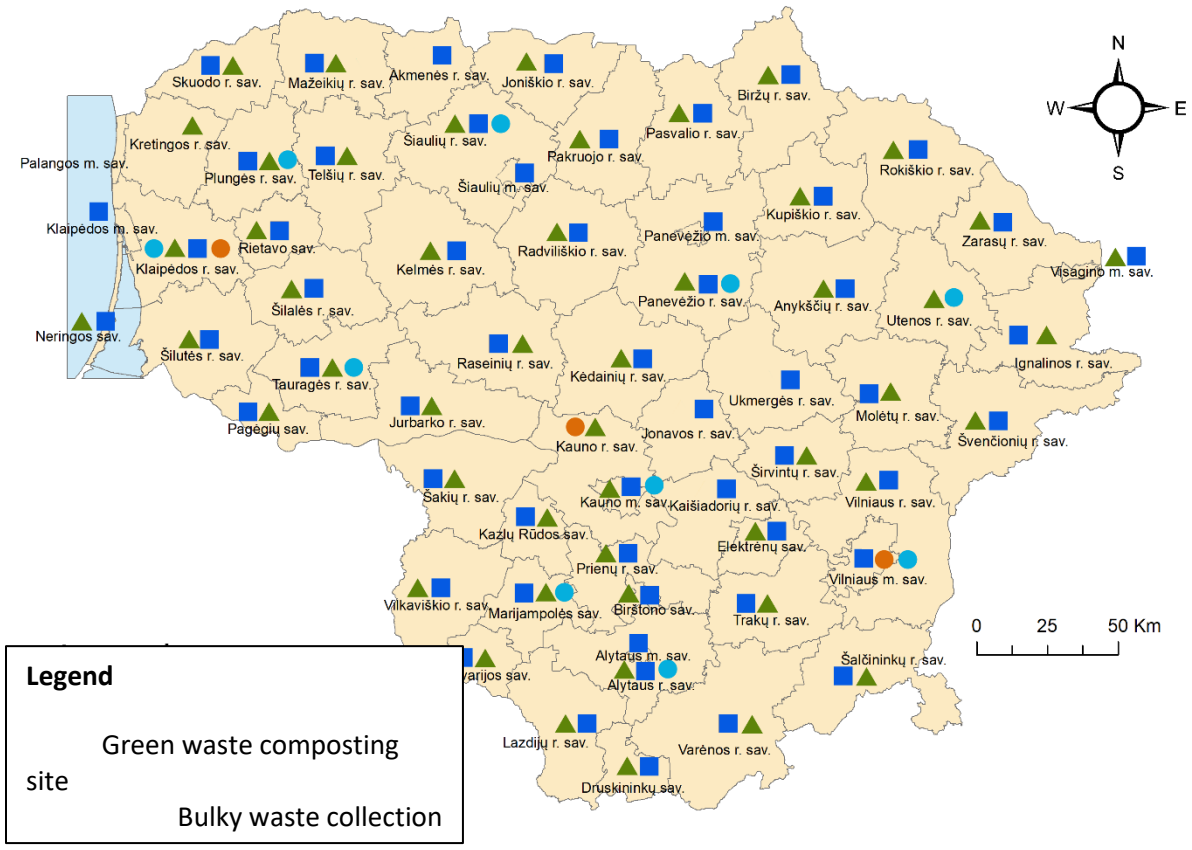


Figure 5: Lithuania's Regional waste management centres.[308]

[307] Government of Lithuania. (2021). Economic Recovery and Resilience Measure "New Generation Lithuania". Retrieved from: Ministry of Finance website

[308] Source: Regional waste management centers.

Green waste composting and Bulky waste sites are present in (almost) all of the counties. There are also ten MBA facilities and three waste incineration plants operating across the country. All three Cogeneration power plants supply heat energy to the central heating systems of Klaipėda, Vilnius and Kaunas cities. Akmenės cementas is replacing the traditional fuel (coal) with waste fuel burned in cement clinker. According to technical projects, until 2021, bottom ashes and slag from Klaipeda's cogeneration plant were treated and used for onsite purposes such as recultivation of construction of local roads. However, recently, this waste treatment was moved to a special lot next to the landfill and is performed by another waste managing company (not landfill operator) that had plans to produce mineral material for construction purposes.[309]

Moreover, according to the Lithuanian law and the recent position of the Ministry of Environment (AM), registration according to REACH, or compliance with Waste Management Law, is now necessary to realise/sell such products. This recent development has temporarily stopped all the projects of production and realisation of products. The other two cogeneration plants in Vilnius and Kaunas share the same situation. However, since they recently started operating, their waste incineration slag and ash collection is much lower and still have broader possibilities to use at a local landfill for their local needs. Notably, some recent regulatory developments can potentially affect the functioning of incineration plants.[310]

No.	Facility type	Location	Operator	Waste type	Waste management activity	Capacity of installations, t/year
1.	Cogeneration power plant	Vilnius city municipality	UAB Vilniaus kogeneracinė jėgainė	Municipal waste*	R1	160,000
2.		Kaunas district municipality	UAB Kauno kogeneracinė jėgainė	Industrial and other economic activity's waste, municipal waste*	R1	200,000
3.		Klaipėda district municipality	UAB Fortum Klaipėda	Industrial and other economic activity's waste, municipal waste*, non-hazardous medical waste	R1	255,000
4.	Hazardous waste incineration plant	Šiauliai district municipality	UAB Toksika	Hazardous, medical waste	R1, D10	10,000
5.	Cement production facility	Akmenė district municipality	AB Akmenės cementas	Total amount of waste (industrial and other economic activity's waste), including: RDF, sludge, and used tyres	R1	216,220: - RDF 170,000 - Sludge 30,000 - Used tyres 21,000

Note: Municipal waste after treatment at MA/MBT.

Table 12: Main waste management facilities in Lithuania

[309] Fortum. (n.d.). Waste incineration slag and ash. Retrieved from: Fortum website

[310] The Draft of the National Waste Prevention and Treatment Plan (2021-2027) shows preparations to 1) amend the Law on Environmental Pollution Tax and introduce a pollution tax for bottom ash disposal, and 2) prepare an AM order establishing end-of-waste criteria for bottom ash and slag (with reference to REACH).

Waste incineration capacity has been recently substantially expanded and currently amounts to 615,000 tonnes in cogeneration power plants (see table 12), plus 216,220 tonnes from the Akmenės cement plant. The new Vilnius and Kaunas cogeneration power plants were designed according to the waste generation/management situation in the period where EU waste recycling/prevention targets were not yet defined. Hence, in order to follow the new EU targets set for (65%) municipal waste recycling, as well as waste prevention and circular economy goals, the amount of municipal waste that will be recycled or prevented will increase. There is a risk of overcapacity if the amount of treated municipal waste not suitable for recycling and entering incineration plants will be reduced. Besides, the Akmenes cement plant also has the IPPC permit for incineration of Refuse-derived fuel (RDF) and other industrial waste (allowed for a total of 216.220 t/year (see table 12). They are preparing a new project to install additional equipment in order to make the use of RDF in a more technically suitable way (currently they are preparing information for Screening of Environmental Impact Assessment for this technical solution). The project may be part of the EU's Just Transition Fund.

Several special projects are also planned to implement the necessary infrastructure to treat separately collected food-kitchen waste (from municipal waste flow) under regional municipal waste management systems in 7 out of 10 regions. EU financing is foreseen for more than €11 million to be invested in developing treatment capacities (amounting to 23,703 t/y of food waste until the end of 2023). Technologies are expected to vary from site to site, but they will all be designed to produce compost of better quality compared to the one that we get from mixed municipal waste treatment in RATC.

Overall, waste treatment infrastructure is problematic because of low levels of separate waste collection and low-quality recycling. For plastics and textiles, separate collection levels of recycling capacity and quality recycling are all low, and there is a need for bigger and better collection and recycling infrastructures. For example, there is still a lack of infrastructure to manage plastic packaging waste volumes adequately. There are three operational PET recycling facilities; in Vilnius (allowed up to 43,800 t/y), in Trakai district municipality (30,372 t/y), and in Visaginas municipality (12,000 t/y). There is also one more planned (NEO Group). Lithuania also has recycling capacity for other types of plastic, especially PE, which meet its demands. However, the absence or insufficient modern technologies (i.e. washing lines) prevents more effective and efficient recycling. There is also a lack of manufacturing capacity of food grade pellets, regardless of plastic type. Hence, the secondary raw materials obtained from plastics recycling are generally low-quality, making them only suitable to manufacture garbage bags, pipes or other similar products. Due to a lack of sufficient and modern recycling plants that could sort plastic, recycling options within Lithuania are severely limited. As a result, a large part of packaging is exported abroad, whether this waste is recycled or incinerated in destination is unknown. Another example of the waste treatment capacity being slowed down by a lack of more modern and innovative technologies and techniques is the Waste Accounting System (GPAIS). Theoretically, this is a national automated data collection, analysis and monitoring system for product, packaging and waste accounting. Still, it lacks practical use and accessibility and is thus an ineffective and inefficient system.

Municipal waste

Lithuania has made some notable progress regarding municipal waste management during the past two decades, primarily due to legal compliance (ban on landfilling) and improved infrastructure.[311] Municipal waste generation in Lithuania (472 kg/y/inhabitant, 2019) is slightly below the EU average (502 kg/y/inhabitant).[312] Recovery targets and economic and market incentives, such as taxes for packaging and other chargeable goods, deposit refund systems for beverage packaging as well as incentives for the set-up of reuse centres are being used.[313] Currently, there are diverse businesses and associations that collect used products from different streams (i.e. electronics, batteries and light bulbs) in containers at stores or supermarkets, although they are relatively small in scale. These products are then sorted and prepared for reuse or recycling depending on the type of waste and its potential use as secondary materials. This type of infrastructure has been incentivised since the amendment of the Waste Management Rules in 2017[314], and has the potential to continue growing, as there are waste streams that are currently underexplored. However, municipal waste sorting is still relatively inefficient due to a lack of funding to modernise and upgrade the facilities with, for example, new technologies that would improve their sorting capacity and quality. Another problem is limited separate collection rates, for example of textiles, that currently lies around 15% of the clothing consumed per capita.[315]

Industrial waste

Industrial waste treatment infrastructure is adequate and well-organised. However, household and industrial waste are not separated, so there is a lack of data available for companies to better understand the dimension of their waste problem and, for example, direct their R&D efforts to address them. Still, the basic infrastructure for industrial waste treatment is already present and functioning. According to the 2019 data of the State Waste Accounting system[316], treatment of collected industrial and other economic activity's waste is as follows:

Including phosphogypsum:

- 52,8 % recovered (used or recycled (R2-R11), exported, pre-treated for use or disposal (R12, S5)
- 42,1% landfilled (D1, D5),
- 1,8% incinerated (R1, D10),
- 0,2% disposed of by other means (D2, D4, D6),
- 3% remained unmanaged,

[311] Merta, E. (2016). Municipal solid waste management. Lithuania Country factsheet 2016. VTT Technical Research Centre of Finland. Retrieved from: Eionet portal

[312] Eurostat. (2021). Municipal waste generated, 2005 and 2019. Retrieved from: Eurostat website

[313] European Commission. (2012). Lithuania country factsheet. Retrieved from: EC website

[314] Eionet. (2019). Country Report, Lithuania. Retrieved from: Eionet portal

[315] Watson, D. (2020). Textile flows in the Baltic states (and what they tell us). Retrieved from: SEI website

[316] Environmental Protection Agency (EPA). (2021). Collection and management of waste from manufacturing and other economic activities. Retrieved from: EPA website

Excluding phosphogypsum:

- 87,8 % recovered (used or recycled (R2-R11), exported, pre-treated for use or disposal (R12, S5)
- 3,8% landfilled (D1, D5),
- 3% incinerated (R1, D10),
- 0,4% disposed of by other means (D2, D4, D6),
- 5% remained unmanaged

For packaging waste and secondary raw materials (glass, plastic, paper/cardboard, metal, wood waste). According to Green Dot information[317],there are around 65 companies performing recycling/recovery of glass, paper and cardboard, plastic, PET, metal, wooden and combined packaging waste. Some recycled materials, such as glass, plastic or paper, are used in the manufacture of new products: glass bottles, bags, pipes, paper packaging, furniture fibres, etc. The rest of secondary raw materials are exported. Additionally, UAB Toksika[318] is a state owned company that deals with Hazardous waste. It operates an incineration plant (allowed up to 10,000 t/y) and a waste landfill (disposal allowed of up to 9,000 t/y) in Šiauliai district municipality. There is also an animal by-product treatment plant In Rietavas municipality.[319]

Liquid waste and sewage

Even though the law forbids the landfill of liquid waste, an unknown part of it is still entering the sewage system and is not adequately accounted for. Certain liquids (i.e. blood) in some facilities, such as slaughterhouses, are already collected separately and used for feed production or other purposes. Additionally, some liquid chemical waste treatment facilities or these wastes are recovered on generation sites with regeneration/distillation or similar installations.

Modern sludge treatment facilities were planned and installed during the 2007-2013 and 2014-2020 EU financing period. According to the State Waste Accounting data, in 2018, 45,416 tonnes of sewage sludge were generated, of which 32% were composted, 42% were used for fertilisation, 16% accumulated, and 10% of sewage sludge was used otherwise.[320] Generally, the main wastewater treatment plants, which have methane tanks, all produce electricity and heat for their own use. Current installed capacity is sufficient: in Lithuania, about 83% of generated sludge is managed in dry anaerobic sludge digesters, 10% in composting areas and 7% in drying installations. After treatment, sludge is used for fertilisation (agricultural and forests), recultivation or incineration. The use of treated sewage sludge for field fertilisation is strictly regulated. Due to high concentrations of heavy metals, sewage sludge is used in a limited way. Unsuitable sludge for fertilisation/recultivation is

[317] Green Dot. (n.d.). Waste management in Lithuania. Retrieved from: Green Dot website
[318] UBA Totsika. (n.d.). About us. Retrieved from: Totskia website
[319] Biovast. (n.d.). About us. Retrieved from: Biovast website
[320] Government of Lithuania. (2021). Draft National Waste Prevention and Management Plan. (Unpublished).

incinerated in Akmenes cementas. However, more than half of wastewater is stored in storage plants and landfills, although it is increasingly being used for energy generation.[321]

4.3 Knowledge infrastructure and Innovation Ecosystem

Developing knowledge is a critical input to the advancement of social, economic and environmental development. By knowledge infrastructure we refer to the networks of physical, human, and intellectual (i.e. knowledge itself) resources related to the production, maintenance and sharing of knowledge (i.e. research, science and technology). Developing knowledge infrastructure requires planning and long-term investment, and maintenance over time can be costly. In Lithuania, funding for R&D and innovation activities remains heavily dependent on EU funds.[322] Schools, universities and research institutions have traditionally been the core assets of knowledge infrastructure. However, government agencies, private research institutions, and innovation hubs, to name a few, are also key players. By innovation ecosystem we understand "the evolving set of actors, activities, and artifacts, and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors".[323] The main assets of Lithuania's knowledge infrastructure are listed below.

Research and development infrastructure

Lithuania's research and innovation infrastructure is mainly publicly funded and dominated. European funding is an important financing mechanism. Policy and investment efforts since the middle 2000s have achieved substantial improvements in developing knowledge, research and innovation infrastructure. Since 2007, the considerable policy focus has been on upgrading the capabilities of public R&D infrastructures, which led to the creation of the concept of science, studies and business valleys and the development of Open access R&D infrastructure (OAC).[324] According to the National Audit Office of the Republic of Lithuania (2017), between 2006-2013, Lithuania spent €411 million to develop its R&D infrastructure and science valleys. Another €679 million were put into the further enhancement of R&D capacity over the period 2014-2020.[325] Currently, there are a total of 16 universities and 19 colleges in Lithuania. R&D activities are predominantly carried out by the public sector, represented by 13 state universities and 13 research institutes as well as other public research organisations (PROs) created and/or managed by them. All universities in Lithuania have courses or programmes related to sustainability and circular economy. However, there are only two main technical universities: Kaunas University of Technology (KTU) and Vilnius Gediminas Technical

[321] Praspaliauskas, M. & Pedišius, N. (2017). A review of sludge characteristics in Lithuania's wastewater treatment plants and perspectives of its usage in thermal processes. doi:10.1016/j.rser.2016.09.041

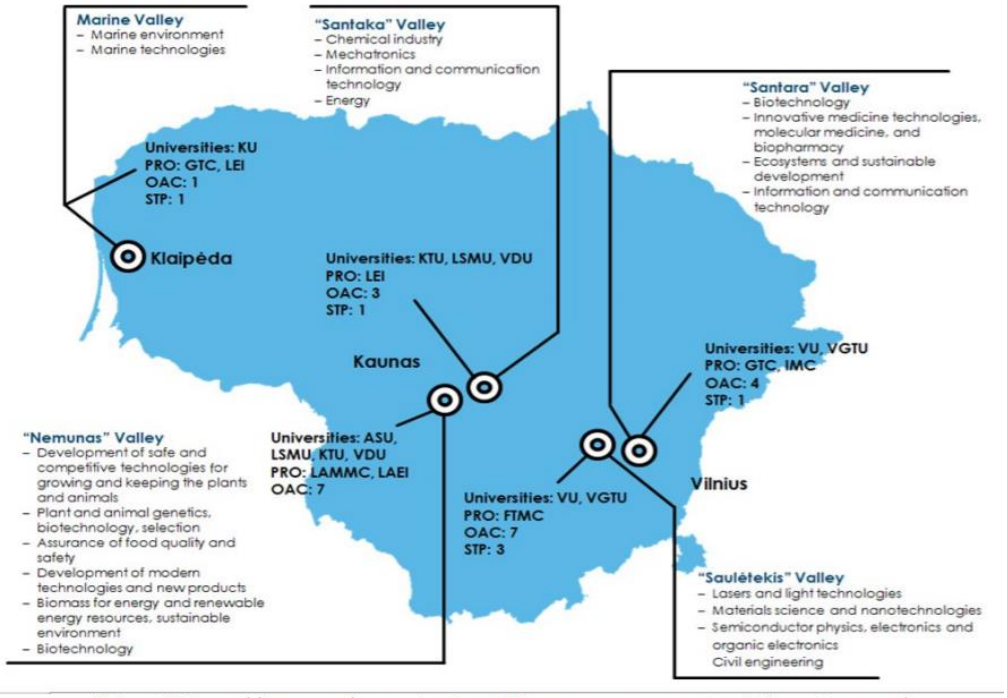
[322] European Commission. (2020). Country Report Lithuania 2020. Retrieved from: EUR-Lex website

[323] Granstrand, O. & Holgersson, M. (2019). Innovation ecosystems: A conceptual review and a new definition. doi:10.1016/j.technovation.2019.102098

[324] Open access centres was a concept used until April 2016, when legislation changed the terminology to Open access R&D infrastructures. Both are considered OACs here.

[325] Invest Lithuania. (n.d.). Innovation and R&D. Retrieved from: Invest Lithuania website

University (VGTU). Additionally, six colleges specialise in applied sciences, technical and technological applications, and design.[326] KTU and VGTU have more specialised industry-related sustainability study programmes, offering exceptional competencies related to the circular economy. For example, KTU offers an MSc programme on "Sustainable management and production", an interdisciplinary programme that integrates environmental engineering, production engineering and business. 2021 has produced its 17th edition of graduates. In addition, there is a similar programme with a more technical focus in VGTU's faculty of Environmental Engineering.



Notes: PRO – public research organisation, OAC – open access centre, STP – science and technology park.
Source: MITA (2016b), publicly available information on valleys

Note: Since 2019 ASU is part of VDU.
Figure 6: Mapping valleys and open research centres by their R&D specialisation.[327]

Free Economic Zones (FEZs)

Being a country on the EU's border, Lithuania has established seven FEZs, located at Vilnius, Kaunas, Klaipėda, Šiauliai, Kėdainiai, Panevėžys and Marijampolė.[328] R&D activities in these FEZs are mainly funded by European Structural and Investment Funds (ESIF) and EU research grants under programmes such as EU *Horizon 2020*. Research and academic institutions in Lithuania have been very actively involved in these programmes. However, interest and participation among industry and

[326] LAMA BPO. (n.d.). High Schools Lithuania. Retrieved from: LAMABPO website
[327] European Commission. (2017). Specific Support for Lithuania: Background Report. Retrieved from: EC website
[328] Invest Lithuania. (n.d.). Free Economic Zones. Retrieved from: Invest Lithuania website

businesses have been relatively low. Similarly, analysing applications of Lithuanian institutions to Horizon2020, proposals led by Lithuanians are few, but the success rate of applications in Lithuania (14.35%) is slightly above the EU average (12.05%).[329]

Governmental scientific, research, and innovation institutions.

Public institutions and government agencies engaging in the collection, process, analysis and dissemination of data and information are also central assets to Lithuania's knowledge infrastructure and innovation's ecosystem. The Governmental Agency for Science, Innovation and Technology (MITA)[330], the Lithuanian Innovation Centre (LIC)[331] and the Government Strategic Analysis Center (STRATA)[332] are three key government agencies related to Lithuania's innovation ecosystem. MITA is tasked with, among other things, developing and implementing technology and innovation programmes, and LIC provides innovation support services and implements Lithuanian innovation policy. STRATA is also a relevant component of the country's knowledge infrastructure since it plays a central role in providing research and input to shape public policy in, among others, issues related to education, science and innovation (such as the Smart specialisation strategy).

Lithuanian cluster network

There are around 60 research and development clusters operating in Lithuania, most of them concentrated in and around Vilnius and Kaunas. They focus their research and development activities on the following areas: a) ICT (e-services, anti-piracy, banking); b) photovoltaic technology; c) food; d) biomedicine (orthopaedics, rehabilitation, stem cells, odontology); e) creative industries and cinema; f) lasers; and g) engineering.[333] Clusters carrying out R&D activities for the five selected sectors include the following: Smart Food Cluster (16 members), National Food Cluster (21), Food Technologies Digitalization LT (15 members), AgriFood Lithuania DIH (26), Plastics Cluster (12 members), Lithuanian prefabricated wooden house cluster – PrefabLT (10 members), Smart Construction and Real Estate Cluster (4), the Baltic Furniture cluster (11), and the We Are Baltic Cluster (home textiles) (8). Additionally, the Health Technology cluster iVita (24 members) also works with Smart textiles, although these are not its main focus. MITA is taking an active role in the clusterisation process as a facilitator/coach. There are eight science and technology parks, where an increasing number of technology transfer and innovation centres provide commercialisation services.[334]

[329] European Commission. (n.d.). Lithuania Horizon 2020 country profile. Retrieved from: EC website
[330] MITA. (n.d.). About us. Activities. Retrieved from: MITA website
[331] Lithuanian Innovation Centre (LIC). (n.d.). About us. Retrieved from: LIC website
[332] STRATA. (n.d.). About us. Retrieved from: STRATA website
[333] MITA. (n.d.). Clusters in Lithuania. Retrieved from: MITA website
[334] European Commission. (2017). Specific Support for Lithuania: Background Report. Retrieved from: EC website

Digital Innovation Hubs (DIHs)

DIHs are also important assets of the knowledge infrastructure system and have a clear link with the Digitisation roadmap. There are several DIHs focused on, among other things, digital transformation, advanced manufacturing, engineering industries and technical universities. Some of the most prominent are Agrifood DIH, Robotics DIH, and Smart Energy DIH. However, it is important to note that DIHs differ substantially in terms of their maturity. Additionally, as part of the European Digital Strategy, the EU has set up dg Connect and the forthcoming European Digital Innovation Hubs (EDIHs) network[335]. Lithuanian has teamed up to make alliances nationally: one DIH in Vilnius and one for the whole country.

Despite developing strongly during the past two decades, analysis of the research infrastructure identified that Lithuania's knowledge infrastructure and innovation ecosystem faces several challenges.[336] Primarily the fragmentation of the innovation ecosystem, R&D infrastructures and their different types together with information asymmetry regarding available R&D services. There is also an excessive reliance on EU funds for innovation funding.[337] Notably, there's also a lack of academic and R&D activities focusing on infrastructure itself. For example, there's only an Institute of Energy, which partly addresses energy-related infrastructure. However, there is currently a recommendation to the Ministry of Education to create an Institute of Infrastructure that can support the Lithuanian industry in key areas, such as transport and logistics and digital infrastructure.

Lithuania's positioning in European Strategic value chains

Given the summative description of Lithuania's innovation ecosystem above, it is instructive to regard the country's positioning in the European Strategic Value Chains, as listed below:

(1) Smart Health
(2) Low-carbon industry
(3) Connected, clean and autonomous vehicles
(4) Cyber-security
(5) Industrial IoT
(6) Hydrogen technologies and systems
(7) Batteries
(8) High-performance computing
(9) Microelectronics.

[335] European Commission. (2021). European Digital Innovation Hubs. Retrieved from: EC website
[336] European Commission. (2017). Specific Support for Lithuania: Background Report. Retrieved from: EC website
[337] European Commission. (2020). Country Report Lithuania 2020. Retrieved from: EUR-Lex website

As shown by the sectoral capability mapping performed by the Public Policy and Management Institute (PPMI)[338], **Lithuanian companies have capabilities to work in microelectronics; clean, connected and autonomous vehicles; and smart health** value chains (to a lesser extent). Noting that:

- **Lithuanian firms or other players are lagging behind in participating in the EU's industrial alliances**: battery alliance, critical raw materials alliance and clean hydrogen alliance.
- **Lithuania's ICT sector is best-placed** to play its role in many strategic value chains: Cybersecurity; Industrial IoT; and High-performance computing. To a lesser extent: Smart health and Clean, connected and autonomous vehicles.
- Lithuania is leading the Cyber Rapid Response Teams under the Permanent Structured Cooperation on defence (PESCO), which **shows the E's trust level in Lithuanian cybersecurity knowledge**.
- This is also revealed because Lithuanian organisations participate in another EU's key industrial undertaking: **the high-performance computing Joint Undertaking (EuroHPC).**
- In 2018, Lithuania signed the EuroHPC Declaration, which enables Lithuanian researchers and businesses to participate in European High-performance computing research and development programme invitations. However, Lithuanian involvement in the programme is limited: **there are four joint projects that Lithuanian organisations are involved in** (in comparison, for example, the Czech Republic has 12 projects).
- Lithuania is not yet participating in the **Joint Undertaking for Electronic Components and Systems for European Leadership**.

The overview above has provided us a snapshot of the industrial make-up of the country and the waste hierarchy options exercised for specific material flows. In addition, a brief overview of the industrial and innovation policy provides us with an impression of the desired direction of development and the support available. Having this knowledge, we can assess the fitness of the opportunities identified in the next chapter (5) for the Lithuanian context.

[338] PPMI. (2021). Report on the Lithuanian industrial landscape and its potential to integrate into European value chains. (Unpublished)

5. Identification of opportunities

5.1 Introduction to opportunities in a circular economy for Lithuania

Circle Economy utilises the Key Elements Framework to identify opportunities for sectors and material flows. The Key Elements Framework renders the elements of the circular economy salient and serves as a basis to derive contextual strategies and interventions. The Framework consists of:

- **Core Elements**: Activities handling product or material flows with a direct influence on regeneration, and/or reducing extraction, waste, emissions to air and dispersion to water or land is prevented, and materials are recovered at their highest value.
- **Enabling Elements:** Activities that remove obstacles for core actors, and generally create the environment for high value recovery of technical materials and biomass cascades.

The two tables below describe the elements in more detail. Table 12 indicates the Core Elements and their proposed effect on flows.

Element	*Description*
 *Prioritise Regenerative Resources*	*Renewable, reusable and non-toxic resources in water, material and energy cycles. Replace non-regenerative resources (such as fossil fuels, and critical materials as defined by this list) with corresponding processes to support regeneration of ecosystems. Apply measures of efficiency to do more with less, for instance energy efficiency measures in production and in the use phase, as well as efficient use of materials and water.*
 *Stretch the Lifetime*	*Resources and products are maintained, repaired and upgraded to maximise their lifetime and usage intensity. Products and materials are used more intensely than they would have been.*
 *Use Waste as a Resource*	*Where waste creation is not avoidable, recover it for recycling. Use waste streams as a source of secondary resources within and across industries. Close the loop.*

Table 12: Core Elements of Key Elements Framework.

Using waste as a resource is a common starting point for circular economy opportunity analysis, however this end-of-pipe opportunity must be extended further upstream to use and manufacture strategies, as well as design and inputs, through to a wider systemic perspective on how to enable the circulation of material flows more broadly - *before* they become waste. The Core Elements deal with

these opportunities that relate directly to material and product flows at any point in the production and consumption process. Realising core opportunities should have a direct impact on materials and emissions.

Despite the increased interest in and efforts towards implementing core elements of the circular economy, there are persistent obstacles to their implementation. Some of the main obstacles to achieving the transition are that dominant economic incentives largely rely on traditional linear ways of creating value; it's difficult to keep track of cycled resources; or recover resources from existing products and a general lack of awareness and knowledge about the circular economy. There is an increasing awareness of the risks, and therefore the costs, of using non-regenerative materials for instance in the context of mining companies facing the risk of stranded assets and high environmental remediation penalties. These costs will permeate down the supply chain for energy intensive industries, who could mitigate both financial and environmental risks from switching to alternative fuels and regenerative materials.

Enabling elements are strategies that help to adopt circularity by removing some of these obstacles. They can use new technologies to create opportunities for circular activities, but they can also change the economic, social, or legal environment in a way that makes circular activities easier to adopt. Some of them explicitly facilitate a specific action, for example the implementation of a marketplace to facilitate the exchange of secondary materials, whereas others create a broader environment that is conducive to circular activities, for example, training on the circular economy.

Realising enabling opportunities is crucial to set up an environment in which core opportunities can be realized, however the effects of enabling opportunities may be more indirectly related to changes in material consumption and emissions. Note that enabling opportunities may take place within an organization (for instance initiating an internal training program) or at a wider systemic level by government (for instance introducing a digital platform to coordinate material exchange).

The following table, Table 13, indicates the Enabling Elements and the obstacles they address.

CIRCLE ECONOMY'S ENABLING ELEMENTS	DESCRIPTION	BARRIER ADDRESSED
Design for the Future	Account for the systems perspective during the design process, to use the right materials, to design for appropriate lifetime and to design for extended future use	Ability to disassemble products and reuse components or materials due to design flaws Ability to recover value from waste due to contamination, lack of knowledge, or legislation
Rethink the Business Model	Consider opportunities to create greater value and align incentives that build on the interaction between products and services	Economic incentives are misaligned to a regenerative ecosystem and the wellbeing of society
Incorporate Digital Technology	Use digital, online platforms and technologies that provide insights to track and optimise resource use, strengthen connections between supply chain actors, and enable the implementation of circular models	Incomplete information about location and condition of assets or resource usage leads to inability to optimise resource usage within and across organisations
Team Up to Create Joint Value	Work together throughout the supply chain, internally within organisations and with the public sector and communities to increase transparency and create joint value	Conflicting interests and misaligned goals between stakeholders in the value chain stymies progress and/or generates wasted resources
Strengthen and Advance Knowledge	Develop research, structure knowledge, encourage innovation networks and disseminate findings with integrity	Lack of knowledge, information silos and asymmetries, and generally disaggregated and unstructured information

Table 13: Enabling Elements of Key Elements Framework.

In the context of this study, we utilise the Key Elements as a framework to assess completeness of the opportunities we are proposing in the Lithuanian context, and as a simple means to categorise where key potential areas of activities are. A basic illustration of how the Key Elements relate to each of the Lithuanian sectors is presented in the table, please see the appendix for a longlist of examples per sector.

Illustration of the Key Elements relating to the Lithuanian sectors.

Sector	Illustration of the Key Elements in Action
Food and Agriculture	Explore the manufacture of alternative fuels and other products from manure and biowaste. Utilise regenerative agriculture best practice.
Construction	Explore the use of bio based building materials such as wood. On the disassembly of a building, capture products and components that may be reused. Consider the use of alternative fuel sources for construction processes.
Textiles	Build flexible recycling systems for textiles waste that can support both mechanical and chemical recycling. Ensure renewable energy is used in all processing facilities. Maintain & repair machines to stretch the lifetime.
Plastics and Packaging	Utilise bio-based or compostable packaging as an alternative, and ensure that all packaging can be collected and reused directly, or processed for reuse.
Furniture	Design for modularity and use of recycled materials in furniture production to extend the lifetime of products and increase the uptake of secondary materials in manufacturing while reducing the need for raw material inputs.

We consider an opportunity to be a measure with regard to a material in a certain sector. *For example; saving textiles by adapting designs in the furniture industry.*

5.2 Circular opportunities identified based on surveys and interviews

The Key Elements framework was used as the basis to survey Lithuanian industry stakeholders. The results of the survey served to inform the questions in our interviews we conducted with captains of industry, representatives of industry organisations and directors of factories. To complement these insights, we did additional desktop research to identify a list of opportunities to explore further.

5.2a Findings from the survey

When asked about which **Core Elements** have a high potential to realise a circular economy, 40% of respondents indicated **secondary materials markets (using waste as a resource).** Of these respondents, approximately 60% of them had indicated secondary materials markets as already being implemented to realise a circular economy. Therefore, we can assume that these respondents are expressing that there remains a great opportunity to leverage and scale this strategy further, and perhaps even that they are already seeing positive results from this and validating it to proceed and scale up.

Sector	Further insights into Core strategies "Utilising Waste as a Resource"
Food and Agriculture	Respondents working within the farming industry indicate the potential to work with other Agriculture stakeholders, as well as with the Energy sector to produce biogas from manure and biowaste. Further to this, there is potential to modify production processes to be completely waste free either through the use of new technology or through regenerative farming practices. One participant indicated that they are already cooperating with the municipal wastewater treatment sector and biomass boilers to employ nutrient rich waste to increase biomass yields on marginal lands. Another indicated the priority to focus on biowaste to energy first, and to fertilizer second resulting in no waste and completing the cycle.
Construction	Respondents within the Construction industry indicate the opportunity to collaborate with the wood sector and other products of vegetal biomass, yet there is a lack of knowledge about technical possibilities and applications. Construction practitioners also indicate the potential to use (wood) waste as fuel but indicate that the current legal framework does not support this.
Textiles	Respondents see the potential to recover textile waste, both mechanically and through the use of chemical recycling. As related to retail, respondents view fast changing fashion as the primary barrier for uptake of secondhand markets for clothing.
Plastics and Packaging	Respondents indicate the potential to modify the material composition of packaging, so that the packaging material may be easier collected and processed for reuse - either as packaging again or decomposed into oil. There is a very latent secondary resources market for this feedstock.
Furniture	Respondents see the potential to use furniture production scraps for recycling and adapt it to the production of new materials. There is also mention of innovative materials and designs, although no further detail is given. Another respondent mentions the use of recycled packaging, this could be extended to recyclable packaging.

We asked stakeholders to indicate which **enabling element** was most relevant to operationalise this strategy, and 29% responded that **collaboration models** (with government and industry) are the most effective enabling strategy, followed by **knowledge advancement** (skills and training) (24% of respondents), and **alternative designs** (22% of respondents).

When asked about challenges in implementation of circular economy, about one third of respondents indicate cultural perception as the biggest challenge,being this the most common response. When asked to elaborate, many respondents indicate the lack of knowledge as a problem, their own knowledge or that of supply chains, governments and consumers. This indicates an opportunity for training and education in these sectors. Several respondents cited opportunities to work with the Education sector more structurally, for instance to have ongoing research and collaboration programmes with relevant educational institutes.

The second most common challenge is lack of financing for circular innovation and technology upgrading, followed by low demand for circular products by consumers (21%).

Sector	Further insights into Enabling Strategies
Food and Agriculture	Circular Agriculture could be enabled by unlocking funding to coordinate stakeholders and enable farm to fork (shorter supply chains) regionally. Furthermore research and updates to the legislation around processing agricultural and biowastes for reentry into production systems is required. Systemic strategies would require coordination of all the actors in the food chain from agricultural producers to food processers to retailers and waste handlers / biogas /biofuel facilities, as well as infrastructure to support management of this.
Construction	Knowledge and upskilling are required to understand how to introduce circular construction methods, as well as funding to conduct research. There is little demand from industry to explore and develop circular business models.
Textiles	There are challenges around sorting and processing materials for reuse due to the unknown and/or diverse compositions of materials. Regulating and enforcing transparency around these topics, as well as encouraging the use of design via novel materials could serve to enable circular textiles.
Plastics and Packaging	Closer cooperation between science, business and regulators is needed. Technology and knowledge is available but regulations and guidelines need to be developed and agreed upon.
Furniture	Alternative business models and adjustments to the economic incentives around circular furniture need to be investigated. Currently demand is too low and the price points are too high for circular furniture to be feasible as a business model.

When considering which circular strategy brings about economic, environmental or societal impact - respondents consistently cite secondary materials markets as the primary strategy across all impact areas:

- Financial benefits - 41% respondents cite secondary materials
- Strategic advantage - 32% respondents cite secondary materials
- Reduce material consumption - 48% respondents cite secondary materials
- Reduce emissions - 32% respondents cite secondary materials

In cases where circular strategies are already possible to implement, businesses indicate that employing them lowers costs and emissions which is beneficial for their business and perception of their business. This is most tangibly the case in the Plastics and Packaging sector. The Furniture and Food sectors see the Circular economy more as a means to have a positive environmental impact, i.e. as a means to reduce material consumption and/or reduce emissions. Textiles respondents see an equal blend of positive environmental (material reduction) and economic impacts derived from the circular economy. The Construction sector sees benefits across the board from financial to environmental, and indicates the most strategic advantage (de-risking) from circular economy strategies versus the other sectors.

5.2b Sector Specific Opportunities and proposed selection of shortlist

Following the survey, we conducted interviews with stakeholders to further discover opportunities that are present within each sector. This section presents the long list of opportunities identified per sector. Next to each of the items in the long-list is a score based on the framework below. The scoring was performed by the Circle Economy team; each item is scored by two independent researchers without prior knowledge of the other's score. The scoring allows the team to come to a *proposal* for a selection of opportunities that we believe is most fit for further analysis.

However, the final selection of up to 3 opportunities per sector is up for discussion at the steering group workshop on april 30th. During this workshop, we will discuss in detail the opportunities and their ranking to come to an agreed selection, fed by the appreciated and in-depth knowledge of local stakeholders from the key Lithuanian sectors.

The score that we present here is a single percentage that is derived by dividing the obtained score by the maximum possible score. Since there are 8 categories each having a maximum score of 3, scored by 2 researchers, each opportunity's maximum score is 48. The final score is thus the sum of scores per aspect divided by 48. We present the scores below as a percentage out of 100 (ie. 78%).

Category	Aspect	Range	scoring
Impact	Net change in material flows	1-3	1 - low expected change or change unknown 3 - high expected change (positive or negative)
	Change in carbon emissions	1-3	
	Change in value creation	1-3	
	Change in jobs and required skills	1-3	
Feasibility	Alignment with policy priorities	1-3	1 - low or no alignment, alignment unclear 3 - good alignment
	Alignment with innovation ecosystem	1-3	
	Alignment with physical infrastructure and industrial ecosystem	1-3	
	Technology readiness level	1-3	1: TRL 1-3 2: TRL 4-6 3: TRL 7-9

I. Food and Agriculture

For the Agriculture and Food sector in Lithuania, we have focused our research on opportunities primarily on the food processing and production sector as the MFA pointed out that this is the largest cause of mass flows. We thus focused less on the production of agricultural commodities - dairy, grains, vegetables and nuts- while we acknowledge that much is to gain in farming practices in most countries and that Lithuania is no different in that respect. That is why we also consider organic farming, for example, as an opportunity, and we pay special attention to the production of phosphate fertilizers that is both energy intensive and yields a huge amount of waste material (phosphogypsum).

Interviewees and literature provided some specifically relevant circular opportunities for Lithuania that are either early in the value chain (fertiliser production) or further down the value chain (food preparation and processing). Literature has also guided us to include one opportunity related to the production of fertilisers: the industries have high emissions to air, a heavy energy footprint and at the same time a waste stream (phosphogypsum) that might be suitable for the construction sector.

Relations with other industries and industrial structure
The MFA pointed out that Agricultural waste streams including vegetal waste and manure make up a significant waste stream, but that they already end up predominantly recycled: recommendations to use these streams should be primarily focused on diverting flows to higher value applications rather

than “preventing waste” . The Lithuanian food processing industry focuses primarily on exports towards (western) European countries. A large portion of its production is for foreign labels, that sets the demands for both ingredients and packaging. Pricing is an important part of the possibilities for sustainability and margins are slim. Interviewees mention for example that organic food has a 2-4% share in sales, although this is growing by some 20-30% per year, mostly from foreign demand. Producers are usually SMEs and/or family companies. Interviewees state that relations with upstream companies are good and that, wherever possible, food residues are already cycled back to farms as cattle feed for example. In addition, since profit margins are slim, there is a focus on reducing food waste anyway as it is the most costly ingredient of their outputs.

The most important (possible relations with other industries are with **construction**, due to the production of fibres from crop residues that can serve as feedstock for composite materials. In addition, the phosphogypsum stock should find some application in construction too. Other options for the agricultural sector to deposit waste streams are the production of **fabrics and filings for furniture or textiles**. Interviewees suggested for example the use of soy husk for the production of textiles.

Most important policy aspects

The Lithuanian rural development fund is an important instrument for Lithuanian farming policy, and has in the past dedicated a (modest, 15%) share towards organic farming. Responsible ministries are the Ministry of the Interior and the Ministry of Agriculture. For the food processing sector, regulations relating to packaging that come into contact with food are relevant, as well as requirements for perishability and “end of waste” criteria. In addition, the ban on landfilling biodegradable waste[339] is a strong incentive for better use of the material, although incineration is still taking place.

Considering the above and the score of the opportunities below, we suggest investigating the following opportunities in more depth. However, the final choice remains a result of the workshop and agreement among the research team involving KTU, MITA and the Client;

1) **Collaborate with clients to introduce more sustainable (mono-material) packaging.**
   The food processing sector is a heavy user of packaging and often uses multiple materials in packaging the same product, greatly reducing the recyclability. We thus scored this opportunity high because nanomaterials can significantly increase secondary material quality in Lithuania and abroad, and enhance value creation from secondary materials. Collaboration would also aid in policy alignment. Moreover, we scored high the suitability of both policy, industrial and innovation infrastructure: it is a feasible approach using existing technology that is desired politically and within the sector.
2) **Provide guidance for the industry to enhance options for higher processing options of food processing residues.**

[339] European Commission. (2012). Lithuania country fact sheet. Retrieved from: EC website

This opportunity scored high particularly because of its high feasibility in terms of policy and technology. With regard to mass flows we expect a smaller impact because the options are very dependent on the kind of stream and the vicinity of suitable processing facilities such as digesters or bakeries -depending again very much on the kind of material. It is exactly this variety of materials and options that necessitates guidance to change cultural habits and exploit innovations to their highest potential.

3) **Upgrade processes for ammonia and fertiliser production to reduce emissions into air and improve opportunities for phosphogypsum reuse.**
Being a national ETS sector, the production of fertilisers has a high energy footprint on a national scale. Changes in the process will thus have significant changes in mass flows, such that the option scored high in this regard. Changes in the process could include capture of N2O, CO2 and further limiting methane emissions.

Element[340]	*Circular Opportunities*
Prioritise Regenerative Resources	• **Promote organic farming and substitute synthetic pesticide, herbicide and synthetic fertilisers with natural alternatives (58%)**. Since this market is rapidly growing and delivers higher added value, there is a significant opportunity to invest in organic farming practices. Once a sufficient scale is reached and the sector develops, prices may drop, thus also stimulating domestic demand.
Use Waste as a Resource	• **Collaborate with clients to introduce more sustainable (mono-material) packaging (69%).** The most prominent problem in (plastic) food packaging is the secondary material flow purity. Even trace amounts of various kinds of plastic can severely degrade recyclability and usability. Moreover, EU demands for plastics certified to be in contact with food are stringent and allow for little to no contamination. Introducing mono-material packaging ensures less contamination with other plastics in the secondary resource flow, increasing the quality, price and suitability for the highest possible application.
Design for the Future	• **Upgrade processes for ammonia and fertiliser production to reduce emissions into air (63%)**. The Lithuanian fertiliser production sector is reported to produce emissions and pollution while also consuming energy above EU average. To reduce the material and emissions footprint while also saving on energy costs, thereby

[340] Note: options from the Key Elements Framework not listed explicitly are: *Prioritise Regenerative Resources; Stretch the Lifetime; and Incorporate Digital Technology.*

	making the sector more resilient to energy price fluctuations, it is essential to modernise the installations in this sector.
Collaborate to Create Joint Value	• **Promote wherever possible the local relations between food-processing industries and farmers (63%)**. Interviewees noted that food processors already have good ties with their suppliers and return waste streams for best application, for example beer-brewing residues as cattle feed. However, some streams (non-edible for cattle or humans) are still landfilled or incinerated while they could be used as soil remediators.
Rethink the Business Model	• **Provide guidance for the industry to enhance options for human-consumption of food processing residues (67%)**. While using food-processing remains as cattle feed is reasonably established, higher consumption options may be available. For example, brewer's spent grain can be used to make bread and other preparations suitable for human consumption. In addition, some survey and interview respondents mentioned options for pharmaceutical derivatives from food processing residues.

II. Construction

The Lithuanian construction sector was found to focus primarily on domestic activities. Interestingly, Lithuania has little net stock additions of buildings and infrastructure as compared to other European countries. Owing to a shift from rural to urban population and a net population decline, it should pay off to focus on energy-efficient urban development based on renewable materials, while keeping existing and new buildings in use for as long as possible - focusing also on changing the function of the building according to the latest needs. This again relates to shifts in population density. The recent shift towards bio-based fuels (wood) in district heating should be supplemented by renewed efforts for modernisation of existing apartment buildings. Moreover, since the net stock additions are relatively low, aggressively focusing on using renewable materials could actually make a strong contribution towards making the sector more circular.

Relations with other industries and industrial structure

The construction sector can have symbiotic ties to the **agricultural** and **textile** sectors as suppliers of base materials. With respect to the former, the use of crop residues in composite materials and applying nationally grown (cross-laminated) timber can greatly reduce the demand for non-renewable, non-metallic mineral resources. Interviewees stated that this may require a change in forestry practice to grow denser wood species, for which promising initiatives already exist. with regard to the latter, the large supply of textiles, either synthetic or organic, could provide feedstock for the production of insulation material. In addition, the **waste incineration sector** can provide bottom

ash as clinker supplement, while sorting installations could provide solid residual fractions for cement production, thereby reducing the demand for demand and substituting fossil fuels.

Most important policy aspects

Especially relevant for the construction sector are Lithuania's National Programme for the Implementation of Green Procurement measures and the as well as the Guidelines on Innovative Public Procurement. This demonstrates that policy is in place, although in 2018, Green Public Procurement represented as little as 7.3% in value of all public procurement, whilst the set target is to reach 45% for 2018.[341] Another cornerstone for future policy for the construction and the built environment is the 'Multi-apartment Buildings Modernisation (Renovation) Programme', causing significant impacts in energy saved and jobs created.

Considering the above and the score of the opportunities below, we suggest investigating the following opportunities in more depth. However, the final choice remains a result of the workshop and agreement among the research team involving KTU, MITA and the Client;

1) **Renovate the existing building stock to minimise energy consumption in buildings**
   This opportunity scores particularly high because technology and policy are ready, while it also gives a large boost to jobs creation and should severely reduce the huge material impact of energy consumption as identified in the MFA.
2) **Integrate environmental standards in Public Procurement Processes**
   National governments are usually the largest single clients of a nation's construction sector, be it for office buildings, schools, hospitals or infrastructure ranging from roads to seaports to metros. Adapting requirements for such projects ensures that there is a market for innovative practices that can subsequently mature and lower prices so other clients can enter. Therefore, the opportunity scored high on material impact, carbon emissions (due to energy consumed in buildings but also contained in construction materials). The opportunity also scores high on all feasibility categories except national policies. This is because there is a clear political desire for more sustainability but we haven't found evidence for policies actually positioning the government as a launching customer.
3) **Innovate to use the enormous supply of phosphogypsum presently being stockpiled in Lithuania**
   This opportunity particularly scores high on material impact and the opportunities for value creation in both the fertiliser sector and the construction sector. Although the technology readiness level and industrial infrastructure readiness scores lower, the opportunity should fit well within existing policies and stimulating the practice can also boost Lithuania's presence in the international research domain on the topic of this global issue.

[341] Lithuanian Innovation Centre (LIC). (2020). Regional guidebook on circular procurement. Retrieved from: LIC website

Element[342]	*Circular Opportunities*
Prioritise Regenerative Resources	• **Use timber from sustainably managed Lithuanian forests or agricultural residues for construction materials (65%)**. Since Lithuania has a strongly developed timber sector, it makes sense using the materials provided to their highest potential. A logical option is to replace concrete with cross-laminated-timber wherever possible, or use crop-residues from mint, hemp or other long-fibred crops to produce composite materials like hempcrete. • **Continue renovation of the existing building stock to minimise energy consumption in buildings and introduce circular elements (88%)**. Lithuania's successful apartment renovation programme could be continued to save energy, as energy is the largest material footprint of Lithuania. Adding circular strategies for reuse of demolition material and including renewable resources can enhance the environmental performance of the programme. • **Upgrade cement production facilities to reduce carbon emissions from clinker (58%).** Lithuanian cement production is reported to have higher CO2 emissions than the EU average. Reconsidering the fuel mix and adapting the installations as necessary can reduce fuel costs and exposure to global commodity markets while simultaneously reducing emissions.
Stretch the Lifetime	• **Redesign buildings to be able to change function and purpose to prevent demolishing (69%).** Lithuania already has relatively low stock additions for buildings, meaning the net amount of added floor space is relatively low. This performance can be enhanced by ensuring that new buildings are designed to be flexible in usage. That means offices could later serve as homes and vice versa, but also that homes can (be converted to) cover an entire lifespan, from young adult, to family to elderly dwellings.
Use Waste as a Resource	• **Innovate to use the enormous supply of phosphogypsum presently being stockpiled in Lithuania (81%).** Lithuania is known to have a large stockpile of phosphogypsum - making up to around 85% of all landfilled waste and half of the country's total waste disposal. The material is problematic to use currently, due to its toxic and sometimes radioactive[343] nature. Because the quantities available are so large, it may pay off to seek some application of the material. Moreover, since the issue is global, collaboration with international knowledge partners and producers seems a good opportunity to share costs of R&D. Promising signs of solutions are already present from Lithuanian research. • **Use bottom-ash in the production of cement and clinker and include SRF as a fuel for cement production (63%).** Because in cement only a portion of the cement actually reacts to form bonding structures, the non-reacting part of the cement could be replaced with fillers, thus reducing the need for (energy intensive) cement production. An additional option for cement production is replacing the fuel (usually fossil; either coal or natural gas) with Solid Recovered

[342] Note: options from the Key Elements Framework not listed explicitly are: *Prioritise Regenerative Resources; Stretch the Lifetime; and Incorporate Digital Technology.*

[343] Tayibi, H. et al. (2009). Environmental impact and management of phosphogypsum. doi:10.1016/j.jenvman.2009.03.007

	Fraction; a by-product of recycling processes for non-hazardous materials from municipal solid waste.
Design for the Future	• **Integrate environmental standards in Public Procurement Processes (83%).** For instance, environmental standards could be included in tenders for the construction of public infrastructure and buildings with a focus on sustainable and secondary materials but most importantly on energy performance of buildings.
Rethink the Business Model	• **Establish a secondary materials market (and digital platform for better matching) for waste flows between renovation and new build projects (48%).** A building materials depot and market can help redestine precious materials (copper, wood) or building components (concrete stairwells, facades, trusses) for use in other projects.

III. Textiles

The Lithuanian textiles sector is large, well developed and involves not only the production of new garments but also one of Europe's largest import, sorting and recycling activities in used clothing. Together with the furniture sector, the textile sector's footprint amounts to about 4% in material use, 3% in greenhouse gas emissions and 4% in Gross Value Added.

Considering the *production* of new garments, Lithuania takes a role as a European service supplier for many foreign brands. Increasingly, producers are shifting towards more sustainable production means because of 1) demand from brands using sustainability as a selling point or 2) to increase their own margins and distinguish themselves with respect to producers from Asia, with whom they cannot compete on the labour-cost component. The secondary textile subsector imports clean streams of secondary clothing from Western Europe on large scale and sorts them according to quality, after which a share of it is either re-exported again to countries according to their purchasing power: the highest quality to high purchasing power countries, and lower grades to regions Belarus, Ukraine or further towards Central Asia.

with regard to the secondary textile industry, there are challenges abound. Especially the domestic infrastructure for collecting post-consumer textile underperforms: Interviewees mentioned that In 2018, only 2000 tonnes of textiles from Lithuania were collected due to lacking infrastructure and incentives for collection. The situation is getting better each year, but still about 8% of municipal waste is reported to be textile waste (compared to 5% EU average). The limited separate textile collection currently lies around ~15% of new clothing consumed per capita and 10% of secondary textile consumption.[344] In addition, the textiles delivered through separate collection containers lack quality and cleanliness, while further infrastructure to actually process the domestically collected materials

[344] The Nordic Council of Ministers. (2020). Textile flows in the baltic states (and what they tell us). Retrieved from: SEI website

is reported to be lacking. Subsequently, due to quality and competition from imported streams, most of it is processed to rags or sent to incineration or landfills. One interviewee commented that although these statistics are disappointing, a possible cause besides infrastructure and good separation could be that Lituanians already wear clothing longer and repair more often than the EU average.

Relations with other industries and industrial structure

The textile industry has some promising links to other Lithuanian industrial sectors as either sources or sinks. Sourcing for the textile sector can take place from **agriculture and forestry**, providing fibre derived from crop residues and proteins contained in them. A logical source of synthetic fibre could be the **plastics and packaging** industry, as is already being done one some scale with recycling PET to fabrics. Especially the used clothing subsector can use other sectors as sinks: the **construction industry** could use either synthetic or natural fibres as insulation material, while applications in **agriculture** have been found as geotextiles. Of course there are strong ties with the **furniture** sector that can use both high quality (recovered) fabrics as well as fibres and non-woven materials for fillings. Moreover, the economies of scale and the infrastructure are present to develop several promising circular opportunities for the textile industry in Lithuania that we describe in more detail below.

Most important policies

As with the furniture sector, for a manufacturing sector like textiles containing many SMEs the innovation support for SMEs is important - and in place. Opportunities for automation are less extensive in the production of new garments as sewing remains a manual process for some time to come. with regard to the used clothing sector,the picture is different. Digitisation can play a role in item, material and quality determination - a notable issue when sorting fabrics - and subsequent automation could play a role in sorting the fabrics and clothes. Innovation support for smaller and larger enterprises aspiring to use such technologies can boost the domestic market for Lithuania's digital startup ecosystem too. Equally relevant is policy for ensuring cleaner secondary streams from the domestic market.

Considering the above and the score of the opportunities below, we suggest investigating the following opportunities in more depth. However, the final choice remains a result of the workshop and agreement among the research team involving KTU, MITA and the Client;

1) **Collaborate with brands to modify designs of clothing for reduced material needs or better separability of pre-consumer waste flows.**
   This opportunity scored high on feasibility because the capacities are demonstrably present while the market for sustainable textiles is growing. Starting the conversation and collaborating with brands that do not have sustainability in their core business can help to prepare for changing demands while also being able to generate higher margins from their activities.
2) **Create (tax) incentives to lower costs of post-consumer products and services for consumers.**

A common remark from interviews was that Lithuanians often cannot afford the sustainability premium due to the lower purchasing power of the country compared to other european countries. The opportunity thus scores high on value created and jobs and skills affected. We acknowledge that taxation instruments are usually difficult to implement due to it being the core source of income for a country, discrimination concerns for other sectors, and harmonisation requirements of VAT rates among EU members, which is why it scored low on these aspects. However, with regard to industrial infrastructure, technological readiness and the innovation ecosystem the other aspects of feasibility score high in general.

3) **Investigate options for a more effective local used textiles circularity system.**
This opportunity scored particularly high because it appears that a suitable infrastructure is present for sorting the stream of imported textiles, but it is not within reach for the domestic textile. Connecting these dots seems like a win-win scenario for both the importers - that can access a new stream with low logistics costs - and the country of Lithuania to increase circularity of domestic textiles.

Element[345]	*Circular Opportunities*
Use Waste as a Resource	• **Use textiles produced from recycled feedstock, discarded clothes or crop residues as filling or fabric (67%).** Examples were found of (PET) plastics being processed and used as fabrics and fillings in the furniture industry. This could greatly reduce the demand for new synthetic materials. Specifically, since Lithuania holds large parts of the petrochemistry chain *and* a thriving textile sector, a stronger symbiotic relation is logical. Residues from fibrous crop or food-processing also remain an interesting option to use as, for example, geotextiles. An interesting example is producing yarns from forestry products.[346] • **Invest in advanced sorting and processing plants to recover textiles up to the fibre level (63%).** Since Lithuania is one of the EU's largest used clothes processors, this is the best place to develop an advanced installation for the recovery of textiles up to the fibre level.
Design for the Future	• **Collaborate with brands to modify designs of clothing for reduced material needs or better separability (81%).** Lithuanian clothing manufacturers often work for foreign brands. While some already demand sustainable or circular goods and practices - and are willing to pay the associated premium - material efficiency and process redesign can reduce costs while increasing sustainability at the same time.

[345] Note: options from the Key Elements Framework not listed explicitly are: *Prioritise Regenerative Resources; Stretch the Lifetime; and Incorporate Digital Technology.*
[346] DP acetate. (n.d.). About us. Retrieved from: DP acetate website

Collaborate to Create Joint Value	• **Investigate options for a more effective domestic recycling infrastructure (75%)**. Create strategic partnerships with collectors, municipalities, (foreign textile) recyclers and circular businesses to make sure post-consumer materials are clean and usable to their highest potential. Also consider developing EPR for this textiles sold in Lithuania and develop a universal code of practice to harmonise textile collection, sales of secondary materials and recycling.
Rethink the Business Model	• **Create (tax) incentives to lower costs of circular products and services for consumers (75%).** Value added tax and labour tax greatly add to the costs of manual labour, that is an essential component in the clothing sector, be it for sorting secondary streams, repairing clothes or producing new ones. Shifting from labour taxation to consumption taxation and at the same time lowering taxes for repairs helps preserve materials for as long as possible.
Strengthen and Advance Knowledge	• **Stimulate second hand clothing and repair/renewal services in attractive retail environments (65%).** Since cultural issues with second hand items have been often mentioned as a barrier for circularity in clothing, boosting the image and availability of services to prolong the lifetime of clothes can help. A local example is the international success of Vinted. • **Stimulate knowledge among citizens about the importance of correct separation of textiles from municipal waste and best practices for post-consumer textiles (48%)**. Material contamination is one of the key reasons for the low application grade of domestic post-consumer textile. Increasing the stream's quality should reduce the incineration and landfilling rates.

IV. Plastics and Packaging

The Lithuanian plastics and packaging sector sector has some production capacity across all of the stages of the chemicals value chain, from production of primary and intermediate goods to the sales and distribution of the finished products[347]. Primary plastic production is limited to a handful of facilities, some owned by foreign companies. Some businesses are represented in the Circular Plastics Alliance, and promising innovations have taken place in the recent past. For example, NEO group recently unveiled their capacity to produce chemically recycled (depolymerised) PET from secondary PET, which can serve as a very pure feedstock in the PET bottle industry. The MFA pointed out that the Chemistry and Plastics sector[348]is responsible for 6% of material consumption, 4% of carbon emissions and 3% of Gross Value added. This means the sector has a relatively modest footprint in comparison to the country as a whole, which doesn't mean there is no room for improvement.

[347] PPMI. (2021). Report on the Lithuanian industrial landscape and its potential to integrate into European value chains. (Unpublished)

[348] Note: in the Material Flow Analysis this includes the footprint of the fertiliser industry.

Relations with other industries and industrial structure

Having production capacities across the value chain within Lithuania implies there is room for industrial symbiosis and collaboration within Lithuania. Plastics and packaging are specifically interesting for Lithuania because the country is export oriented, and a large fraction of the items exported requires specific packaging, either because of retailer demands in **clothing** or **furniture** or because of the product properties in the case of **food**. Increasing the environmental performance of packaging in Lithuania thus contributes to environmental performance of packaging in the client countries, too. The Lithuanian packaging sector sources secondary materials on the international commodity market or the local domestic market, depending on the commodity price and the product quality. A shortage of companies producing high quality secondary materials in Lithuania has been mentioned. Post-consumer secondary plastic has been said to be of lower quality in Lithuania too, because of contamination with other substances and volatility in supply. The quality concerns and the higher effort required to produce secondary plastics than virgin plastics causes the primary input of the plastics and packaging sector to still be largely based on virgin materials.

A specific barrier to increased circularity in the plastics sector is the material quality and the diversity of plastics- and both are related. A single bottle can for example have a PET body, a polypropylene cap and a label of either another type of plastic or paper. Even more difficult are flexible laminated packages - often found in the **food industry** - that have a great variety of plastics and aluminium sheets fused together to obtain optimal conservation qualities with minimal weight, which are practically non-recyclable. And even if a pure stream comes out, it is the freedom of a recycler to choose the form of output, for example pellets, flakes or resins. This means that the feedstock may not be suitable for a plastic processor due to its shape, even though the material itself may be of sufficient quality.

Most important policies

Lithuania is mentioned by some for leading on recycling of plastic packaging, with a recycling rate of 69% in 2018[349]. This is in part due to the taxes for packaging and other chargeable goods, deposit refund systems for beverage packaging as well as incentives for the set-up of local reuse centres. Critics mention that the actual recycling rate is lower than statistics show, and that the deposit scheme only covers 10% of total packaging placed on the market. Nonetheless, policies have enabled a shift from landfilling recyclable goods - among which plastics - from 92% to 59%[350]. SUpport for high-tech innovation is essential for the development and maturation of technologies that increase stream quality and recyclability. This being a European effort, a good R&D connection (e.g. with Horizon 2020 funding mechanisms) with other European plastics producers and processors is essential.

Considering the above and the score of the opportunities below, we suggest investigating the following opportunities in more depth. However, the final choice remains a result of the workshop and agreement among the research team involving KTU, MITA and the Client;

[349] Eurostat. (n.d.). Retrieved from: Eurostat

[350] Merta, E. (2016). Municipal solid waste management. Lithuania Country factsheet 2016. VTT Technical Research Centre of Finland. Retrieved from: Eionet portal

1) **Make better use of the available mechanical recycling capacity for plastics by collaborating throughout the supply chain to ensure a more pure stream.**
   Interviewees and statistics indicate that still a large fraction of collected plastics doesn't find its way back into Lithuanian products. Various causes (chiefly quality and price mechanisms) lead to incineration of contaminated streams as well as exports of higher quality streams. This subsequently results in avoidable transport movements and materials lost. The opportunity scores particularly high because of its feasibility on all levels (technology, policy, innovation and industry) while the impacts on material flows, carbon emissions and value creation are also relatively high.
2) **Invest in the ability to use more diverse inputs for production processes: pellets, flakes, resins, etc. (instead of only one form).**
   This opportunity scores high because of its technological readiness and relative ease of introduction, requiring only an investment at the intake of an installation. Moreover, the added value scores high because the opportunity also allows plastic processors to diversify their sourcing, limiting their exposure to or dependence on single supply streams. The feasibility of this opportunity also scores high on all fronts.
3) **Collaborate with innovative suppliers that enhance secondary material content.**
   This opportunity scores high on potential mass flow impact and value created. It scores lower on the feasibility with regard to industrial and innovation infrastructure, because the costs are still substantial and the innovation capacity of the sector is limited due to the size. This could be resolved by cross-chain collaboration and participation in the Circular Plastics Alliance. The opportunity also scores lower on technological readiness as it is still only available on demonstration scale.

Element[351]	*Circular Opportunities*

[351] Note: options from the Key Elements Framework not listed are: *Stretch the Lifetime; Rethink the business model;* and *Incorporate Digital Technology.*

Prioritise Regenerative Resources	• **Shift to bio-based materials for packaging (46%).** This can establish greater industrial symbiosis and reuse of secondary materials - ie from furniture, forestry, food processing, and chemicals sector. For example, polymers can be made using starch extracted from potato peels. Note should be made that the available feedstock is problematic, whereas bio-based does not imply biodegradable.
Use Waste as a Resource	• **Invest in the ability to use more diverse inputs for production processes (73%).** By diversifying the inputs accepted for the process from plastics to products, the process becomes more suited to accept the diverse stream of pellets, flakes, resins, and other forms that secondary plastics may come in. Currently, most installations that process crude plastics into preforms or products only accept one form of input. Moreover, diversification ensures the installation can switch to the economically most feasible stream depending on supply.
Design for the Future	• **Redesign products to reduce material consumption and/or increase recyclability (58%).** Lightweighting items can be a first step to reduce material demand, but other options like material substitution or reducing the number of materials used can also add to increased recyclability. For example, shifting to mono-materials where possible can alleviate the laminates problem, whereas reconsidering the material of labels on PET bottles or even directly printing on bottles could also reduce the problem of mixed plastics.
Collaborate to Create Joint Value	• **Make better use of the available mechanical recycling capacity for plastics (75%).** Currently, the mechanical recycling capacity offered in Lithuania is not yet fully used to its potential. Collaborating throughout the supply chain can increase the useful supply offered to the mechanical recycling installations. • **Invest in a materials and sustainability agenda for the sector to reduce regulatory uncertainty and decide investment priorities and intrasectorial material demands (56%).** By integrating materials, design and process requirements the sector can achieve a higher degree of interoperability with regard to material streams and their suitability for recycling.
Strengthen and Advance Knowledge	• **Collaborate with innovative suppliers that enhance secondary material content (63%)**. While chemical recycling is still not technologically mature, the technology is promising and can greatly reduce efforts in sorting while increasing secondary

resource quality. In addition, most essential industrial elements for the process are present in Lithuania.

V. Furniture

Owing to relatively low labour costs, the Lithuanian furniture sector is largely export oriented towards a small number of large clients that place the products further in (Western) European countries, IKEA being the most notable. Its material footprint as identified by the MFA is about 4% in material use, 3% in greenhouse gas emissions (GHG) and 4% in Gross Value Added (GVA).

The sector is characterised by a large number of SMEs, many of them family businesses, and employed at the beginning of 2021 around 29,000 people.[352] Activities include factory-scale furniture production but also "project furnituring" providing customised interiors to for example schools, cruise ships, theatres. The sector has to deal with the significant buying power of large parties, who in turn not only set quality or material standards but also process requirements for, for example, traceability of contents and labour conditions. Interviews and the survey have surfaced increasing attention for sustainability, driven by "branded idealism" towards wealthier consumers but also out of cost efficiency and the capabilities that digital design and manufacturing allow. The latter leads to promising opportunities for process improvement to reduce the overconsumption of materials and re-using internal "waste" flows by keeping stock of size, quantity and quality of the materials remaining after a project.

Relations with other industries and industrial structure

Furniture production relies heavily on use of **timber** (often processed into particle boards) and **textile** as either filling or cover. The manufacturers are spread throughout the country and source some of their inputs from international markets - interviewees mention Belarus and Latvia, for example. For some material flows this can be a concern as the sustainability of, especially, wood cannot be guaranteed, or only at a premium that domestic customers cannot afford. with regard to project furnituring, the **construction sector** is a relevant client where collaboration could lead to increased sustainability. For example, collaboration could improve recoverability of complete furniture should building use change. On the other hand, the construction industry could use fillings or textile scraps as insulation material provided they meet hygiene and purity requirements, whereas wood waste from construction could be reused in particle boards for furniture. The **Agricultural** sector could be a promising source of fibres in textiles, reducing demand for virgin materials. Finally, the **packaging industry** is involved through supplying textiles produced from recycled PET bottles, which for some companies make a good " green" marketing point.

Most important policies

[352] Enterprise Lithuania. (n.d.). Furniture industry. Retrieved from: Enterprise Lithuania website

Being a manufacturing sector with high potential for automation and digitisation, the furniture industry can benefit from industry 4.0 ingredients such as robotisation, digitisation of design and manufacturing processes.[353] To be able to make most of these benefits, the EUREKA innovation funding towards SMEs is particularly relevant, as is support for skills development for digitalisation through the smart specialisation strategies.

Considering the above and the score of the opportunities below, we suggest investigating the following opportunities in more depth. However, the final choice remains a result of the workshop and agreement among the research team involving KTU, MITA and the Client;

1) **Promote the practice of using secondary materials for filling and fabrics.**
   This opportunity ranked particularly high because of its synergy with the textiles sector, notably the secondary textiles that do not meet the quality requirements for use in clothing but that can be made into filling. We rated the feasibility of this opportunity high, because the industrial ecosystem is well positioned to develop it as all elements are present. For what concerns reusing secondary materials from textile as topping fabrics, demands are higher and upcycling material on a fibre basis may need to be developed - a recommendation that we will discuss in the next section.
2) **Use digital design systems to minimise materials bought for new products.**
   This opportunity scored high because of its ability to cost-effectively reduce material consumption by up to 30%, while improving the quality of projects towards clients, because the costs become more predictable too. Moreover, digitisation of fabrication processes fits well within the Lithuanian industry 4.0 ambitions and the current, well developed software startup ecosystem. The technology is essentially ready to go and requires minor investments for most companies, although training may be required for personnel to use the methods.
3) **Train designers to develop furniture that is circular and develop accompanying business models.**
   Efficient design of products was quoted to reduce the total waste from production by up to 5%. Moreover, circular designs allow for increased repairability and thus increased lifetime, all of which adds to a high material flow score. The opportunity also creates value in several ways: 1) by reducing the costs of input materials and 2) by increasing the quality and thus desirability of the product. We assessed the feasibility as high on all fronts except the industrial ecosystem, that may need to adapt processes and equipment to be able to absorb the opportunity.

Element[354]	*Circular Opportunities*

[353] Ministry of the Economy and Innovation. (2018). Lithuanian Industry Digitization Roadmap 2019-2030. Retrieved from: Industrie 4.0 Lithuania

[354] Note: options from the Key Elements Framework not listed explicitly are: *Prioritise Regenerative Resources; Stretch the Lifetime; and Incorporate Digital Technology.*

Use Waste as a Resource	• **Promote the practice of using secondary materials for filling and fabrics (88%).** Research has surfaced applications of PET bottles as feedstock for fabric for furniture covering. In addition, furniture contains textiles that many people don't even see: the fillings. Especially in Lithuania with its well established (secondary) clothing sector, it makes sense to divert as much material as possible from landfill and incineration towards higher value applications, among which these in the furniture industry.
Design for the Future	• **Redesign items to reduce the amount and diversity of materials and reduce disassembly & repair complexity (73%).** Redesigning furniture items can lead to significant savings caused by using different inputs. For example, choosing different finishings can increase recyclability, while using different joints can increase the repairability of furniture items.
Incorporate Digital Technology	• **Use digital design systems to minimise input materials (79%)**. With the increasing digitisation of design processes, it has become easier to make a complete inventory of all the materials needed and their quantities before making a single product. Doing so ensures that overbuying of inputs is eliminated and so rest flows are reduced. • **Use digital design systems to keep an inventory of residue materials and maximise their usage for new products (79%).** Where rest flows do remain, it makes sense to develop a policy for what materials to keep (depending on size, quality) and subsequently keep an inventory of materials available for reuse. This opportunity is specifically relevant for project furnituring where quotes are often lump-sum, the rest materials are "paid for" and there are little financial consequences for discarding.
Collaborate to Create Joint Value	• **Collaborate with clients to integrate sustainability demands into process, product and business model (77%).** Demand for responsible and sustainable furniture is increasing. Starting a collaboration with clients to discuss concerns and opportunities may lead to new, more sustainable products or even business models. In addition, a fruitful collaboration and intensified client relation can ensure that investments made in sustainability are profitable by agreeing on the duration of the collaboration and the size of investments.
Rethink the Business Model	
Strengthen and Advance Knowledge	• **Train designers to develop furniture that is circular and develop accompanying business models (79%)**. Circular design requires different modes of thinking that can be taught to designers. Examples are eliminating glue or fused materials, maximising repairability and using secondary resources to begin with. By training designers in

this practice, circularity can not only lead to better products but also to reduced costs and improved processes.

6. Opportunity analysis

The previous chapter presented a long list of opportunities to advance circularity in the five selected demonstration sectors: Food and Agriculture, Construction, Textiles, Plastic and Packaging, and Furniture. As previously explained, these opportunities were categorised using the Key Elements Framework to identify opportunities to advance circularity in the different sectors and material flows. Following the Stakeholder Consultation workshop on the 30th of April 2021, where local experts and stakeholders were divided in sector-specific worksessions and asked to rank the different opportunities based on the local context and their expertise and knowledge, the top three opportunities per sector were selected. Chapter 6 of the report thus analyses the selected top three opportunities to advance circularity in each of the five demonstration sectors. The analysis assesses the feasibility and scalability[355] of each opportunity by drawing on relevant case studies, interviews with local experts, and by examining the existing industrial, technological and innovation infrastructure as well as the European and national policy landscape. Additionally, the impact assessment of applying circular strategies is holistic, with demonstrated environmental, social and economic benefits.

6.1 Food and Agriculture

6.1a Promote collaboration from food-processing industries and agriculture for valorisation of by-products and residues

This opportunity focuses on the valorisation of food processing and agricultural residues that could serve as feedstock for the bio-based industry. According to the Lithuanian Official Statistics Portal (OSP), the total amount of organic waste (by-products) generated in agriculture in 2019 was estimated at almost 14 million tonnes, composed primarily of straw, manure, slurry and similar agricultural residues.[356] Additionally, food losses originating from food processing are a critical example of inefficient resource management. Even though quantifying food losses has proven to be a challenge, experts suggest that it can represent up to 50% of total food production.[357] According to interviews

[355] Relevant terms and definitions:
Feasibility: The degree to which climate goals and response options are considered possible and/or desirable. Feasibility depends on geophysical, ecological, technological, economic, social and institutional conditions for change. Conditions underpinning feasibility are dynamic, spatially variable, and may vary between different groups.
Enabling conditions: Conditions that affect the feasibility of adaptation and mitigation options, and can accelerate and scale-up systemic transitions that would limit temperature increase to 1.5°C and enhance capacities of systems and societies to adapt to the associated climate change, while achieving sustainable development, eradicating poverty and reducing inequalities. Enabling conditions include finance, technological innovation, strengthening policy instruments, institutional capacity, multilevel governance, and changes in human behaviour and lifestyles. They also include inclusive processes, attention to power asymmetries and unequal opportunities for development and reconsideration of values. Source

[356] Official Statistics Portal of Lithuania. (2021). Waste generation and treatment. Retrieved from: OSP website

[357] World Wildlife Fund (WWF). (2012). Tons for the trash. Retrieved from: WWF website

with local experts, and the study undertaken by the Bio-based Industries Consortium in 2020[358], these residues are largely recycled through local reapplication to soil. While this ensures the important ecological cycling of nutrients, it also signifies a loss of potential economic value: further potential to reduce greenhouse gas (GHG) emissions lies in using such residues to produce bio-based materials. Although ecological cycling should be prioritised in a bid to replenish soil nutrients, the large volumes of biomass residues point to further opportunities for valorisation. Most residues are rich in cellulose, phytonutrients and energy and could serve as feedstock for the bio-based industry: they have potential for valorisation through a range of applications, from further processing in the packaging, furniture, pharmaceutical and construction sectors.[359][360]

Feasibility and scalability

This opportunity is highly feasible from a policy, business and technological perspective. Specific valorisation applications are very dependent on the functional properties and volumes of residual streams, and the proximity of suitable processing facilities such as biogas digesters or manufacturing plants.[361] Due to the heterogeneity of food and agricultural residues, and the variety of potential industrial applications, it is difficult to accurately scope the full potential for scalability. A key barrier to scalability could be capital equipment costs, such as laboratory and processing technologies. Even though it is difficult accurately quantify the potential of organic residue recovery, data demonstrates that the food industry in general[362], and Lithuania particularly[363], have a great margin for enhancing the treatment of such resources. In Lithuania, only about 10% of total agriculture waste is diverted for other uses rather than being treated on site: the country's bio-based economy has a large potential for scaling. Biomass production and supply, via agriculture, forestry and fishing represents approximately 3.7% of total economic activity, while the Bio-Based Manufacturing Industry (a potential user of organic residues) represents approximately 5.6% of total economic activity[364]. Bio-based manufacturing includes food processing, beverage production and tobacco, the most prominent food processing sectors in Lithuania being milk, meat and grain processing[365], as well as the wood products and paper sector. Within each of these sectors, numerous business examples of residual reuse exist in the construction, packaging, pharmaceutical and chemical industries. Some prominent examples include:

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[358] Bio-based Industries Consortium. (2020). Mapping Lithuania's bio-based potential. Retrieved from: BIC website

[359] Smil, V. (1999). Crop Residues: Agriculture's Largest Harvest: Crop residues incorporate more than half of the world's agricultural phytomass. doi:10.2307/1313613

[360] Gupta P, Ray J, Aggarwal BK and Goyal P. (2015). Food Processing Residue Analysis and its Functional Components as Related to Human Health: Recent Developments. Retrieved from: Austin Publishing Group website

[361] Wageningen University & Research (WUR). (2019). Standards and Regulations for the Bio-based Industry. Retrieved from: WUR website

[362] Ellen MacArthur Foundation. (2019). Cities and Circular Economy for Food. Retrieved from: EMF website

[363] Bio-based Industries Consortium. (2020). Mapping Lithuania's bio-based potential. Retrieved from: BIC website
Agriculture, Forestry and Fishing data was updated with 2020 data. Retrieved from OSP website

[364] Bio-based Industries Consortium. (2020). Mapping Lithuania's bio-based potential. Retrieved from: BIC website
Agriculture, Forestry and Fishing data was updated with 2020 data. Retrieved from OSP website

[365] Melnikienė, R. et al. (2019). Agricultural and Food Sector in Lithuania 2018. Lithuanian institute of agrarian economics.

- **Qmilk** is a compostable milk fiber invented in Germany in 2011 by the company Qmilk. The fiber is made of casein, a milk protein, extracted from processed residual dairy. Qmilk is composed of 100% organic polymer without plasticizers, solvents and chemicals, and it breaks down free of residues within a few months. By using milk waste, the overall negative impact to produce both fibers and milk is reduced. The Qmilk fiber is very versatile and it can be used for different purposes in the textile industry, and to produce cosmetics and sustainable packaging.[366]

- **CuanTec,** a biotechnology company based in Scotland, has developed the world's first clear Chitosan film by using waste from the seafood industry. The film has natural antimicrobial properties and it aims to replace single-use plastics. By using Chitosan as a key ingredient in packaging, Cuaten's technology ensures extended shelf life of fresh seafood, consequently reducing food losses.[367]

- **Wheatboard**. Chesapeake Plywood, a US producer of binderless fibreboard, produces the Wheatboard, also called Ecoboard, which is used in a wide range of applications in the construction and furniture industries. Wheatboard is manufactured from 100% high-quality natural wheat straw, without timber. The agricultural fibers used are left-overs from harvests, a by-product that is usually disposed of. Strong fibers in plant stems are bonded together by modified formaldehyde-free adhesive, making the Wheatboard the perfect upgrade product for traditional wood-based panels.[368]

Industrial and technological infrastructure

Lithuania's food processing industry is very well established, with an increasing number of innovative SMEs utilising modern technologies. The country also houses many 'beneficiary' industries such as construction, furniture manufacturing, pharmaceutical and packaging; all of which are well connected to logistics networks. There is an excellent practice of upholding stringent quality and environmental standards, which provides a favourable outlook for significant innovations focused on the valorisation of food processing residues and agricultural by-products.[369] However, the production capacities of local producers for some specific sectors are small-scale; a deficiency of raw materials from local producers necessitates further exploration of collaboration with neighbouring countries to increase capacity and scaling potential.[370]

[366] Tasnim, N. (2019). Eco-friendly Manufacturing Process of Casein Fiber with It's Sustainable Features & Comfortable Uses. doi:10.5923/j.ajee.20190902.02

[367] Cuantec. (n.d.). Retrieved from: Cuantec website

[368] Chesapeake Plywood. (n.d.). Biofiber Wheatboard. Retrieved from: Chesapeake Plywood website

[369] Enterprise Lithuania. (n.d.). Food and beverages. Retrieved from: Enterprise Lithuania website

[370] PPMI. (2021). Report on the Lithuanian industrial landscape and its potential to integrate into European value chains. (Unpublished).

Innovation infrastructure

As part of the R&D infrastructure, there are five clusters related to agro-innovation and food technology[371] that could potentially support the implementation of this opportunity. The most signficant are the National Food Cluster, Food Technologies Digitalisation LT, and the Agrifood DIHLithuania. There is also an active community of SMEs in the bioplastics, cosmetics and pharmaceuticals, and building materials sectors in addition to agriculture and food processing. This indicates a good range of specific knowledge, and the possibility for establishing collaboration in niche, low-volume, high-value markets. However, it is also important to note that the implementation of this opportunity depends on management solutions in addition to technological innovations.

Policy landscape

There are several legislative initiatives and strategies at the EU level concerning food and food waste.[372,373,374,375] In particular, the *Updated Bioeconomy Strategy* aims to integrate the bioeconomy with sustainable and renewable industrial processes. To this end, cooperation and collaboration between different actors is crucial to prevent residues by valorising and enabling the use of agricultural and non-edible by-products. Preventing food waste is also central to the *Farm to Fork Strategy*: the European Commission proposes introducing legally binding food waste reduction targets by the end of 2023 for Member States to take action. Nationally, food is one of the value chains prioritised in the *Lithuanian Industry Digitisation Roadmap*.[376] After the narrowing down of the *Smart Specialisation Strategy* (S3) following the end of the period 2014–2020, 'Agro innovation and food technologies' are no longer considered a key priority area for the period 2021–2027. However, these initiatives could still be covered and funded under the remaining key priorities of 'Biotechnologies' or 'New production processes, materials and technologies'. As one of the key GHG emitters in Lithuania, the modernisation of technologies and practices in agriculture and food is central to the *Lithuanian Climate Change Management Policy* and its implementation.[377]

[371] MITA. (n.d.). Clusters in Lithuania. Retrieved from: MITA website

[372] European Commission. (2018). Updated Bioeconomy Strategy. Retrieved from: Publications Office of the EU website

[373] European Commission. (2020). Farm to Fork Strategy. Retrieved from: EC website

[374] European Commission. (n.d). EU common agricultural policy (CAP). Retrieved from: EC website

[375] European Commission. (2020). Circular Economy Action Plan. Retrieved from: EC website

[376] Lithuanian Innovation Centre (LIC). (2020). Lithuanian Industry Digitisation Roadmap 2020-2030. REVISED DRAFT updated within a framework of the "Follow up" project. Retrieved from: EIMIN website

[377] Ministry of the Environment of Lithuania. (n.d.). National Climate Change Management Policy Strategy. Retrieved from: AM website

Impact potential

Shifting to a bioeconomy can improve Lithuania's resource security by reducing its dependence on oil, coal and gas[378] and by reducing overall exposure to price volatility or to new regulations that address the negative externalities of these conventional inputs.[379] In addition, the overall amount of organic waste generated in agriculture in 2016 in Lithuania represents a significant amount of agricultural residues that could serve as feedstock for the bio-based industry: over 14 million tonnes[380], which could amount to between €12.7 and €17.5 billion of turnover and over 85,000 jobs created.[381] Besides positive effects in terms of employment creation, the development of bio-based value chains can improve the profitability of food companies and hence contribute positively to the safeguard of employment levels in the food industry[382].

6.1b Introduce circular (mono-material) packaging

This opportunity focuses on addressing non-circular packaging materials, specifically within the food and beverage processing industry. In Europe,production of plastic packaging is estimated to demand approximately 20.5 millions tonnes of plastic per year, of which approximately 8.2 million tonnes are used for food and beverage products: this is comparable to the weight of over 8 million cars[383][384]. After the use phase, over 83% of this plastic packaging becomes waste[385] with a strong potential for high-value recovery and reuse. In 2018, Lithuania's total plastic packaging waste generation (for all economic activities) amounted to about 75,857 tonnes[386] (27.08 kilograms per capita[387]). However, packaging is ubiquitous across the economy, as suggested by the high demand for packaging plastic in Europe. It is also a disproportionate driver of ecosystem impacts, non-renewable resource depletion and GHG emissions.[388] The food processing sector often uses heterogeneous materials in

[378] European Commission. (n.d.). Bio-based products and services. Retrieved from: EC website

[379] Circle Economy & Shifting Paradigms. (2021). Climate change mitigation through the circular economy. Retrieved from: Circle Economy website

[380] Bio-based Industries Consortium. (2020). Mapping Lithuania's bio-based potential. Country Report. Retrieved from: Bioconsortium website

[381] Based on the EU bioeconomy's estimated turnover of around 2 trillion EUR, employment of more than 17 million people and use of the 1,600 to 2,200 million tonnes of biomass produced within Europe yearly. Source: The Bioeconomy in the European Union in numbers

[382] European Federation of Food, Agriculture and Tourism Trade Unions. (2017). The bioeconomy and a future biobased food sector: How can workers' organisations shape the change? Retrieved from: EFFAT website

[383] Plastics Europe. (2019). Plastics - the facts 2019. Retrieved from: Plastics Europe website

[384] ING Bank. (2019). Plastic packaging in the food sector. Retrieved from: ING think Economic and Financial analysis website

[385] Eurostat. (2021). Packaging waste by waste management operations. Retrieved from: Eurostat website (Last accessed 12/06/2021)

[386] Eurostat. (2021). Packaging waste by waste management operations. Retrieved from: Eurostat website (Last accessed 12/06/2021)

[387] Idem.

[388] Oki, Y. & Sasaki, H. (2000). Social and environmental impacts of packaging (LCA and assessment of packaging functions). doi:10.1002/1099-1522(200003/04)13:2<45::AID-PTS496>3.0.CO;2-%23

packaging the same product, greatly reducing recyclability. Assuming that the proportion of European plastic demand for packaging production over total plastic demand is the same as for plastic packaging waste generation, the waste generated by the Lithuanian food and beverage plastic packaging industry amounts to about 30,343 tonnes. Shifting to mono materials and sustainably managed bio-based materials that can be used over multiple life cycles can significantly increase recovery and reduce plastic packaging's impacts both in Lithuania and abroad. It could also greatly boost the added value and competitive advantage of the local packaging industry, considering recent shifts in policy at the EU level.[389]

Feasibility and scalability

The technical and policy feasibility of this opportunity is very high, and there are numerous examples of mono material packaging products on the market[390], and numerous other material innovations and research projects underway[391]. This is largely due to shifting policy priorities in only the past few years, driven by the EU[392,393] and Lithuania[394]. While there are generally positive business cases for circular packaging materials, the market feasibility may prove to be slightly more challenging. According to interviews with local experts, a large portion of Lithuania's food production business is directed to foreign labels that set demands for both ingredients and packaging. Pricing is an important factor in regards to possibilities for sustainability innovations, as margins are slim. Interviewees have mentioned that organic food has a 2 to 4% share in sales, but is growing by some 20 to 30% per year, mostly due to foreign demand. Producers are usually SMEs and relations with upstream companies are good, indicating high receptiveness and potential for innovation in this space.

The scalability of such an opportunity is likely to be very high, as the packaging manufacturing industry is a high volume business, which produced over 20.5 million tonnes of plastic packaging in Europe in 2018[395], with relatively limited material and product variation. There are high volumes of agricultural by-products, almost 14 million tonnes in 2019[396], that is a critical capability in enabling reliable feedstocks for bio-based and monomaterial packaging innovations. The key investment requirements will likely centre around improving household plastic waste sorting and collection, new process alignment and potentially new capital equipment capable of processing new feedstocks to the required manufacturing standards.

[389] European Commission. (n.d). Packaging waste. Retrieved from: EC website
[390] Packaging Europe. (2019). The monomaterials challenge. Retrieved from: Packaging Europe website
[391] Closed Loop Partners. (n.d.). Plastic Packaging. Retrieved from: CLP website
[392] European Commission. (2018). A European Strategy for Plastics in a Circular Economy. Retrieved from: EUR-Lex website
[393] European Commission. (2020). Circular Economy Action Plan. Retrieved from: EC website
[394] ACR+. (2019). Deposit-refund systems for one-way beverage packing in Europe. The case of Lithuania. Retrieved from: ACR+ website
[395] Plastics Europe. (2019). Plastics - the facts 2019. Retrieved from: Plastics Europe website
[396] Official Statistics Portal of Lithuania.

The food packaging market is large, with an approximate size of €56 billion in 2019[397], with many material options to suit specific applications. A few companies can be highlighted for their best practices in this market:

- **Compostable and lightweight cellulose packaging material.** VTT developed a compostable and lightweight packaging material by combining cellulose films with different but complementary properties. The plastic-like packaging material is suitable for dry and greasy products, such as nuts, cereals, coffee, condiments and raisins. The greatest benefits can be reached when the material is used for packaging products with a long shelf life.[398]

- **Collaborative innovation.**[399][400] To address the challenge of making flexible materials more easily recyclable, Dow and Menshen announced a new technology that enables the production of spouted pouches made of mono-material films (the 'Reverse Spout Sealing Technology'). The new process is designed to easily seal spouts in more heat sensitive, mono-material structures made entirely from polypropylene or polyethylene packaging layers. This is the result of a three year joint development between Dow and Menshen, which is also working with a number of partners on technology integration and assisting brand owners and converters to put the new sealing approach into practice. Both companies are working with leading manufacturers of pouch-packaging machines worldwide to commercialise the technology.

- **Recycled and recyclable packaging for meat, poultry and fish.**[401] Faerch Plast's MAPET II is mono-packaging produced from a single material, specially developed for sealing fresh meat, poultry and fish. This allows consumers to transport packs home without the risk of leakage and potential contamination from juices, and ensures the modified atmosphere is maintained. MAPET II is manufactured from Post-Consumer Recycled PET materials and can be easily sorted and recycled where the right infrastructure is in place.

Industrial and technological infrastructure

The manufacturing of rubber and plastic products generated €476 million of Gross Value added (GVA) in 2018, with approximately a 24% GVA growth in the 2015–2018 period.[402] This growth trend is in line with Europe and the rest of the world, and demonstrates that Lithuania's technical and industrial infrastructure capacity is growing: the country could leverage this opportunity and enable innovation

[397] Plastics Europe. (2020). Plastics - the facts 2020. Retrieved from: Plastics Europe website

[398] VTT Research. (2018). The Ellen MacArthur Foundation awards VTT for a bio-based packaging solution that reduces the use of plastics. Retrieved from: VTT website

[399] Skoda, E. (2019). The mono-materials challenge. Retrieved from: Packaging Europe website

[400] Packaging Insights. (2019). Reverse technology bring mono-material benefits: Dow and Menshen launch sustainable spouted pouches. Retrieved from: Packaging Insights website

[401] Showunmi, J. (2016). Faerch Plast's MAPET II mono material granted European patent. Retrieved from: Interplas insights website

[402] Official Statistics Portal of Lithuania. (2021). Gross value added, at current prices. Retrieved from: OSP website

within the packaging industry, specifically for the food processing sector. While industrial plastic waste collection and treatment in Lithuaniais high, according to expert local interviewees, there is room to improve municipal plastic packaging waste collection infrastructure, increasing its effectiveness and improving the value treatment of waste plastic packaging, and to expand, adapt and upgrade Mechanical Biological Treatment (MBT) facilities to accommodate larger plastic and packaging waste streams. Enhancing this infrastructure would create enabling conditions for the food packaging sector to invest and innovate in circular and mono-material packaging. However, in the mid-run, recent investments in waste-to-energy could hinder an increase in packaging recycling due to low prices for incineration.

Innovation infrastructure

According to interviews with local experts, there is an overall need to increase cooperation between large companies from various sectors and academia: doing so presents an opportunity to advance innovation, and in this case, to focus R&D on the development of circular packaging that can valorise plastic packaging materials after use and extend their lifetime.

There seem to be sufficient knowledge stakeholders and capabilities within the country to develop and bring the necessary innovations to market. The main technical universities; Kaunas University of Technology (KTU) and Vilnius Gediminas Technical University (VGTU) as well as research institutes carry out work in the area of packaging. The Plastics Cluster, focused on innovation within the plastics sector, is another important active participant. Consumer demand for more sustainable packaging coupled with stricter regulations on plastic waste across the EU are also supporting the advancement of sustainable innovations. For example, due to EU funding, eco-innovation related to using plastic as secondary material has developed in Lithuania.[403]

Policy landscape

There is a strong push at the EU level to move towards sustainable plastics and packaging.[404,405,406,407] EU guidelines state that, by 2030, all plastic packaging must be recyclable or reusable, highlighting the importance of standardisation, design for recycling and the simplification of plastic packaging, which indirectly promotes monomaterials. Revised EU taxonomy for sustainable activities strongly supports recycling.[408] National regulations also support the implementation of this opportunity. For example, key priority areas one ('Health and biotechnologies') and two ('New production processes, materials

[403] Eco-Innovation Observatory. (n.d.). Lithuania country profile 2018-2019. Retrieved from: EC website

[404] European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste. Retrieved from: EUR-Lex website

[405] European Commission. (2018). A European Strategy for Plastics in a Circular Economy. Retrieved from: EUR-Lex website

[406] Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment. Retrieved from: EUR-Lex website

[407] European Commission. (2020). Circular Economy Action Plan. Retrieved from: EC website

[408] Forum Ökologisch-Soziale Marktwirtschaft (FÖS). (2021). Introduction to the EU Taxonomy for a Circular Economy. Berlin. Retrieved from: NABU website

and technologies') of the S3, support this opportunity by promoting eco-innovation around 100% reusable and recyclable packaging. Moreover, the implementation of Lithuania's deposit-refund system has successfully increased collection and recycling rates for specific products.[409] However, there is still room for improvement in the form of stricter plastic waste regulations (for example, extended producer responsibility (EPR) schemes).

Impact potential

A shift to mono-material packaging will simplify manufacturing and logistics costs due to weight and volume reductions[410]—and with it, will bring substantial CO2 emissions savings.[411] By increasing mono-material packaging production, Lithuania's plastic packaging manufacturers could reduce production costs by 58%, according to recent research[412]. And the market for such materials is expected to spike: currently valued at US$58.9 billion, demand for mono-material flexible polymer packaging is predicted to grow by 3.9% annually until 2025.[413,414] Local manufacturers are poised to benefit greatly from this global trend, given the country's dynamic plastic manufacturing and recycling sector and openness to innovation and international trade. Plastic recyclers will also see positive impacts from this opportunity, as the rise of mono-material packaging will boost inflows of highly-recyclable materials and thus increase turnover.

6.1c Regulations on food labelling and awareness-raising

This opportunity directly targets edible food waste and losses over the entire value chain through the creation of amendments to existing regulations on food labelling, combined with awareness-raising efforts. Food waste in the EU is estimated to represent a total economic loss of nearly €143 billion in 2012, and total annual food waste volumes of amount to approximately 88 million tonnes[415]. Recent data from the ministry of environment on total food waste generation in Lithuania is currently not available. However, relevant data points are available from the ministry of environment that illustrate the order of magnitude of restaurant and canteen waste (3,309 tonnes in 2016), edible oils and fats (2,443 tonnes in 2016) and mixed municipal waste (780,650 tonnes in 2016).[416] A study commissioned

[409] ACR+. (2019). Deposit-refund systems for one-way beverage packing in Europe. The case of Lithuania. Retrieved from: ACR+ website

[410] Grassl, P. (2018, October). Monomaterial packaging: A solution to the global plastics crisis. *OndrugDelivery Magazine*. Retrieved from: ONdrugDelivery Magazine website

[411] Gore-Langton, L. (2021, 23 March). Tyler Packaging's recyclable pet food packs outperform alternatives in life cycle assessment. *Packaging Insights*. Retrieved from: Packaging Insights website

[412] Grassl, P. (2018, October). Monomaterial packaging: A solution to the global plastics crisis. OndrugDelivery Magazine. Retrieved from: ONdrugDelivery Magazine website

[413] Platt, D. (2020). The future of mono-material plastic packaging film to 2025. Retrieved from: Smithers Website

[414] Plastics in Packaging Newsroom. (2020, 11 August). Mono-material flexible packaging to be worth $71bn. Plastics in Packaging. Retrieved from: Plastics in Packaging website

[415] European Commission. (n.d.). Food waste. Retrieved from: EC website

[416] Ministry of Environment of Lithuania, Maisto atliekų ekonominė analizė. Galutinė ataskaita. (2018)

by the European Commission in 2010 using data from 2006 estimates that total food waste volumes amount to 581,000 tonnes. At a per capita level this comes to 176 kilograms in 2006.[417] Market studies at the EU level quantify that around 10% of food waste is currently related to date labelling.[418] Food waste is not only an economic issue but a critical source of detrimental social and environmental impacts globally.[419] Addressing this issue through policy amendments, including labelling would allow for the legal sale and distribution of food after 'best before' dates (but prior to expiration). Combined with awareness-raising efforts to encourage public participation, significant progress could be made in ensuring that food is consumed and food waste is minimised.

Feasibility and scalability

Achieving reductions in food waste through regulatory innovations and awareness-raising efforts have proven to be very feasible, with many tangible examples of business, policy and civil initiatives flooding this space, especially over the past few years.[420] There have been a wide variety of successful food waste recovery initiatives, ranging from digital apps and platforms, and the extension of food sharing, resale, and donation activities, to labelling and awareness campaigns across the globe. Many supermarkets have areas designated for products on the brink of expiry, which can be purchased at a discount, according to interviewees; while digital technology like the Flashfood app[421] connects consumers to discounted items in an effort to reduce food waste. This opportunity is also highly scalable: there is already good progress in this area, collaboration between private and public actors on the topic of sustainable food systems, and strong political will at the national and EU level. There are also a number of best practices and approaches taken by other countries that can be directly drawn from and adapted to the Lithuanian context. If we focus specifically on regulatory changes, labelling, and awareness-raising campaigns, a handful of best practices stand out, including:

- **Love Food Hate Waste (LFHW) national campaign.** WRAP's LFHW campaign, launched in 2007, helps UK households tackle food waste in response to WRAP's groundbreaking research on the scale and types of food wasted from UK homes. Working with retailers and brand owners, local authorities, businesses, communities and campaign groups, LFHW provides tips, recipes, messages, graphics and consumer insights as part of targeted campaigns.[422] According to WRAP's research, there was a 15% reduction of household food and drink waste, amounting to 1.3 million tonnes, between 2007 and 2012 in the UK, despite household numbers increasing 4%.[423]

[417] European Commission. (2010). Preparatory study on food waste across EU 27. Retrieved from: EC website

[418] European Commission. (2018). Market study on date marking and other information provided on food labels and food waste prevention. Retrieved from: Publications Office of the EU website

[419] Scherhaufer, S. et al. (2018). Environmental impacts of food waste in Europe. doi:10.1016/j.wasman.2018.04.038

[420] WRAP. (2019). Food waste trends survey 2019. Retrieved from: WRAP website

[421] Flashfood. (n.d.). Save money and fight against food waste. Retrieved from: Flashfood Website

[422] Government of British Columbia. (n.d.). Love Food Hate Waste - Organics case study 1: Waste reduction. Retrieved from: Government of British Columbia website

[423] Yamakawa, H., Williams, I., Shaw, P. & Watanabe, K. (2017). Food waste prevention: lessons from the Love Food, Hate Waste campaign in the UK. Retrieved from: ResearchGate website

- **Improved and standardised date labelling.** Standardising date labels and improving consumer's understanding of what they mean can considerably reduce food waste at home. This can be driven by governments, businesses and civil society. For example, the *Food Date Labeling Act*, introduced in 2019, is a piece of US legislation that establishes a dual label system reducing the available labelling language to two phrases: one quality date indicator and one safety date indicator. It also streamlines the language used to indicate quality versus safety, eliminates state laws that bar the sale or donation of food past the quality date and educates consumers on the meaning of new labels so that they can make better economic and safety decisions. Research organisation WRAP published best practice guidelines on food labelling[424], whilst companies have also demonstrated leadership in this field: the Co-operative Food retested the product life for all of their protein products and found that it was possible to add one to three days to the expiration date without compromising product safety or quality.[425] A **'Call to Action for Standardised Food Labelling'** also saw the world's largest food and beverage companies—including Tesco, Kellogg, Walmart, Campbell Soup, Bimbo, Pick n Pay, Nestlé, Carrefour and Unilever—pledging to standardise food date labels globally by 2020.[426] [No update is yet available on progress made].
- **'Look, smell, taste and fold' campaign.** The Netherlands launched a public awareness-raising campaign in January 2021 on the difference between 'use by' and 'best before' food labels, as part of their efforts to halve food waste by 2030.[427] The initiative was a collaboration between the national platform on food waste reduction (*Samen Tegen Voedselverspilling*), the dairy industry, the supermarket sector and beverage carton producers, and focused on educating consumers on how to assess the quality and safety of dairy products.[428]

Industrial and technological infrastructure

The industrial and technological infrastructure required to effectuate change toward food labelling systems and awareness-raising is very well established. The food processing and retail sectors are large, innovative and adhere to modern policies and regulations.

Innovation infrastructure

The knowledge infrastructure needed to realise this opportunity is sufficiently present. However, according to interviews with local experts and feedback received at the consultation workshop in April 2021, a more holistic view of the food system needs to be included in R&I. Most stakeholders who are involved in R&I are working in primary production. In order to capture the value of this opportunity,

[424] WRAP. (2019). Label better, less waste: Food date labelling guidance. Retrieved from: WRAP website
[425] ReFed. (n.d.). ReFED Solution database: Standardized date labels. Retrieved from: ReFed Insight engine
[426] FoodBev news desk. (2017). Food and drink companies to standardise date labels by 2020. Retrieved from: FoodBev website
[427] Food Tank. (2021). The Netherlands Launches Public Awareness Campaign to Reduce Food Waste. Retrieved from: Food Tank website
[428] Samen Tegen Voedselverspilling. (2021). 'Look, smell, taste and fold!' campaign. Retrieved from: Samen Tegen Voedselverspilling website

the involvement of all the stakeholders is required. For example, by embedding food system challenges and opportunities within public health R&I, involving the market and trade in shaping Lithuania's food system or actively engaging citizens is a key component for the development of a circular food system. Beyond the knowledge infrastructure referred to in the previous opportunity (6.1b), there is an Agrifood Digital Innovation Hub, which could be capable of supporting the implementation of this opportunity. In addition to the work being carried out by the KTU & VGTU in this area, Vytautas Magnus University (VDU) is expanding its research focus on lyophilised food (i.e. freeze dried food). However, as already mentioned above, these initiatives require a multi-stakeholder approach, market-academia collaboration, and policy and regulatory support.

Policy landscape

A legal basis for regulatory changes to take place is crucial for the implementation of this opportunity. There are many legislative initiatives and strategies at the EU level concerning food and food waste.[429,430,431] Information labelling instruments applicable to food products across the EU include two main date markings: "use by" and 'best before' dates. There is also an EU Platform on Food Losses and Food Waste[432] with a dedicated sub-group on date marking and food waste prevention[433]. The policy and legal foundations are there, however, the current EU policy framework lacks the necessary coherence to tackle food waste across the whole EU food system effectively.[434] Nationally, there is a limited focus on regulation concerning food waste and labelling. While there is a 0% VAT rate for donated food products in Lithuania, and funds available for food assistance,[435] national policies concerning food waste focus mainly on waste management and sorting[436] rather than prevention. In addition, to effectively change regulations on food labelling, raising awareness among consumers is key. Education programmes and information campaigns are essential complements to policy affecting consumer behaviour, such as food labelling and food waste prevention[437]. It is also essential that public institutions and policies support proactive stakeholder engagement between regional and national policymakers, consumer associations, trade networks and educators. Thus far, according to local experts interviewed, this is unfortunately lacking—but there are some positive initiatives. For instance, an initiative in which food producers donate aesthetically unappealing but perfectly edible food to charity.[438]

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[429] European Commission. (2018). Updated Bioeconomy Strategy. Retrieved from: Publications Office of the EU website

[430] European Commission. (2020). Farm to Fork Strategy. Retrieved from: EC website

[431] European Commission. (n.d). EU's common agricultural policy (CAP). Retrieved from: EC website

[432] European Commission. (n.d). EU Platform on Food Losses and Food Waste. Retrieved from: EC website

[433] European Commission. (2018). Sub-group on date marking and food waste prevention. Retrieved from: EC website

[434] Graske, B. et al. (2020). Challenges of Food Waste Governance: An Assessment of European Legislation on Food Waste and Recommendations for Improvement by Economic Instruments. doi:10.3390/land9070231

[435] EU Platform on Food Losses and Food Waste. (2019). Redistribution of surplus food: Examples of practices in the Member States. Retrieved from: CNCDA website

[436] National Waste Management Plan for 2014-2020 (adopted in 2012).

[437] Žičkienė, S., Kovierienė, A., & Griščiūtė, V. (2020). Public attitude towards food waste: the case of Lithuania. doi:10.25167/ees.2020.53.2

[438] Interview with the food sector.

Impact potential

In Lithuania, standardised date labelling practices alone could help divert over 50,000 tonnes of food from landfill[439] and prevent over €800 million in associated costs[440], with most economic benefits accruing to households—as they gain a better understanding of food date labels and reduce their own food waste—and the bulk of the costs taken on by manufacturers and to a lesser extent, retailers—as they amend date labelling practices on food products.[441] Next to this, public awareness-raising campaigns could help reduce household food waste by 15% over a five year period.[442]

6.2 Construction

6.2a Valorise and reduce the supply of phosphogypsum

This opportunity targets Lithuania's massive stockpile of phosphogypsum in an attempt to limit its generation and find valuable economic reuse applications, while upholding stringent standards for human and environmental health. Total phosphogypsum volumes landfilled are estimated at around 50 million tonnes.[443] In addition, the annual generation of phosphogypsum waste in Lithuania is currently measured at 2.6 million tonnes, due to the fact that phosphoric acid production (in the fertiliser industry) is still very active. For every tonne of phosphoric acid, just about 5 tonnes of phosphogypsum are created[444]. This is a very costly industrial waste to store, yet poses a number of limitations for reuse because of mild radioactivity[445] and the presence of heavy metals and other hazardous substances, but also the methods of recycling have yet proven to be very costly.[446] Given the latter, the minimisation of phosphogypsum waste generation by transforming the phosphite fertiliser production towards circular fertilizer production is of high importance. However, the ability to valorise this stockpile is being investigated through uses in agriculture and forestry as soil amendment, in construction and in roadbuilding or as a source of calcium, calcite, lithium sulfate monohydrate or phosphorus[447][448] (for use in different industries, e.g.: lithium sulfate monohydrate can be used in lithium batteries production) is worth to continue being explored as it will represent

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[439] Market study on date marking and other information provided on food labels and food waste prevention. Based on EU averages, this assumes 10% of the 502,957 tonnes of food estimated above to be wasted in Lithuania is due to confusing or ineffective date labelling practices. Retrieved from: Publications Office of the EU website

[440] Based on an estimated €143 billion of costs that food waste is responsible for at EU level. Source: Food Waste - EU

[441] ReFED. (n.d.). Standardized Date Labels. Retrieved from: ReFED Insights Engine

[442] Yamakawa, H., Williams, I., Shaw, P. & Watanabe, K. (2017). Food waste prevention: lessons from the Love Food, Hate Waste campaign in the UK. Retrieved from: ResearchGate website

[443] Interview, Lifosa AB. Conducted in June 2021.

[444] Blazevicius, E., Kaminskas, R. & Raginis, A.V. (1998). The problems of phosphogypsum utilization in Lithuania. Retrieved from: Irbnet

[445] Saadaoui, E. et al. (2017). Phosphogypsum: potential uses and problems–a review. doi:10.1080/00207233.2017.1330582

[446] J. Dastikas apie fosfogipso kalnus Kėdainiuose ir perdirbimo technologiją. Publikuota: 2019-06-28

[447] International Fertilizer Association (2020). Phosphogypsum Leadership Innovation Partnership. Retrieved from: IFA website.

[448] Chernysh, Y. et al. (2021). Phosphogypsum Recycling: A Review of Environmental Issues, Current Trends, and Prospects. doi:10.3390/app11041575

an economic opportunity by valorising key components of phosphogypsum[449] resource while reducing the long term environmental and health risks due to its centralised storage[450]. Additionally, as mentioned above

Feasibility and scalability

The utilisation of phosphogypsum stockpiles has been difficult due to the environmental and health hazards associated with the substance, but also the energy-intensive and costly processes needed for recycling. Many governments have taken action to limit its application, making stockpiling the most convenient and economically feasible option. One approach is therefore to limit the additional stockpiling of this substance, through alternative approaches to fertiliser production[451]. Developing alternative, circular and organic fertiliser production instead of focusing on phosphate fertiliser production would have a long-term effect on phosphogypsum waste generation and also allow the development of new uses for agriculture and food processing by-products in fertiliser production[452].

Several recent innovations have offered a new perspective on the possibility for reuse or recovery of elements of this substance, from calcium or rare metals (according to interviewees, Seltenerden Storkwitz AG has managed to extract rare metals from PG, although it is an expensive process) recovery to reuse as a construction material (e.g. cement) or pre-pavement for road paving (according to literature and interviews with local experts), however the feasibility and scalability of these applications have not been tested at scale yet[453][454]. Significant regulatory involvement would be required to ensure that the final uses are indeed safe from an environmental and human health perspective. The scalability of such an opportunity is dependent on a number of factors. Sewage sludge can be used as a reference as it is a similar by-product: very rich in mineral components but with a high presence of diverse pollutants (such as dioxins, furans and heavy metals). Investigation has identified cost-effective and environmentally friendly recovery and reuse practices in conjunction with different sectors (such as construction or fertiliser production)[455][456]. While the total size of Lithuania's phosphogypsum stockpile would allow for large-scale solutions, many of the current recycling methods for phosphogypsum are energy intensive, making up-scaling potentially costly and emissions-intensive. The scalability potential is also limited by demand. Virgin gypsum production is

[449] Ennaciri, Y. et al. (2018). Procedure to convert phosphogypsum waste into valuable products. doi:10.1080/10426914.2018.1476763

[450] Attallah, M.F. et al. (2019). Environmental impact assessment of phosphate fertilizers and phosphogypsum waste: Elemental and radiological effects. doi:10.1016/j.microc.2019.02.001

[451] Scholtz, M. (2017). Creating a circular economy for phosphorus fertilizers. Retrieved from: Ostara website

[452] Chojnacka, K. et al. (2020). Bio-based fertilizers: A practical approach towards circular economy. doi:10.1016/j.biortech.2019.122223

[453] Ennaciri, Y. et al. (2018). Procedure to convert phosphogypsum waste into valuable products. doi:10.1080/10426914.2018.1476763

[454] Rashad, A.M. (2017). Phosphogypsum as a construction material. doi:10.1016/j.jclepro.2017.08.049

[455] Raheem, A. et al. (2018). Opportunities and challenges in sustainable treatment and resource reuse of sewage sludge: A review. doi:10.1016/j.cej.2017.12.149

[456] Chang, Z. et al. (2020). Valorization of sewage sludge in the fabrication of construction and building materials: A review. doi:10.1016/j.resconrec.2019.104606

inexpensive and few neighbouring countries have a strong demand for processed phosphogypsum. Stronger regulatory support and investment in R&I for large-scale recovery solutions could foster a scalable solution for this challenge in the foreseeable future: this as demonstrated in the case of sewage sludge (example of 2008 report for the European Commission to inform policy making on sewage sludge valorisation and treatment[457]).

Some of the most promising avenues for valorisation of this substance or developing solutions for bio-based fertilisers production include:

- **Phosphogypsum (PG) used as construction material**. Extensive investigations have proved that PG from the industry of phosphate fertilizer can be reused as set controller in cement manufactures and building materials, allowing to divert PG from landfill and to reduce the amount of new materials needed for the construction industry.[458] It is also found that calcination contributes to the reduction of PG impurities and increases mechanical strength in materials, therefore delivering satisfactory performances[459].

- **Phosphogypsum with cement and fly ash for soil stabilization.** Tests showed that the use of two waste by-products, phosphogypsum and fly ash may provide an inexpensive and advantageous construction product. Indeed, treatment with cement, fly ash and phosphogypsum generally reduces the plasticity index of soil and unconfined compressive strength tests proved the successful application of soil stabiliser in the construction sector.[460]

- **Re-Nuble**[461] is an Minority and Women-owned Business Enterprise (MWBE)-certified agricultural technology company that has developed a closed-loop process that transforms unrecoverable food by-products into organic goods for soilless farming, while eliminating landfill waste and greenhouse gasses. With its organic science approach, Re-Numble aims to help soilless farms uncover cost reductions while optimizing their operations. Water soluble is captured and introduced by the system, while organic nutrients from their production waste become a free, supplementary, and sterile biostimulant source. This approach allows farms to use a fully integrated, closed loop, and self-sustaining nutrient system that reduces input and disposal costs.

[457] Milieu Environmental Law & Policy for the European Commission (2008). *Environmental, economic and social impacts of the use of sewage sludge on land*. Retrieved from: EC website

[458] Rashad, A. M. (2017). Phosphogypsum as a construction material. Journal of Cleaner Production, 166, 732-743. doi:10.1016/j.jclepro.2017.08.049

[459] Calderón-Morales, B. R. S. et al. (2021). Valorization of phosphogypsum in cement-based materials: Limits and potential in eco-efficient construction. Journal of Building Engineering. doi:10.1016/j.jobe.2021.102506

[460] Degirmenci, N., Okucub, A. & Turabib, A. (2006). Application of phosphogypsum in soil stabilization. doi:10.1016/j.buildenv.2006.08.010

[461] Re-Nuble. (n.d.). Bringing back closed loop food. Retrieved from: Re-Nuble website

Industrial and technological infrastructure

Lithuania has many of the industrial and technological infrastructure requirements to up-scale the recovery of phosphogypsum, with many large scale material processing facilities, when a feasible recycling technique will be in place. However, as mentioned in other opportunities, the quality of logistics and transport infrastructure needs to be enhanced to enable an optimal match of the supply and demand. The manufacture of fertilisers is a well-established sector that has the capabilities and capacity to adapt the production processes to bio-based and circular fertilisers production for the avoidance of phosphogypsum by-product generation.

Innovation infrastructure

Solving the 'phosphogypsum problem' is a national priority, and there is a clear focus on the topic from the innovation perspective. Innovation infrastructure is well-placed, with several technical universities, namely KTU, working on this problem, have proposed solutions. For example, researchers have been researching for a long time now on breakthrough research and innovations. The interest of the business community to utilise phosphogypsum is also there, especially among the construction sector. Fostering collaboration between Academia and the business community is deemed to be key in future innovations around this opportunity. Setting-up a research cluster specifically dedicated to research and development activities focused on phosphogypsum and knowledge exchange with international researchers and businesses who are focusing on the topic, such as Seltenerden Storkwitz AG, the Laboratory of Physical Chemistry of Materials (LPCM) of the Faculty of Sciences in El Jadida or the National Research Centre in Cairo, can also play an important role.[462][463]

Policy landscape

Although the technology readiness level and industrial infrastructure readiness scores low, the opportunity should fit well within existing policies and stimulating the practice can also boost Lithuania's presence in the international research domain on the topic of this global issue. This opportunity could take advantage of the Updated Bioeconomy Strategy which aims to foster cooperation and collaboration between different actors is crucial to prevent residues by valorising and enabling the use of agricultural and non-edible by-products, which directly connects to the phosphogypsum waste stream. Furthermore, even though not directly related to CE, the three key priority areas of the S3 are enabling horizontal approaches that can support the valorisation and use of phosphogypsum in the construction sector. Specifically key priority 'New production processes, materials and technologies', can target and support this opportunity.

[462] Ennaciri, Y. et al. (2018). Procedure to convert phosphogypsum waste into valuable products. doi:10.1080/10426914.2018.1476763

[463] Rashad, A.M. (2017). Phosphogypsum as a construction material. doi:10.1016/j.jclepro.2017.08.049

Impact potential

The management of phosphogypsum disposal is a costly process and can reach up to €5 per tonne.[464] In Lithuania, this could amount to up to €13 million in waste management costs[465] that could potentially be avoided by shifting towards more circular fertiliser production processes that do not result in phosphogypsum production or by using phosphogypsum as input to different industries. For more information on the potential impact of shifting to bio-based products such as bio-based fertilisers, see Opportunity 6.1a.

Considering the potential effects to the labour market, there is likely a net positive impact because new processes would be required to transform an otherwise 'dead end' material. The overall volume of jobs would likely not be that high because of the need to control costs as discussed above. The variety of jobs would also likely be quite low. Based on the case study examples that are described in this section, jobs would mostly focus on heavy equipment operators, construction project and site managers, and a handful of highly skilled scientist and managerial positions to monitor standards.[466]

6.2b Design new buildings for extended lifetimes

This opportunity focuses on design and regulatory solutions that ensure that all new buildings can be adapted to suit various functions and remain in use for as long as possible. Due to low demand and shifts in population density, it is important to extend the life of existing buildings wherever possible (see Opportunity 6.2c). Designing new constructions for the long-term functionality and usability of materials ensures utilisation and value of key assets, by using durable materials and construction standards that can reduce maintenance costs and extend the economic viability of a building., Smart design and regulatory incentives can ensure that new structures are designed with the future in mind, allowing buildings and the built environment as a whole to better meet shifting needs well into the future, reducing the need for continued demolition and new construction.[467]

Feasibility and scalability

The feasibility of design and regulatory interventions that allow for future reuse, repurposing, and more adaptability in building design and urban planning is quite high, with several innovative best practices in the past few years. Such approaches can be limited by labour costs and split incentives among stakeholders and managers. Digitalisation of materials management, the automation of construction, and continuous learning and improvement are therefore important factors in the

[464] WUR. (2009). Phosphorus in agriculture: global resources, trends and developments. Retrieved from: WUR website
[465] Based on current Lithuanian annual phosphogypsum production of 2.6 million tonnes.
[466] Ennaciri, Y. et al. (2018). Procedure to convert phosphogypsum waste into valuable products. doi:10.1080/10426914.2018.1476763
[467] Hampel, F. (2020). A framework for sustainable adaptive reuse of industrial buildings. Retrieved from: KTH website

successful deployment of such strategies.[468] This is especially relevant in dense urban centres where demands can continuously shift and balance between residential, commercial, cultural and public functions. A few best practices of these approaches are described below:

- **Extending the lifespan of buildings through design.**[469] OpenBuilding.co is a group of Dutch architects, engineers and developers dedicated to extending the lifespan of buildings, significantly lowering the ecological footprint and creating healthy communities. Open Buildings are flexible, adaptable, circular and resilient. With distinct architecture, they contribute to a dynamic urban context. The infill is co-created with future users to encourage and consolidate inclusion and belonging. OpenBuilding.co advocates a physical division of building components that have different life cycles. In doing so, Open Buildings incorporate not only flexibility to move with social tendencies, climate change and new regulations, but also form the basis for a circular construction economy.

- **White Collar Factory.** Arup, a services firm with a focus on the built environment, together with architects Allford Hall and Monaghan Morris, implemented sustainable solutions for Derwent London's White Collar Factory in Old Street, London. In particular, the building has been designed using exposed services, and adaptable floor plates and internal fittings to allow for easy subdivision, interactivity and flexibility over time, facilitating the prolonging of the building's lifespan. Concrete core cooling, durable materials, passive systems that maximise natural daylighting and ventilation, and power and data systems have been implemented, providing help with repairs, maintenance and longevity. Moreover, an innovative tablet-friendly building management system enables occupants to see how the building is performing, and to improve comfort levels. White Collar Factory is designed to emit 25% less carbon dioxide than standard buildings and it offers up to 33% reduction in operational energy costs per annum.[470]

- **Flexible zoning regulations**. According to Shank,[471] flexible zoning can help municipalities to rebuild communities after COVID-19, allowing us to adapt and respond to constantly shifting social and economic conditions. In particular, Shank offers a list of suggestions about how to implement flexible zoning regulations in municipalities: by reducing and consolidating the number of base zoning districts for less confusing regulations and to allow better planning across municipal boundaries; by considering mixed-used districts; by re-defining dimensional standards; by rethinking parking requirements; and finally by streamlining procedures and lightening administrative burdens.

[468] Material Economics. (2018). The Circular Economy - A Powerful Force for Climate Mitigation. Retrieved from: Material Economics website

[469] Open Building. (2021). Manifesto OpenBuilding.co. Retrieved from: Open Building website

[470] Arup. (2016). Circular economy in the built environment. Retrieved from: Arup website

[471] Shank, C. (2020). Defining the "new normal": how flexible zoning can help us rebuild our communities. Retrieved from: McNees website

Industrial and technological infrastructure

Lithuania has a healthy construction sector, generating over €640 million in Gross Value Added (GVA) in 2021, or about 6% of the total national GVA.[472] The sector is limited in its specialised construction and engineering activities and technological capacity, which creates a potential barrier to efficiently implementing such a strategy. Efficient processes and advanced site management tools are often identified as key barriers to the implementation of more circular design and construction processes.[473] When considering the sixty six thousand construction companies active in the sector in 2019, only 7.9% belonged to the architectural and engineering activities and 5.9% to the manufacturing sub-sectors.[474] With only a limited group of companies with specialised and advanced construction practices, this could hinder Lithuania's capacity to implement more circular innovations in the the design, assembly and life-cycle maintenance of materials, components and buildings that would be envisaged in this opportunity.

Innovation infrastructure

Lithuania scores below the EU average on four out of the five indicators related to eco-innovation in the construction sector[475], and innovation activities within construction companies are reported to be low.[476] There are some notable R&D and eco-design activities in the construction sector that indicate that innovation is happening towards this opportunity. For example, the Lithuanian prefabricated wooden house cluster – PrefabLT (10 members) and Smart Construction and Real Estate Cluster (4) could contribute to the implementation of circular building designs and components. Moreover, the public institution *Skaitmeninė Statyba* (Digital Construction), set up in 2014 by the Lithuanian Association of Builders together with 12 other relevant associations, fosters the development of Building Information Modelling (BIM) and the introduction of National Construction Classification and Industry Foundation Classes (IFC) in the Lithuanian construction sector.[477] BIM systems in particular are a crucial ingredient to realising the low-cost and efficient management, maintenance, and adaptability of buildings and components.[478]

[472] CEIC data. (2021). GVA Lithuanian construction sector. Retrieved from: CEIC data website

[473] Ghaffar, S. H. et al. (2020). Pathways to circular construction: An integrated management of construction and demolition waste for resource recovery. Retrieved from: doi:10.1016/j.jclepro.2019.118710

[474] European Commission. (2020). European Construction Sector Observatory. Country profile Lithuania. Retrieved from: EC website

[475] Idem.

[476] European Investment Bank. (2019). EIB Investment Survey. Lithuania overview. Retrieved from: EIB website

[477] Lithuania Builders Association. (2014). Brochure of the Lithuanian Association of Builders. Retrieved from: LBA website

[478] Juan, Y. (2017). BIM-Based Approach to Simulate Building Adaptive Performance and Life Cycle Costs for an Open Building Design. doi:10.3390/app7080837

Policy landscape

GIven its high material and carbon footprint, construction is a key priority sector in the EU CE framework.[479,480] The EU, via the 'Circular Economy - Principles for Building Design'[481] and 'Level(s)'[482], the voluntary reporting European framework for sustainable buildings, proposes an approach to circular construction design that focuses on durability and adaptability but also on waste reduction and effective waste management.[483] At the same time, Green Public Procurement (GPP) guidelines and regulation at the EU level also serve as core instruments supporting the advancement of circularity in the built environment.[484] The public sector and national regulations are key enablers for the development of circular construction methods and practices. In Lithuania, especially relevant for advancing circularity in the construction sector are the National Programme for the Implementation of Green Procurement measures and the Guidelines on Innovative Public Procurement. The Government also made BIM methods mandatory for public buildings and certain mobile facilities and infrastructure, with a gradual implementation from 2021 onwards.[485][486] These developments indicate the readiness of the public sector in fostering eco innovation within the construction sector by supporting demand through public procurement, establishing clear guidelines, and promoting the introduction of key technological enablers such as BIM. Moreover, 'Technology for the Development and Use of Smart Low-Energy Buildings - Digital Construction' was part of the 2015-2020 Action Plan. It is no longer, however, considered a key S3 priority. But 'New production processes, materials and technologies' and 'ICT' can support the opportunity given their horizontal nature.

Impact potential

The environmental impact reductions realised by designing buildings for longer lifespans can be significant. As an example, an average building lifespan of 80 years can reduce its environmental impact by 29%, 100 years by 38% and 120 years by 44%, all in relation to a lifespan of 50 years.[487] By way of comparison, the median building lifespan in Lithuania in 2014 was between 45-69 years, with only a fifth of buildings older than 70 years and nearly half of all buildings built in the last 45 years or less, leaving significant room for extended use.[488] From an economic point of view, modular

[479] European Commission. (2015). Closing the loop - An EU action plan for the Circular Economy. Retrieved from: EUR-Lex website

[480] European Commission. (2020). Circular Economy Action Plan. Retrieved from: EC website

[481] European Commission. (2020). Circular Economy - Principles for Building Design. Retrieved from: EC website

[482] European Commission. (n.d.). Lever(s). Retrieved from: EC website

[483] European Commission. (2020). Designing buildings in the context of the circular economy. Retrieved from: EC website

[484] European Commission. (n.d.). EU GPP Criteria. Retrieved from: EC website

[485] Construction 4.0. (2020). The government has agreed to make bim methods mandatory from 2021 onwards. Retrieved from: Statyba 4.0 website

[486] Kumar, V. et al. (2019). Towards a more Circular Construction Model: Conceptualizing an open-BIM based Estimation Framework for Urban Mining. Retrieved from: Research gate

[487] Marsh. R. (2016). Building lifespan: effect on the environmental impact of building components in a Danish perspective. doi:10.1080/17452007.2016.1205471

[488] European Commission. (2021) European Building Factsheets. Retrieved from: EC website

approaches to construction can speed up the construction process by as much as 50% and cut costs by 20%.[489] Modular construction could scale to an industry of more than US$100 billion in the US and European real estate, delivering US$20 billion in annual savings.[490]

From an employment perspective, strategies focusing on lengthening the building life span through modular and adaptive approaches would not likely lead to significant job losses or opportunities, but rather the introduction of new skills and knowledge for construction work, facility management and planning and design. These new skills would require upskilling of the work force and focus mostly on materials handling and management, digital skills, and planning and management.[491,492]

6.2c Repurpose existing buildings to prevent demolition and use demolition materials as a resource

This opportunity focuses on solutions to keep existing buildings and structures in the built environment in use for as long as possible. This opportunity acknowledges the relatively low additions to building stock and the need to better utilise existing structures wherever possible. We have estimated that net stock additions in Lithuania are at around 37% of total consumption, which is substantially lower than the 50% reported for Norway and similar to the 38% reported for the Netherlands.[493] By increasing the efficiency and effectiveness of material use in Lithuania's built environment even further, through smart reuse strategies for secondary materials and regulatory provisions, much of the existing stock can be repurposed and transformed to meet shifting needs well into the future, thereby maintaining the cultural and historical heritage of urban spaces and reducing the need for the traditional cycle of demolition and new construction.[494]

Feasibility and scalability

The feasibility of reuse, repurposing, and adaptability strategies in building design and urban planning is very high, with countless examples and best practices that can be pointed out all over the world. These strategies are actively being applied, studied, and improved over time, especially in dense urban centres with high levels of cultural or heritage sites that need to evolve to meet shifting demands. As shown in the examples below, the economic, environmental, and social benefits from adaptive reuse strategies can work in close synergy:

[489] McKinsey & Company (2019). Modular construction: From projects to products. Retrieved from: McKinsey website
[490] Idem.
[491] Circle Economy. (2020). The Circularity Gap Report: Norway. Retrieved from: Circle Economy website
[492] Circle Economy. (n.d.). The Future of Work: Baseline Employment Analysis and Skills Pathways for the Circular Economy in Scotland. Retrieved from: Circle Economy website
[493] Circle Economy Analysis, Metabolism analysis, see methodology in appendix C. Data from Netherlands and Norway. Retrieved from: Circularity Gap website
[494] Hampel, F. (2020). A framework for sustainable adaptive reuse of industrial buildings. Retrieved from: KTH website

- **Crosstown Concourse, Memphis.**[495] The 1.5 million-square foot Crosstown Concourse in Memphis, Tennessee, is the world's largest adaptive reuse project to earn LEED Platinum certification.[496] The building was originally constructed in the 1920s, and abandoned by the early 1990s. The nonprofit Crosstown Arts had the idea to redevelop the building and to transform the site into a sustainable, mixed-use, vertical urban village, while preserving as much of the original historic fabric as possible. 92.2% of the building's materials were reused, 93.5% of the construction waste (65 million pounds) were diverted from the landfill, water use has been reduced of 40%, $750,000 per year are approximately saved from energy-efficient strategies like advanced HVAC systems and extensive use of daylighting through atria. Finally, 50% of the building's electricity comes from renewable sources, helping to avoid 8,277,606 pounds of carbon emissions.

- **Fábrica de Hielo, Valencia**, it is an adaptive reuse project that has involved the restoration and reconfiguration of an early 20th-century industrial building with sustainability as its cornerstone.[497] The majority of the building materials (bricks) were recovered and recycled or reused. The project has rendered several results: the recovery of the existing building, the reconfiguration of the covers, the improvement of bioclimatic functioning, and the flexibility in the use.

- **Reuse of secondary materials**. The O-House is a designed for disassembly circular building where at least 50% of the building material is based on either recycled or reuse of material[498]. This pilot project was designed and developed as an outcome of the Kongsvinger region Circle Scan[499]. Digital solutions and material passport solutions such as Loopfront[500], Excess Material Exchange[501] or Madaster[502] are key enablers to upscale the reuse of demolition materials and use of secondary materials.

Industrial and technological infrastructure

Building on Opportunity 6.2b, Lithuania has an active construction sector with around sixty-six thousand companies in operation, and a strong logistics infrastructure that could support the sorting, processing and (reverse) logistics of construction and demolition (C&D) waste across the country. Mixed waste fractions of C&D waste are reported to be very high compared to the EU average,

[495] Haverty, A. (2019). The LEED Platinum Crosstown Concourse exemplifies green redevelopment (USGBC Tennessee). Retrieved from: U.S. Green Building Council website

[496] U.S. Green Building Council. (n.d.). LEED rating system. Retrieved from: U.S. Green Building Council website

[497] De Gregorio, S. et al. (2020). Designing the Sustainable Adaptive Reuse of Industrial Heritage to Enhance the Local Context. doi:10.3390/su12219059

[498] O-house. (2020). O-house (Circle House) project. Retrieved from: O-house website

[499] Circle Economy. (2020). Kongsvinger region Circle Scan. Retrieved from: Circle Economy website

[500] Loopfront. (n.d.). Loopfront. Retrieved from: Loopfront website

[501] Excess Material Exchange. (n.d.). Excess Material Exchange. Retrieved from: Excess Material Exchange website

[502] Madaster. (n.d.). Digital library of materials. Retrieved from: Madaster website

indicating that this is not a common practice and a barrier to the realisation of such an opportunity.[503] As described in Opportunity 6.2b, BIM systems and digital infrastructures that can optimise secondary material recovery and create markets that allow for reuse strategies for existing structures are also not commonly used by companies in the sector. This indicates that, while much of the physical infrastructure is present, the technological infrastructures are lagging behind.

Innovation infrastructure

In line with the previous opportunity (see 6.2b), Lithuania has innovation infrastructure capacity related to R&D and eco-design activities in the construction sector. Moreover, there is also certain knowledge and expertise capacity derived from the Multi-Apartment Renovation Programme that can be applied, redirected to building renovation and retrofitting activities.

Policy landscape

Currently, as in many other European countries, policy and regulation is hindering the development of this circular opportunity. Change and adaptation of current waste management regulation is key in order to enable and allow for the optimal reuse of building materials and further uptake of secondary materials in new constructions. Additionally, though not technically redesign or repurposing, the Multi-Apartment Renovation Programme has renovated about 500 multi-apartment buildings a year during the period 2014-2020, improving their energy efficiency and reducing substantially energy consumption.[504] The (partial) success and popularity of this programme can reveal the extent to which similar measures focused on adaptive reuse of buildings can also be successfully implemented.

Impact potential

As described in Opportunity 6.2b, the overall environmental impact reduction that comes from extending a building's lifetime to 100 years could be as much as 40%.[505] Adaptive reuse strategies and specifically the reuse of building components can save up to 70% of materials that would otherwise go to waste.[506] Considering that Lithuania currently has an average building vacancy rate of about 4% or about 60,000 buildings in total, the environmental impact savings compared to demolition and new build could be significant.[507][508] The economic benefits of adaptive reuse strategies compared to new

[503] Miliūtė, J. & Staniškis, J. K. (2006). Analysis and Possibilities for Improving the Lithuanian Construction and Demolition Waste Management System. Retrieved from: Researchgate

[504] European Commission. (2020). European Construction Sector Observatory. Country profile Lithuania. Retrieved from: EC website

[505] Marsh. R. (2016). Building lifespan: effect on the environmental impact of building components in a Danish perspective. doi:10.1080/17452007.2016.1205471

[506] Material Economics. (2020). The Circular Economy - a Powerful Force for Climate Mitigation. Retrieved from: Material economics website

[507] Ober-Haus. (2020). Commercial real estate market commentary. Retrieved from: Ober-Haus website

[508] Official Statistics Portal of Lithuania. (2019). Lietuvos statistikos metraštis. Retrieved from: OSP website

build are also favourable, with a typical return on investment ranging from 10-30%.[509] The overall costs of adaptive reuse compared to new build projects depend greatly on the type of project, but can be less expensive than a new build, especially after taking the land purchase price into account.[510]

The expected impact on the labour market would largely reflect the shift of skills as described in Opportunity 6.2b, with a potential increase in jobs pertaining to procurement, product development and design.[511] Architects and civil engineers with knowledge of circular design and modular design would also be key to supporting the cycling of material flows.[512]

6.3 Textiles

6.3a Better utilisation of secondary and residual textile fibres across industrial value chains

This opportunity focuses on expanding the use of fabrics and fibres made from recycled feedstock in higher quality applications, such as new garment or home textile production, as well as in other applications such as geotextiles, filling in the furniture industry, and insulation in the construction industry. This opportunity is particularly important as the trend of 'fast fashion' has dramatically increased the volume of virgin textiles used—therefore leading to greater volumes of textile waste . The flow of new textiles in Lithuania each year totals around 19,600 tonnes—and in 2018, only 2,000 tonnes of discarded textiles from Lithuania were collected due to lacking infrastructure and incentives for collection.[513] The situation is changing, but still about 8% of municipal waste comprises textiles (compared to 5% EU average) and most is processed into rags, carpets and other low-value, non-apparel applications[514], exported or incinerated. Additionally, post-industrial and pre-consumer textile flows are usually difficult to quantify, due to a lack of separate reporting on this waste stream by companies, so additional quantities of feedstock available can be expected. This shows us that there is potential for direct reuse of secondary materials within the Lithuanian textiles sector, but possibly a strategic role within the broader European textiles value chain as well.

Feasibility and scalability

High-value reuse approaches within the textiles sector have been rapidly developing over the past decade, with numerous advancements in technical, material and business innovation, making the

[509] Shipley, R. et al. (2006). Does Adaptive Reuse Pay? A Study of the Business of Building Renovation in Ontario, Canada. doi: 10.1080/13527250600940181

[510] MGAC. (2020). Cost Drivers of Historic Adaptive Reuse Projects. Retrieved from: MGAC website

[511] Circle Economy. (2020). The Circularity Gap Report: Norway. Retrieved from: Circle Economy website

[512] Idem.

[513] Watson, D. et al. (2021). Post-consumer textile circularity in the Baltic countries: Current status and recommendations for the future. Retrieved from: Norden website

[514] Baltija, K, Trikotažas, U., Textale & the Lithuanian Textile and Apparel Association. (2021). Phone Interview.

transition to a fully circular value chain quite a tangible possibility. Local examples were found of (PET) plastics being processed into fabrics and fillings in the Lithuanian furniture industry, with further experiments in the country focused on transforming textile waste into building bricks, insulation panels and packaging[515]. Such initiatives could be extended to include fibrous crop or food-processing residues, for use in, for example, geotextiles or insulation in the construction industry, or even textiles for new garments. Many survey respondents acknowledge the feasibility of recovering and better utilising textile waste, while noting that scaling such an opportunity would require legal, systemic changes that encourage collaboration between sectors and value chains. A few best practices stand out as highly relevant for the Lithuanian context:

- **Really**[516] from Kvadrat, is using post industrial wool and cotton cut offs and remnants from the textile manufacturing industry and industrial laundries to manufacture their Solid Textile Boards and Acoustic Textile Felt products. Considering the relevance of furniture manufacturing in Lithuania, there is strong potential for collaboration across industries with these types of products.

- **Renewcell**[517], in Sweden, has developed a technology that dissolves used cotton and other cellulose fibres and recycles them into a new, biodegradable raw material: Circulose® pulp. Their manufacturing and brand customers, such as BESTSELLER, Levi's and H&M, use it to make biodegradable, virgin quality viscose or lyocell textile fibres and fabrics for their products. The potential for industry collaboration between Nordic innovators, the Baltic manufacturing industry and EU brand market players could provide a great opportunity for increased use of post-consumer recycled textiles.

- **Worn Again**[518], from the UK, has developed a chemical polymer recycling technology that offers innovative ways of handling blended textiles, which have become increasingly prevalent in the clothing manufacturing industry over the past decades. The process is equipped to deal with a significant percentage of non-rewearable PCT as 'feedstock' materials, particularly textiles of pure polyester and polycotton blends. The technology is also able to handle up to 10% of other fibre types, for example, elastane, polyamide and wool.

Industrial and technological infrastructure

The Lithuanian textile industry has some promising links to other industrial sectors that could act as either sources or sinks. The construction industry could use either synthetic or natural fibres as an insulation material, while applications in agriculture include geotextiles. There are strong ties with the

[515] Idem.
[516] Kvadrat. (n.d.). Really. Retrieved from: Kvadrat website
[517] Renewcell. (n.d.). Circulose. Retrieved from: Renewcell website
[518] Circle Economy. (2020). Fibersort: Overcoming barriers for long-term implementation. Retrieved from: Circle Economy website

furniture sector, which can use both high quality (recovered) fabrics as well as fibres for fillings. Moreover, the economies of scale and infrastructure are present to develop several promising circular opportunities for the textile industry in Lithuania, most notably the prospect of producing new yarns from discarded textiles. However, according to interviews conducted, separate textile waste collection levels are low, rendering low quality recycling. There is thus a need to expand capacity and quality in waste infrastructure to accommodate the implementation of this opportunity.

Innovation infrastructure

Despite having an industrial ecosystem that is well positioned to utilise secondary materials from textiles as outer fabrics, geotextiles, furniture filling and building insulation, the practice of designing to incorporate secondary textile flows could be expanded to enable a more circular textiles chain. Precise knowledge barriers are not clear, indicating that further investments in R&D, building greater awareness between industries and establishing bolder policy incentives to promote reuse and material cascading could all be improved to drive greater collaboration.

Policy landscape

The European policy framework places a strong focus on textiles as a sector for circular development. Firstly, following the *Circular Economy Package* adopted in 2015 and the roll-out of the *Circular Economy Action Plan*, a EU-wide Strategy for Textiles is due to be published in 2021. This strategy will aim to boost the EU market for sustainable and circular textiles, including a new sustainable product framework which encourages the uptake of secondary raw materials and tackles the presence of hazardous chemicals that may hinder future recycling options. Additionally, the amended *Waste Framework Directive* requires that, by 2025, used textiles are collected as a separate waste stream. By 2024, the European Commission also must consider whether targets for reuse and recycling of textiles are to be implemented. All of these policies should increase the volumes of textiles collected locally that could be used as feedstock. Nevertheless, the implementation strategies for these requirements have been largely left to Member States to date. Some countries are considering the uptake of mandatory EPR schemes for textiles and footwear. France was the first country in the EU to introduce this measure, and has quadrupled its textile collection rates between 2006 and 2018. Considering Lithuania already has EPR schemes in place for other streams, this may be a relevant instrument to consider for the sector. Lastly, GPP may be an excellent market pull for the integration of recycled fibres and textiles in publicly procured goods. The EU GPP criteria for textile products and services[519], published in 2017, may serve as a good basis for the Lithuanian Public Procurement agencies to build on. Nationally, the S3 priority of 'new materials, processes and technologies' may help direct funding and research on material innovation within the textile sector, as well as on possibilities for industrial symbiosis with other sectors (i.e. agri-food).

[519] European Commission. (2017). EU green public procurement criteria for textiles products and services. Retrieved from: EC website

Impact potential

The textiles industry is well known to be one of the most impactful to the environment, with impacts ranging from water stress and pollution, greenhouse gas emissions, and waste.[520] Environmental benefits in these areas can be realised through the mass adoption of textile recycling and reuse. The global textile market size reached a value of around US$5 billion in 2020 and is expected to exhibit moderate growth over the next five years.[521] The EU import market for recycled apparel could grow to about €63 billion.[522] Using secondary fibres in the production of apparel can generate a number of environmental benefits. In a pilot project with a jeans manufacturer, the energy savings of recycled fiber compared to virgin fiber were 53%, while the water savings amounted to 99% and chemicals savings were 88%.[523]

The economics of high-value recycling for textiles differ per material, depending on the cost-effectiveness of current recycling technologies. For example, recycled polyester can be 10–30% more expensive than virgin polyester, but recycled wool and wool blends can be 30–40% cheaper than virgin wool.[524] Still, before breakthroughs in recycling technologies are achieved across fibres, there are significant benefits to be gained from increasing the use of secondary textile fibres. By way of comparison, landfilling clothes and household textiles in the UK costs approximately £82 million (approximately €95.7 million) per year. This indicates that significant cost savings could be realised if more circular approaches for reuse are implemented. This cost savings for Lithuania is not trivial as nearly 3.3 million tonnes of textile waste could be diverted from landfill[525].

6.3b Invest in advanced textile sorting and processing capacity

This opportunity focuses on improving the sorting and processing capacity for textile waste streams within Lithuania. The infrastructure for collecting post-consumer textiles, despite having one of the largest import, sorting and recycling hubs for used clothing in Europe, is still underperforming in certain ways. Sorting and processing materials for recycling is challenging due to the unknown and/or diverse compositions of materials. In addition, the textiles delivered domestically through separate collection containers often lack quality and cleanliness, making it difficult to realise high-value reuse

[520] EIPRO. (2012). Environmental impact of products (EIPRO) analysis of the life cycle environmental impacts related to the final consumption of the EU-25. Retrieved from: Publications Office of the EU

[521] Imarc. (2020). Textile Recycling Market: Global Industry Trends, Share, Size, Growth, Opportunity and Forecast 2021-2026. Retrieved from: Imarc website

[522] Ministry of Foreign Affairs of the Netherlands (CBI). (2020).The European market potential for recycled fashion. Retrieved from: CBI website

[523] Ellen MacArthur Foundation. (2020). Fashion: Two key circular investment opportunities. Retrieved from: EMF website

[524] Ellen MacArthur Foundation & Circular Fibres Initiative. (2017). A new textiles economy: Redesigning fashion's future. Retrieved from: EMF website

[525] Eurostat. (n.d.). Treatment of waste by waste category, hazardousness and waste management operations. (2018). Retrieved from: Eurostat website

options. Improvements to infrastructure could therefore address these outstanding challenges and provide Lithuanian industry with higher volumes of reliable secondary products or materials to fulfil a variety of functions (see Opportunity 6.3a).

Feasibility and scalability

The technological maturation of the textile recycling industry has been quite pronounced over the past few years, with a number of innovations in automated sorting, as well as mechanical and chemical recycling processes. Digitisation and automation are key elements in these innovations, enabling much higher accuracy in material and quality determination, and significantly reducing labour costs. However, interviewees did note challenges for the national context—for example, companies shying away from implementing such technologies due to the risks involved in processing complex materials and fibres. There is also hesitation on the part of producers, who often believe the onus for recycling should wall on the waste management sector[526]. Nonetheless, due to the complexity of the processes involved, it is essential that textile recycling remains within the sector—so boosting this opportunity's feasibility is linked to shifting the mindsets of producers. Focusing on the specific challenges identified in Lithuania, a handful of best practices stand out:

- **Fibersort** is a Belgian technology that automatically sorts large volumes of mixed textile waste by material composition. Once sorted, these materials become reliable, consistent inputs for high-value textile-to-textile recycling.[527] This is a critical link in the circular supply chain: due to this technology, textile waste can be reduced and the need for virgin material production is lowered. In its demonstration facility at Wieland Textiles in the Netherlands, the potential for developing a business case for the later stages of material processing (such as hardware removal and disassembly) is currently being tested through a collaboration with the Dutch Center for Circular Textiles (DCCT).[528]

- **WargoTex**[529] is a public-private collaboration based in Sweden, with the aim of establishing a regional sorting centre with advanced sorting technologies that allows for better textile reuse. While the collection and sorting that takes place today is primarily organised by charities in Sweden and is quite small-scale relative to Lithuania's operations, a need for more industrialised operations and handling of textiles is needed. A pilot plant for sorting is now housed in Vargön, Vänersborg municipality, involving close collaboration with other new stakeholders in addition to charities.

[526] Baltija, K, Trikotažas, U., Textale & the Lithuanian Textile and Apparel Association. (2021). Phone Interview.
[527] Fibersort. (n.d.). Fibersort. Retrieved from: Fibersort website
[528] Smart Fiber Sorting. (n.d.). Dutch Center for Circular Textiles in the Metropolitan Region of Amsterdam. Retrieved from: Smart Fiber Sorting
[529] Wargon Innovation. (n.d.). Establishment of test and demo facility for textile resources. Retrieved from: Wargon Innovation website

- **Circular Craft Centres**[530] in the Netherlands are a government project running from 2019 to 2023, where they are implementing repair and reuse centres across Dutch municipalities for various waste streams, including textiles. This kind of municipal-level public-private collaboration is effective in addressing the scaling of repair and remanufacturing services.

It is important to note the high potential for scaling that this opportunity carries: according to interviewees, Lithuania is well-positioned to become the centre of innovative textile recycling in the Baltic region, due to its geographical location and logistic and economic context.

Industrial and technological infrastructure

Lithuania hosts one of Europe's largest import, sorting and recycling sectors for used clothing. The secondary textile subsector imports clean streams of secondary clothing from Western Europe and sorts them by quality, after which they are either re-exported to countries based on purchasing power: the highest quality are sent to countries with high purchasing power, while lower grades are sent to regions such as Belarus, Ukraine or further towards Central Asia. However, according to interviews conducted, barriers centre on the capacity of the collection and sorting infrastructure, and the ability to accurately sort and retain value of the lower material grades given the lack of new and innovative recycling technologies and plants for complex materials. Having separate textile recycling infrastructure is essential for obtaining high quality secondary materials. Moreover, a separate collection of used textiles is lacking, hindering the feasibility and scalability of opportunity 3.3. High incineration capacity and cost-competitiveness also negatively affects recycling to the fibre level.

Innovation infrastructure

Acknowledging that Lithuania already hosts a thriving textiles manufacturing and recycling industry, supported by many SMEs and knowledge institutions, it is clear that the knowledge and innovation infrastructure needed to further advance a circular textiles industry is largely present and active in Lithuania.

Policy landscape

As mentioned previously, the European policy framework plays a large role in ensuring the circularity of this sector. Additionally, the EU *Strategy for Textiles*, to be published in 2021, is expected to provide guidance on how to achieve high shares of separate collection of textile waste, which Member States must ensure by 2025, and lay out overarching regulatory measures, such as EPR, to encourage innovation and industrial development of the sorting, reuse and recycling of textiles.[531]

[530] Circular craft center. (n.d.). Circular craft center. Retrieved from: Circulair Ambachts Centrum website
[531] European Commission. (2021). EU strategy for sustainable textiles. Retrieved from: EC website

Impact potential

This opportunity would function to decrease the high volumes of textile waste being sent to incineration and landfilling, generating environmental benefits such as waste reduction, avoided emissions, and avoided resource extraction.[532] Approximately 7,200 tonnes of total textile waste collected in Lithuania are not being recycled[533], and about 80% of textiles in Lithuania get landfilled or incinerated.[534] The lost value of textile waste amounting to more than US$100 billion annually could be retained, whilst new jobs in collection, sorting and recycling facilities could be created.[535] In Lithuania, the value lost represents a value lost of €20.5 million. If we would also account for the textiles waste not being collected, the value being lost would increase dramatically. Automated sorting for textile recycling could enable capturing the value of garments with an average selling price of about €390 per tonne and net profit margin of 11.5%.[536] In theory, if the recycled fashion strategies gain in force and are appropriately advertised to the public, the EU import market for recycled apparel will be worth at least €63.2 billion.[537]

6.3c Stimulate secondhand clothing and repair services

This opportunity directly targets textile waste prevention by stimulating second-hand clothing sales and repair services. The total volume of textiles consumed in the Lithuanian economy was estimated at approximately 9.7 kilograms per capita in 2018, 7 kilograms of which are new textiles and 2.7 kilograms of which are second-hand. This is lower than the EU average of 12.3 kilograms per capita in 2018, but it does follow the same general upward trend due to the increasing prevalence of low cost fast fashion over the past decades. Between 2017 and 2018 alone, new textile consumption increased 37% in Lithuania.[538] This trend not only increases the volume of textiles in the economy, but the speed by which we consume and dispose of them.[539] Increasing customer-friendly retail options for second-hand clothing and services for clothing repair could play a significant role in changing consumer behaviour, especially if special efforts can be made to ensure that these innovations are affordable, convenient and on-trend.

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[532] Sandin, G & Peters, G. M. (2018). Environmental impact of textile reuse and recycling – A review. Retrieved from: doi:10.1016/j.jclepro.2018.02.266

[533] Material Flow Analysis section, chapter 2.

[534] Ellen MacArthur Foundation. (2020). Fashion: Two key circular investment opportunities. Retrieved from: EMF website

[535] Idem.

[536] WRAP. (2012). A review of commercial textile fibre recycling technologies. Retrieved from: Refashion website

[537] Ellen MacArthur Foundation. (2020). Fashion: Two key circular investment opportunities. Retrieved from: EMF website

[538] Watson, D. et al. (2021). Post-consumer textile circularity in the Baltic countries: Current status and recommendations for the future. Retrieved from: Norden website

[539] Lambert, M. (2014). The Lowest Cost at Any Price: The Impact of Fast Fashion on the Global Fashion Industry. Retrieved from: CORE portal

Feasibility and scalability

The feasibility of this opportunity is very high. Second-hand clothing retail has had a consistent presence in nearly all countries, and the practice of repair has been omnipresent, only until very recently due to more global fashion trends. But while acceptance for second-hand shopping is returning, further efforts are required to expand consumers' search: waste management centres that have made efforts to provide second-hand goods, for example, have been largely unsuccessful, as consumers are less likely to go there in search of alternatives to new products.[540] Several best practices and examples exist where actors have managed to integrate such circular activities in attractive retail centres or online platforms, which provide convenient services for customers:

- **ReTuna**[541], in Sweden, is a mall that aims to change shopping practices and behaviour. Customers bring in old items, and discard them into containers with certain sorting requirements. These are then sorted by mall staff, who take them to the relevant shop in the mall. The shop staff then perform a second sorting, where they choose what they want to repair, fix up, convert or refine—and ultimately sell. In this way, the materials are collected, sorted, repaired and sold all at the same location.

- **Online second-hand clothing platforms.** Vinted is an online Lithuanian second-hand clothing platform that has been very successful over the past few years: the company raised US$303 million in an investment round, was valued at over US$4 billion in May of 2021[542] and is now active in 14 markets in Europe[543]. Beyond Vinted, a growing number of other companies (Textale in Lithuania, for example,[544] and the Switching Gear Enabling Network[545] elsewhere) are emerging to compete for a share of the European market for second-hand clothes, which was estimated to be worth US$14 billion (13 billion EUR) in 2019.[546]

- **The Renewal Workshop**[547] takes discarded apparel and textiles from brands and manufacturers and turns them into Renewed products, upcycled materials or recycling feedstock. It has partnerships with multiple brands and offers its services both through its own online resale platform, as well as by managing the Renewed resale platforms/logistics of the own brands it works with. With a first facility in the US, the organisation opened a second location, based in the Netherlands, in 2019. Lithuania's presence of both a relevant clothing manufacturing industry, with a skilled local workforce in textile trades, as well as substantial

[540] Baltija, K, Trikotažas, U., Textale & the Lithuanian Textile and Apparel Association. (2021). Phone Interview.
[541] ReTuna (n.d.). About us. Retrieved from: Retuna website
[542] Lunden, I. (2021). Vinted raises $303M for its 2nd-hand clothes marketplace, used by 45M and now valued at $4.5B. Retrieved from: TechCrunch website
[543] Vinted. (n.d.). About page. Retrieved from: Vinted website
[544] Textale. (n.d.). About us page. Retrieved from: Textale website
[545] Circle Economy. (n.d.). Switching Gear Enabling Network. Retrieved from: CE website
[546] Togoh, I. (2019). A used-clothing marketplace is Europe's newest And trendiest tech unicorn. Retrieved from: Forbes website
[547] The Renewal Workshop. (n.d.). About us. Retrieved from: Renewal workshop website

volumes of discarded textiles, highlights the relevance of linking and scaling business-to-business repair and renewal services.

The potential for scaling this opportunity is high: the results of the Baltic countries' post-consumer textile flows analysis demonstrates Lithuania's significant role in the sector. If backed by regulatory action and financial support, the Lithuanian industry could play a meaningful role in the North countries market for reuse, according to interviewees.

Industrial and technological infrastructure

Lithuania has a thriving apparel retail industry, with numerous second-hand clothing businesses already present in attractive retail settings. As discussed previously (Opportunities 6.3a and 6.3b) the country also has a very well established hub for second-hand textile collection and sorting. The necessary industrial and technological infrastructures are very much present.

Innovation infrastructure

Vinted (Case study two) is Lithuania's latest unicorn and shows that the technological/digital capacities for further development do exist. Additionally, we can explore some favourable conditions for developing digital businesses—a key factor in enabling second-hand transactions and repair business models. The ease of setting up a business, which can take place online and over the course of a few days, leading e-infrastructure in the EU and an innovation-friendly environment, for example, could spur the success of second-hand shopping and repair models on the Lithuanian market. The country ranks second among EU companies involved in research, development and innovation, expecting the share of innovative firms to increase from 47% (2016) to 53%. And Lithuania has come to the forefront of productivity growth across the EU, with a surge in the number of companies in the medium and high-tech sectors. Conditions, therefore, for an upswing of digital circular business models in the country’s clothing sector are ripe.

Policy landscape

As mentioned previously, the European policy framework plays a large role in achieving the circularity of this sector. Additionally, the EU *Strategy for Textiles* and the new sustainable product framework for textiles is expected to empower both businesses and consumers to have easy access to reuse and repair services, by improving the business and regulatory environment, for example by providing incentives for product-service models. Nationally, the *Industry Digitisation Roadmap 2019–2030* as well as the upcoming *Law on Science, Technology and Innovation* may help shape the potential of digital and technological research and implementation for this market. However, national regulatory or financial incentives that foster the reorientation of production activities towards new more circular business models and markets are lacking. More generally, interviewees also cite the lack of effective national support for the textile industry to effectively and systematically transition to more circular production processes in a cost-competitive manner.

Impact potential

The environmental benefits of extending the life of clothing through repair and reuse are significant due to the avoided resource extraction and emissions associated with new garment manufacturing. On average, extending the life of clothes by just three months per item would lead to a 5–10% reduction in each of the carbon, water and waste footprints of that garment.[548] This opportunity is already becoming an important part of environmental impact reduction with the European market for secondhand clothes currently estimated to be worth €13 billion, and is is projected to reach nearly twice the size of fast fashion by 2029, with resale and rental models expected to drive the increase and growth projected at 414% in the next five years.[549][550] This strong growth in both Europe and the United States shows that the development of well functioning circular value chains will be an important economic opportunity for innovation in the apparel industry.[551]

The impact of this growing market trend on the labour market is also noticeable. Textiles are estimated to have the potential to create between 20 and 35 jobs per 1,000 tonnes collected with a view of being re-used, and similarly, one job can be created for every seven to ten collection point containers.[552] Interviews have shown that local reuse activities have a positive impact on small and medium enterprises as well, and that as the industry grows, it encourages greater collaboration between stakeholders, even beyond the textile value chain.

6.4 Plastics and Packaging

6.4a Redesign products to reduce material consumption and/or increase recyclability

This opportunity aims to increase the recyclability and material efficiency of plastic products across sectors within Lithuania. The Chemistry and Plastics sector is responsible for only 6% of material consumption in Lithuania[553], however the environmental impacts of this relatively small material stream are global. Manufacturing of plastics and plastic products specifically consumes around 1.03 million tonnes in Lithuania.[554] A critical barrier for making the plastics value chain more circular is the quality and heterogeneity of plastic materials currently found in packaging.[555] A single plastic bottle can often have three different types of plastic. Packaging for food can even be more complex,

[548] WRAP. (2019). Textiles: Taking Action. Retrieved from: https://wrap.org.uk/taking-action/textiles
[549] Forbes. (2019). A used Clothing Marketplace Is Europe's newest and Trendiest Tech Unicorn. Retrieved from: Forbes website
[550] Ellen MacArthur Foundation. (2020). Fashion: Two key circular investment opportunities. Retrieved from: EMF website
[551] Idem.
[552] RReuse. (2021). Job Creation in the Reuse Sector. Retrieved from: RReuse website
[553] Circle Economy Analysis.
[554] Circle Economy Analysis, relevant Nace Rev 2 sectors include: 20.16; 20.2.
[555] KTH. (2000). Recycling of Mixed Plastic Waste – Is Separation Worthwhile? Retrieved from: DiVA portal

including metal foils or laminated paper. This greatly inhibits efficient recycling and reuse and often results in incineration or landfilling[556]. This opportunity focuses on product design interventions that prioritise single-material, fully recyclable and easy-to-separate plastic products to enable high quality recovery and end-of-use as well as product design interventions and new business models that replace single-use products with reusable alternatives, reducing the overall material consumption of plastics.

Feasibility and scalability

The strict technical feasibility of developing plastic products that can be cycled over multiple life cycles is high, and there are many best practices of lightweighting and reduced material use in product designs. Where plastic packaging is deemed unavoidable, it is important to ensure that the plastic materials used (for example, PET) are fully recyclable within the existing waste management infrastructure and can be reutilised for many life cycles. There are a number of barriers limiting the scalability of this opportunity, namely the cost and concerns over product safety from consumers, regulators, and even businesses.[557] Introducing more circular value chains often requires notable changes in consumer behaviour, from sorting and separating plastics, to participating in take-back and deposit schemes. There are also practical barriers to eliminating some plastic materials, such as the lack of alternative materials on the market with comparable functionality and price.[558] In addition, the majority of plastic packaging producers collaborate with export markets: scalability, therefore, depends on such markets complying with targets for plastic reduction. Nonetheless, interviewees note that interest in innovative technologies—that tackle multi-material packaging and instead seek to use mono-materials—is growing, and that eco-design approaches are already being adopted.

Despite the challenges described above, there are a handful of best practices that could be useful for the Lithuanian context.

- **Designing for circularity through material and format choices.** PDK is a new type of plastic that allows for indefinite 100% recycling without quality loss. It is cheap and efficient to recycle, but most importantly, also to produce.[559] Other case examples of mono-material packaging design that improve recyclability can be found under Opportunity 6.1b.

- **New business models to facilitate reuse.** Loop, a U.S company, works together with major brands to deliver food in reusable packaging to customers' doorstep in different countries. From an environmental perspective, it takes at least 'five Loop cycles of fill and reuse' for this model to perform better[560] than single use packaging alternatives. In the Netherlands, Pieter Pot has introduced a similar model and estimates that delivering one reusable jar emits less

[556] Ellen MacArthur Foundation. (2017). New plastics economy - Catalysing action. Retrieved from: EMF website
[557] PACE. (2021). PACE action agenda for plastics. Retrieved from: PACE website
[558] PACE. (2021). PACE action agenda for plastics. Retrieved from: PACE website
[559] Kovner, A. (2021).The future looks bright for infinitely recyclable plastic. Retrieved from: Berkeley Lab website
[560] Makower, K. (2019). Loops' launch brings reusable packaging to the world's biggest brands. Retrieved from: Greenbiz website

CO2 than delivering a pack of muesli (+20% CO2), a plastic bottle of ketchup (+157% CO2) or a disposable jar of mayonnaise (+32% CO2). This also assumes 40 repeat uses of the same jar.

- **Cross-governmental collaboration to reduce single-use packaging.** The European Plastics Pact was initiated by the Netherlands, France and Denmark to accelerate the transition towards a circular plastics economy in Europe. 15 governments and 82 companies have signed it and committed to significantly reduce their use of virgin plastics and increase recycling and reuse rates by 2025. All voluntary participants are developing different measures for implementing the pact in their country or organisation, but have committed to engage in cross-border cooperation and report their progress annually. The Dutch government, for example, has increased taxes on landfill, incineration and export of plastic waste, and included eco-based modulation in its EPR scheme for packaging to incentivise recyclable packaging. [561]

Industrial and technological infrastructure

The Lithuanian chemistry, plastics and packaging sector has production capacity across all of the stages of the chemicals value chain, from production of primary and intermediate goods to the sales and distribution of the finished products, such as fertilisers, dyes or plastic packaging.[562] Primary plastic production is limited to a handful of facilities, some owned by foreign companies but with the capacity to quickly implement at a scale innovations related to, for example, eco-design. There are three PET recycling facilities, plus one extra one planned. There is also substantial recycling capacity for other types of plastic, especially PE. However, recycling is of low quality, and there is a need for bigger and better collection and recycling infrastructures. The current ten existing MBT facilities also require expansion, adaptation, and upgrade to accommodate larger plastic and packaging waste streams more efficiently and effectively. Recent investment in the expansion of waste-to-energy capacity can also hinder packaging recycling due to low prices for incineration.

Innovation infrastructure

The knowledge and innovation infrastructure within the Lithuanian plastics value chain is also relatively high. There are some businesses represented in the Circular Plastics Alliance. Promising innovations have taken place in the recent past; for example, NEO group recently unveiled their capacity to produce chemically recycled (depolymerised) PET from secondary PET, which can serve as a very pure feedstock in the PET bottle industry. Moreover, as part of the innovation ecosystem and R&D infrastructure, there is a Plastics Cluster, with 12 members, which is capable of promoting eco-design by acting as a platform for sharing know-how and cooperation. KTU's Centre for Packaging

[561] PACE. (2021). PACE action agenda for plastics. Retrieved from: PACE website

[562] PPMI. (2021). Report on the Lithuanian industrial landscape and its potential to integrate into European value chains. (Unpublished)

Innovations and Research[563] also specialises in packaging eco-design, Life Cycle Assessment for packaging products, and the development and implementation of sustainable strategies for packaging.

Policy landscape

The EU heavily promotes eco-design within the CE framework.[564,565] Particularly for plastics, the EU aims to entirely transform the value chain, from how plastic products are designed and produced to used and recycled. Within this context, design for recycling is a prominent strategy to increase the recyclability of products at their end of life. By 2030 all plastics at the EU must be recyclable, and single-use plastics should be minimised.[566] Within this context, a core instrument to stimulate eco-design is EPR schemes, both at the EU and national level.[567] Lithuania implemented in 2016 a deposit-refund system for plastic (and metal cans and glass) beverage packaging that has proven to be widely successful in increasing the collection and recycling rates of these products.[568] Additionally, the Industry Digitisation Roadmap also identifies 'plastics' as one of the five value chains to implement digital and new technologies.[569]

Impact potential

The environmental benefits of recycling plastics is significant. Globally, plastics are responsible for about 6% of global oil production and approximately 390 million tonnes of CO2.[570] Environmental benefits include the reduction of fossil fuel consumption, greenhouse gas emissions, and plastic pollution to terrestrial and aquatic ecosystems.[571] Using the examples of personal and homecare bottles and carrier bags, about 6 million tonnes of material waste could be saved, and innovative delivery models could result in an 80-90% reduction in packaging material savings. Only switching to reusable bags could replace over 300 billion single-use carrier bags per year. Minimising demand for new plastics production through design interventions could significantly reduce fossil fuel use overall

[563] Kaunas University of Technology (KTU). (n.d.). KTU Centre for Packaging Innovations and Research. Retrieved from: KTU website
[564] European Commission. (2009). Ecodesign Directive (Directive 2009/125/EC). Retrieved from: EUR-Lex website
[565] European Commission. (2015). Closing the loop - An EU action plan for the Circular Economy. Retrieved from: EUR-Lex website
[566] European Commission. (2018). A European Strategy for Plastics in a Circular Economy. Retrieved from: EUR-Lex website
[567] Institute for European Environmental Policy. (2017). EPR in the EU Plastics Strategy and the Circular Economy: A focus on plastic packaging. Retrieved from: IEEE website
[568] ACR+. (2019). Deposit-refund systems for one-way beverage packing in Europe. The case of Lithuania. Retrieved from: ACR+ website
[569] Lithuanian Innovation Centre (LIC). (2020). Lithuanian Industry Digitisation Roadmap 2020-2030. REVISED DRAFT updated within a framework of the "Follow up" project. Retrieved from: EIMIN website
[570] Ellen MacArthur Foundation. (2016). New plastics economy - Rethinking the future of plastics. Retrieved from: EMF website
[571] Circle Economy. (2020). Will you be my partner? Retrieved from: Circle Economy website

and contribute to lower landfill and incineration volumes (and associated emissions)[572][573] as well as lower leakage into the oceans (at least 8 million tonnes of plastics leak into the ocean each year[574]).

Reuse of plastic provides an economically attractive opportunity for at least 20% of plastic packaging globally, and integrated responses to plastic pollution have been found to cost less to governments overall than business-as-usual scenarios, as increased waste management costs are often offset by savings from reduced plastic production, more revenues from recyclate sales or generated energy and avoided business costs for fisheries, tourism and infrastructure operators related to marine pollution.[575][576] Shifting collection, sorting and recycling systems to become less fragmented could enable economies of scale and the delivery of consistent, high quality material streams to recyclers, which in turn could improve recycling economics by an estimated US$80-110 per tonne collected (US$0.8-1.3 billion in OECD nations)[577].

Increasing recycling of plastics presents an opportunity for more formal jobs in collection, sorting, and recycling.[578] While this part of the value chain is likely to benefit from increased jobs, there are also a variety of employment opportunities and skill-development pathways in positions that optimise use of materials such as eco-design and design for reuse, permit extended product life cycles such as repair and repurposing activities, and those that set up territorially based logistics circuits.[579] These tend to be high skilled jobs that are less susceptible to threats of automation, offering strong opportunities for re-skilling and educating the workforce.

6.4b Make better use of the available mechanical recycling capacity for plastics

This opportunity focuses on improving and expanding the degree to which plastics are diverted, collected and processed using the existing mechanical recycling infrastructure in Lithuania. Interviewees and statistics indicate that a large fraction of the plastic collected still doesn't find its way back into Lithuanian products. Contamination, quality and cost concerns limit the high-value treatment of flows and lead to the incineration of lower quality streams.[580] These quality concerns, along with the higher effort required to produce secondary plastics compared to virgin plastics, results in virgin materials remaining the primary input of the plastics and packaging sector. Harmonising,

[572] Dépoues, V. & Bordier, C. (2015). Mitigating Climate Change and Waste Recycling: Household Packaging Case Study. Retrieved from: Institute for Climate Economics website

[573] PACE. (2021). PACE action agenda for plastics. Retrieved from: PACE website

[574] Jambeck, J. R. et al. (2015). Plastic waste inputs from land into the ocean. doi:10.1126/science.1260352

[575] PACE. (2021). PACE action agenda for plastics. Retrieved from: PACE website

[576] Pew Charitable Trusts & SYSTEMIQ. (2020). Breaking the Plastic Wave: A Comprehensive Assessment of Pathways Towards Stopping Ocean Plastic Pollution. Retrieved from: Pew trusts website

[577] Ellen MacArthur Foundation. (2016). New plastics economy - Rethinking the future of plastics. Retrieved from: EMF website

[578] PACE. (2021). PACE action agenda for plastics. Retrieved from: PACE website

[579] Phung, C. G. (2019). Implications of the circular economy and digital transition on skills and green jobs in the plastics industry. Retrieved from: Open Edition Journals website

[580] Pivnenko, K. et al. (2015). Challenges in plastics recycling. Retrieved from: Researchgate

adopting and scaling best practices for collection and sorting systems of plastic waste that ensure excellent sorting and diversion based on quality standards, as well as scaling up high quality recycling processes, could be a significant step in overcoming current challenges and positioning Lithuania as a frontrunner in the so-called 'new plastics economy'[581][582].

Feasibility and scalability

Improving recycling rates will require system-wide change and collaboration among stakeholders, from plastic packaging companies and post-consumer collection to sorting and recycling[583]. According to local experts, although Lithuania recycles large quantities of plastic, there is a need to improve the quality of sorting and collection, as well as the value treatment of plastic waste. Increasing recycling quality has faced many systemic barriers to date, including: mixed and contaminated post-consumer plastics, improper disposal at end-of-use, limited financing models for plastic waste collection, the changing landscape and fragmentation of the waste trade globally, the high cost of sorting plastics and a lack of scalable high quality recycling technology.[584] In addition, it is likely that further investments in innovative recycling technologies will be needed—but efforts to do so have been stalled due to shortages of high quality, uncontaminated plastic waste, according to expert interviews. In order to achieve higher quality recycling standards and capacity levels, national government, regions, municipalities and sorting companies play a key role. Lithuania needs cross-regional coordination and collaboration to ensure that collection systems are aligned and provide high quality recyclable plastics to actors in the sector, which will ultimately make the market for recycled materials more attractive economically, and ready it for the uptake of new recycling innovations[585][586].

Despite the complexity of the effort, by taking a broader view of best practices from around the world, it is clear that there are numerous sources of inspiration to draw from and to explore further.

- **Improving plastic (waste) traceability through tokenisation.** A number of companies are starting to use blockchain technology to improve material traceability and ease mechanical recycling by enabling better sorting and transparency. BASF, a German chemical manufacturer, has successfully piloted such a project in Canada and is looking to scale commercially in 2023[587]. GreenToken.io is piloting a similar initiative in Southeast Asia, where they aim to use outcomes from the pilot to support the development of waste infrastructure

[581] Wageningen University & Research (WUR). (2018). Improvement options for the recycling chain of plastic packaging waste. Retrieved from: WUR website
[582] Ellen MacArthur Foundation. (2017). New plastics economy - Catalysing action. Retrieved from: EMF website
[583] Circle Economy. (2020). Will you be my partner? Retrieved from: Circle Economy website
[584] PACE. (2021). PACE action agenda for plastics. Retrieved from: PACE website
[585] Wageningen University & Research (WUR). (2018). Improvement options for the recycling chain of plastic packaging waste. Retrieved from: WUR website
[586] Ellen MacArthur Foundation. (2017). New plastics economy - Catalysing action. Retrieved from: EMF website
[587] BASF. (n.d.). reciChain Pilot Consortium Members. Retrieved from: Basf website

in Asia.[588] Finally, Circularise—possibly the most established blockchain solution for circularity—has announced a plan to develop its blockchain solution to monitor the rate of plastic recycling activities in Europe in 2020.[589]

- **Innovations to complement existing recycling processes.** Though some barriers to recycling are best addressed at the design stage (for example, the use of ink or multiple materials), innovations that deal with these design choices after-the-fact are necessary to tackle the current supply of plastic waste. Cadel Deinking[590], for example, introduced an innovative process to remove ink from plastic products and thus increase the quality and recoverability rate of mechanical plastics recycling. Another example is Cumapol[591], which uses 'depolymerisation recycling' to complement existing mechanical recycling in closed loops and upcycle otherwise non-recyclable and/or PET prone to downcycling into rPET.

- **Door-to-door waste collection system (DtD).** Citizens are the end-responsibles for household waste separation. Therefore, adopting waste collection systems and infrastructures that make household waste separation as easy as possible is crucial. In the door-to-door collection system, instead of throwing waste away into multi-containers located on the street, households' separated waste is directly collected in the generation point (house) according to a pre-established schedule and calendar. The main objective of the DtD waste management system is to increase the recycling engagement of citizens, improve the quality of the waste separation and reduce the general waste category[592]. This waste collection system has proven to increase waste sorting and recycling for different waste streams, and specifically for plastics[593][594]. Its implementation has successfully been implemented in multiple municipalities Italy[595], followed by Catalonia[596], and dense urban areas are also piloting its implementation, such as Barcelona[597] and Paris[598].

[588] Plastic Energy. (2020). SAP's GreenToken And Plastic Energy Announce Plastic-Tracing Blockchain System. Retrieved from: Plastic Energy website

[589] EuPC & Circularise Plastics Group. (2020). EuPC and Circularise Plastics collaborate to further develop the digital platform to monitor the rate of the plastics recycling activities in Europe. Retrieved from: Circularise website

[590] Cadel Deinking (n.d.). The deinking process. Retrieved from: Cadel Deinking website

[591] Cumapol (n.d.). Mechanical recycling. Retrieved from: Cumapol website

[592] Coll, E., Rieradevall, J. & Doménech, X. (2002). La recogida selectiva puerta a puerta de la materia orgánica. Experiencia municipio Tiana (Cataluña). Retrieved from: Dialnet portal

[593] GAIA. (n.d.). Door-to-door Collection Reduces Waste in Hernani, Spain. Retrieved from: No-burn website

[594] Tsalis, T. et al. (2018). Door-to-door recyclables collection programmes: Willingness to participate and influential factors with a case study in the city of Xanthi (Greece). doi:10.1177/0734242X18764291

[595] Zero waste Europe. (2010). Zero Waste and separate collection. Retrieved from: Zero Waste Europe website

[596] Future Enviro. (2014). Door-to-door selective waste collection in Cataluña. Retrieved from: Futuro Enviro website

[597] Ajuntament de Barcelona. (2018). Door-to-door collection in Sarrià. Retrieved from: Ajuntament Barcelona website

[598] C40 Knowledge. (2019). Cities100: Paris is reducing, reusing and recovering its waste. Retrieved from: C40 Knowledge website

Industrial and technological infrastructure

The Lithuanian chemicals, plastics and packaging sector has production capacity across all of the stages of the chemicals value chain, from the production of primary and intermediate goods to the sales and distribution of finished products, such as fertilisers, dyes or plastic packaging.[599] Primary plastic production is limited to a handful of facilities, some owned by foreign companies. Furthermore, there are three PET recycling facilities, with plans for another in the works. There is also substantial recycling capacity for other types of plastic, especially PET. However, recycling is of low quality, and existing facilities require expansion, adaptation and upgrading to accommodate larger plastic waste streams more efficiently and effectively. Recent investments in waste-to-energy infrastructure can also hinder packaging recycling by decreasing the price of incineration.

As already mentioned, collaboration and coordination between the national government, regions, municipalities and sorting companies is key to increasing the quantity and improving the quality of plastic waste collection and separation in Lithuania. This multi-stakeholder collaboration is key to considering the local ecosystem, residential density and cultural and socioeconomic impact, aligning on where harmonisation is possible or adaptation is needed in the different regions[600]. Further development of combined collection systems and realising more post-separation could result in a higher amount of high quality recyclable plastic inputs going to recyclers. Even though Lithuanian recyclers have a limited impact on the quantity and quality of the resources they receive, they can have a key role in scaling up high quality recycling processes with key financial and regulatory support from policymakers of S3 'New production processes, materials and technologies'; the government and finance sector can also contribute blended financing models for plastic sorting and recycling infrastructure.[601]

Innovation infrastructure

In line with the previous opportunity (see 6.4a.), the knowledge and innovation infrastructure within the Lithuanian plastics value chain is well-established. There are Lithuanian businesses represented in the Circular Plastics Alliance. Promising innovations have taken place in the recent past; for example, Neo Group recently unveiled its capacity to produce chemically recycled (depolymerised) PET from secondary PET, which can serve as a very pure feedstock in the PET bottle industry. Moreover, as part of the innovation ecosystem and R&D infrastructure, the Plastics Cluster is capable of identifying and promoting best practices and exploring innovative methods to improve mechanical recycling activities to avoid the downcycling of recycled plastic and minimise the utilisation of virgin inputs. Lithuania's main technical universities (KTU & VGTU) and research organisations play an essential role in evaluating different recycling technologies, analysing waste streams, monitoring progress, and advising policymakers. In conjunction with civil society, research organisations can also

[599] PPMI. (2021). Report on the Lithuanian industrial landscape and its potential to integrate into European value chains. (Unpublished)
[600] PACE. (2021). Circular Economy Action Agenda - Plastics. Retrieved from: link
[601] PACE. (2021). Circular Economy Action Agenda - Plastics. Retrieved from: link

develop data and knowledge about the economic, environmental and social impacts of different global and local recycling models, to inform strategic decision-making at a national and regional level.[602]

Policy landscape

See the policy landscape assessment for the previous Opportunity (6.4a). Additionally, S3 key priority area number two ('New production processes, materials and technologies') could support the expansion and improvement of existing mechanical recycling infrastructure in Lithuania. However, the enforcement of strict EPR schemes is key to effectively promoting the mechanical recycling of plastics, which already has its technical limitations. Regulatory and fiscal incentives are also crucial, which in many cases are lacking. Moreover, according to the local experts interviewed, policies and strategic planning for technology, infrastructure and capacity planning are limited, which confirms the need to define an overarching, holistic and multi-stakeholder circular economy roadmap for Lithuania that can integrate transversal elements such as infrastructure into the definition of the actions that will be implemented.

Impact potential

The environmental benefits of improved plastic recycling are detailed in Opportunity 6.4a, and are greatly contributed to through improved mechanical recycling systems. Currently, collection and sorting systems are often highly fragmented which greatly hinders the economic potential of plastic recycling systems. To give a sense of the economic opportunity, just converging after-use collection and sorting systems towards good practice could improve plastic packaging recycling economics by an estimated US$80-110 per tonne collected (US$0.8-1.3 billion in OECD nations).[603] If we consider the total system costs of more circular plastic recycling systems, they are reported to be comparable to business-as-usual costs, while investments are expected to shift from upstream to mid/low-stream in the value chain.[604] The economic case becomes stronger when indirect effects and externalities are also considered. For example, putting a stop to marine plastic pollution would have broad and immediate benefits to tourism and fishery industries.

As described in Opportunity 6.4a, increasing recycling of plastics is estimated to create more formal jobs in collection, sorting, and recycling. Based on job creation patterns in waste management France, the French Agency for the Environment and Energy Management estimated that, on average, processing 10,000 tonnes of waste leads to the creation of one FTE when sent to landfill, three to four FTE when recovered by incineration, composting or methanation, 11 FTE when taken to a sorting center, and 50 FTE when complex end-of-life products are disassembled."[605] While automated sorting

[602] PACE. (2021). Circular Economy Action Agenda - Plastics. Retrieved from: PACE website
[603] Idem.
[604] PACE. (2021). Circular Economy Action Agenda - Plastics. Retrieved from: PACE website
[605] Phung, C. G. (2019). Implications of the circular economy and digital transition on skills and green jobs in the plastics industry. Retrieved from: Open Edition Journals website

poses a threat to employment estimates, there are good examples where manual sorting is more efficient than automated sorting.[606][607] Targeted efforts are needed in skills training, education, work formalisation, and social inclusion to ensure a just transition to more decent work and compensation, especially in low- and middle-income countries with larger informal workforces.[608][609]

6.4c Collaborate with suppliers across (other) industries to increase demand for and use of secondary plastic content

This opportunity builds on the previous opportunities (6.4a and 6.4b) to better optimise the uptake and innovative use of secondary plastic feedstocks in open and closed loops of industrial production. It is crucial to ensure that new uses of secondary plastics do not contribute to contamination and otherwise impede the future potential for material cycling (see opportunity 6.4a). Possibilities for greater secondary plastic use in open loops are present in Lithuania, specifically for the agricultural, apparel, food processing and furniture industries. Because many of these industries are export-dominant, use of secondary plastics could offer a competitive advantage by helping to fulfill product sustainability standards in addition to environmental benefits.

Feasibility and scalability

Even though there are technical limitations to quality and functional performance, as well as the impact on the environment that needs to be taken into account[610] (see Opportunities (6.4a and 6.4b), the utilisation of secondary plastic feedstock is feasible and being more widely practiced. An increased use of recycled plastics can be achieved if there is sufficient demand to drive the uptake of resources—and indeed, demand for high quality secondary materials exceeds supply across Europe, according to interviewees. Better matching supply and demand through enhanced transparency and matchmaking mechanisms is essential for enabling the scaling-up of business models in open and closed loops of recycled plastics. As large buyers, businesses across industries and the national government have a critical role in creating an innovative and thriving recycled plastics industry. The Lithuanian Government can use policy instruments, from green procurement and waste management and treatment regulations to taxation to help create a more favorable market ecosystem for recycled plastics. Raising consumer awareness to create more acceptance and preference for products with

[606] PACE. (2021). PACE action agenda for plastics. Retrieved from: PACE website

[607] Phung, C. G. (2019). Implications of the circular economy and digital transition on skills and green jobs in the plastics industry. Retrieved from: Open Edition Journals website

[608] PACE. (2021). PACE action agenda for plastics. Retrieved from: PACE website

[609] Phung, C. G. (2019). Implications of the circular economy and digital transition on skills and green jobs in the plastics industry. Retrieved from: Open Edition Journals website

[610] Brouwer T. M. et al. (2020). Technical Limits in Circularity for Plastic Packages. doi:10.3390/su122310021

recycled content will also be a key driver in scaling-up the overall uptake of recycled plastics across different products.[611][612]

A system-level design approach is required to ensure end-products are actually recyclable and to ensure transparency and monitoring of quality throughout the various processes. Some best practices have been identified that have managed to realise such systems:

- **Nylon-to-nylon recycling.** All the styles in the Napapijri Circular Series are 100% recyclable thanks to their mono-material composition. Fillings and trims are made of Nylon 6, while the fabric is made of ECONYL® Regenerated Nylon, a high-performance Nylon 6 yarn recycled from discarded fishing nets and other waste materials.[613]

- **Plastic waste into urban furniture.** The Print Your City initiative transforms plastic waste in cities into furniture for public spaces with robotic 3D printing and citizens' involvement. This initiative was launched and developed in the city of Amsterdam, where urban furniture was designed and produced using household plastic waste collected separately. For each bench produced, 50 kilograms of plastic waste is reused and 125 kilograms of CO2 is saved.[614][615]

- **Reusing plastic in paving roads**. Shisalanga Construction is the first company in South Africa to begin paving roads out of recycled plastics such as milk bottles. Their innovative product compound is said to be more water-resistant and reliable than traditional asphalt. The company's business model reduces large quantities of plastic waste. It has repaved more than 400 metres of the road with asphalt made from nearly 40,000 recycled two-litre plastic milk bottles.[616] The Indian Government has introduced a similar (but public-sector) initiative, making the use of waste plastic in road construction mandatory. All roads constructed within 50 kilometres of the periphery of any city with a population of over 500,000 must use a 'plastic mix'. The 'plastic mix' (combined with traditional materials) is cheaper than 100% bitumen road and increases life expectancy by raising water resistance. The sale of plastic waste also creates an additional income stream for local councils.[617]

Industrial and technological infrastructure

As previously discussed, plastic recycling capacity is present in Lithuania, although it requires investment to be expanded and upgraded to improve capacity and quality (see Opportunities 6.4a and 6.4b). In order to increase the demand for and use of secondary plastics, it is critical to have a well-performing market, with sufficient transparency on material specifications and composition,

[611] PACE. (2021). Circular Economy Action Agenda - Plastics. Retrieved from: PACE website
[612] Ellen MacArthur Foundation. (2017). New plastics economy - Catalysing action. Retrieved from: EMF website
[613] C2C-Centre. (2020). Napapijri Circular Series. Retrieved from: c2c-centre website
[614] Print your city. (2020). Print your city. Retrieved from: print your city website
[615] Amanda Svachula, A. (2020). Imagine Sitting on Benches Made of Recycled Trash. Retrieved from: Curbed website
[616] Shisalanga Construction case. Retrieved from: Knowledge hub
[617] Government program to reuse plastic in roads. Retrieved from: Knowledge hub

which would enable increased use of recycled plastics and reduced use of virgin materials. Reliability and precision of material composition will increase trust between agents in different sectors and boost the demand for such materials. As already mentioned in previous opportunities, the quality and quantity of waste sorting will be crucial, as will introducing more granular standards for recycled plastics.

Additionally, it is important to mention that the high capacity levels for waste-to-energy facilities and low prices for virgin plastics creates many competing, lower-cost alternatives to secondary plastics.

Innovation infrastructure

Knowledge infrastructure relating to this opportunity has already been presented (see Opportunities (6.4a and 6.4b). Notably, with 12 active members, the Plastics Cluster is a key asset for developing this opportunity as it aggregates stakeholders from across the whole value chain. In addition, its activities have a strong focus on developing business and other relations with suppliers. Lithuania's Cluster network can also help different sectors develop mutually beneficial industrial and business relationships, for example, using recycled plastics in other industries such as food processing and the automotive industry.

Policy landscape

See the policy landscape assessment for previous Opportunities (6.4a and 6.4b). Additionally, the EU's *Circular Plastics Alliance*[618] aims to bring together all relevant stakeholders from the whole value chain to boost the competitiveness and scale of the internal market for recycled plastics, and increase demand for recycled plastic. Policy instruments such as the *Virgin Materials Tax* (VMT) or mandatory eco-design are key enablers and stimulators of secondary plastics demand. Policy and regulation have a crucial role in shifting away from plastic 'waste' to plastic 'resources'. Public procurement plays an important role in generating more demand: in Europe alone over 250,000 public authorities spend around 18% of GDP annually on public procurement. Integrating circular criteria in public tenders will improve the secondary plastics market conditions. Stricter laws and regulations that require the use of recycled materials, or lifting regulations that hinder the use of recycled materials, can be another market driver, and create an impetus for key business players to adapt and comply.[619][620]

Impact potential

As this opportunity focuses primarily on better establishing links between industry to increase the uptake of secondary plastics, it feeds directly into the environmental, economic, and employment benefits and impacts that have been described in Opportunities 6.4a and 6.4b.

[618] European Commission. (2018). Circular Plastics Alliance. Retrieved from: EC website

[619] Ellen MacArthur Foundation. (2017). New plastics economy - Catalysing action. Retrieved from: EMF website

[620] Interempresas - Plástico. (2009). El uso de plástico reciclado en envases para contacto alimentario. Retrieved from: interempresas website

6.5 Furniture

6.5a Promote the use of secondary materials for filling and fabrics

This opportunity relates to Opportunity 6.3a, focusing specifically on expanding the use of fabrics and fibres made from recycled feedstock in furniture applications. The furniture industry has a very strong potential to realise high-value reuse of secondary fabrics, fibres, and fillings from the textile industry, due to the broad range of furniture types and markets (office, commercial and home furnishings) It is estimated that only about 10% of discarded textiles in Lithuania were collected due to lacking infrastructure and incentives for collection, and furthermore, post-industrial and pre-consumer textile flows are difficult to quantify, due to a lack of separate reporting on this waste stream by companies.[621] With strong sustainability trends in both industries, this opportunity demonstrates a strong potential for direct collaboration between the textiles and furniture sector in Lithuania.[622]

Feasibility and scalability

The feasibility and scalability of utilising secondary material streams within the furniture industry should be very high, due to the high volume of secondary material flows in the country, the possibility to match material quality to various applications; for example, high quality fabrics can be selected for luxury furniture applications, where lower quality fibres could be mixed or utilised alone as reinforcement fabrics or fillings which tend to be unseen. The fact that most furniture manufacturers in Lithuania produce for multinationals such as IKEA with business models that are leaning towards circular economy products and practices is a key driver for the Lithuanian furniture sector to increase the use of secondary materials in manufacturing processes.[623] Specific examples of secondary textile use in the furniture sector are abundant and represents a trend that is increasing strongly:

- **Tables made of recycled tights**. Swedish Stockings, a sustainable Swedish hosiery brand, has launched a limited edition collection of furniture made from its customer's old tights, together with furniture designer Gustaf Westman. Tables, depending on their size, contain between 80 and 350 pairs of tights that have been diverted from landfills through a recycling program. Tights are collected, grinded, mixed with recycled fiberglass, and finished into the desired furniture.[624]

[621] Watson, D. et al. (2021). Post-consumer textile circularity in the Baltic countries: Current status and recommendations for the future. Retrieved from: Norden website
[622] Hasek, G. (n.d.). Interest in Sustainable Furniture on the Rise. Retrieved from: GreenBiz website
[623] IKEA. (n.d.). Why the future of furniture is circular. Retrieved from: IKEA website
[624] Swedish Stockings. (n.d.). Innovations by Swedish Stockings. Retrieved from: Swedish Stockings website

- The **Pressing Matters project**[625] started with the objective to make better use of waste generated by the textile, fashion and furnishing industries. Supercyclers, a sustainable furniture designer, and Seljak Brand, blanket designer, joined forces to create the Floor Lounger, the first hybrid furniture created from the collaboration of the two brands composed of 100% textile diverted from landfill from the mattress industry. The project allows to divert from landfill up to 5 kilograms of textile waste per mattress.

- **Pentatonic**, a design company, created for Nike a series of 18 unique furniture pieces by repurposing obsolete team jersey prototypes and a multitude of factory offcuts into the seat shells, intended for Nike's global retail studios.[626]

Industrial and technological infrastructure

The Lithuanian furniture manufacturing industry is competitive and highly developed, with modern production facilities and a highly skilled workforce. The strong presence of active furniture manufacturers and companies involved in the furniture value chain (slightly below 900 as of 2016[627], although the majority are SMEs) suggest that there is a high degree of industrial and technological infrastructure already in place within Lithuania.

Innovation infrastructure

Lithuania's knowledge infrastructure and innovation ecosystem is capable of supporting the implementation of this strategy. For example, there is a Baltic Furniture Cluster uniting eight furniture SME manufacturing companies, two higher education institutions and one regional association of industrialists.[628] Additionally, there is also a specific focus within Academia and research institutions on furniture and wood products: Kaunas University of Applied Sciences offers a degree on "Production of Furniture and Wood Products".[629]

Policy landscape

Furniture, along with high impact intermediary materials, is one of the key priority areas of the 2020 CEAP.[630] Similarly, furniture is one of the main sectors of the Updated Bioeconomy Strategy[631], and

[625] Supercyclers. (n.d.). Pressing matters/Floor lounger. Retrieved from: Supercyclers website
[626] Pentatonic. (n.d.). Pentatonic airtool bar chair x Nike by you. Retrieved from: Pentatonic website
[627] Flanders Investment and Trade. (2018). The furniture industry in the Baltic States. Retrieved from: Flanders Investment and Trade website
[628] Baltic Furniture Cluster. (2021). Companies. Retrieved from: BFC website
[629] Kaunas University of Applied Sciences. (n.d.). Production of Furniture and Wood Products. Retrieved from: Kaunas University of Applied Sciences website
[630] European Commission. (2020). Circular Economy Action Plan. Retrieved from: EC website
[631] European Commission. (2018). Updated Bioeconomy Strategy. Retrieved from: Publications Office of the EU website

specific GPP criteria developed for this sector.[632],[633] There is also a European Ecolabel for furniture. On a national level, there is a lack of specific policy development and support for proactive stakeholder engagement across the sector.

Impact potential

As this opportunity focuses on increasing the uptake of secondary materials for fillings, fabrics and fibres, many of the specific environmental, economic, and employment benefits and impacts have been described in Opportunities 6.3a.

6.5b Redesign furniture to reduce the amount and diversity of materials and reduce disassembly & repair complexity

This opportunity explores the possibility of 'redesign' in the furniture industry to enhance circularity overall. The concept of redesign should be seen from a systemic perspective, involving material selection and product manufacturing, but also service model redesign to enable easier repair, disassembly and remanufacturing options over the life cycle of furniture products. The rapidly growing trends in sustainability and circular economy in the furniture sector, particularly among Lithuania's main export markets[634], make this a particularly attractive opportunity for local companies to innovate and strengthen their competitive advantage in the European market.[635] But even though a large portion of the Lithuanian furniture industry is export focused, there are also furniture manufacturers that serve the domestic market, and who could benefit from such a strategy.[636]

Feasibility and scalability

There is a strong trend toward circular economy design practices in the furniture sector, with a number of specific innovations ranging from secondary material reuse, design for modularity and disassembly, and circular business models like leasing that make such an opportunity appear to be quite feasible. With large global retailers like IKEA taking bold moves toward a circular economy, there is a strong signal that these approaches can also be achieved at scale.[637] As Lithuania hosts many companies in the total furniture value chain, this opportunity could be applied to material and

[632] European Commission. (2018). EU Green Public Procurement Criteria for furniture. Retrieved from: EC website
[633] European Commission. (n.d.). Furniture: Green Public procurement (GPP) Product Sheet. Retrieved from: EC website
[634] Enterprise Lithuania. (n.d.). Lithuanian export stars – furniture makers. Retrieved from: Enterprise Lithuania website
[635] European Environmental Bureau (EEB). (2017). Circular Opportunities in the Furniture Sector. Retrieved from: EEB website
[636] Interviews with furniture manufacturers (i.e. Ergolain) that serve mostly domestic markets acknowledge the potential of circular economy innovations in articulating competitive advantage in the domestic market.
[637] Richard van Hooijdonk. (2019). IKEA is a shining example of the circular economy and sustainability mega-trend. Retrieved from: Richard van Hooijdonk blogspot

component manufacturers as well as full furniture design and retail firms. Some best practices that highlight cutting edge innovation in this space include:

- **DSM-Niaga** designed a 100% recyclable line of medium-life 'bulky' products (MLBPs), like carpets and mattresses to keep them away from the landfill. To do so, they designed an adhesive that decouples on demand and, together with the use of non-toxic, easy recyclable mono-material components, the new modular design of their new products also supports easy maintenance. This has enabled the use of new leasing business models for these products.[638]

- **TAKT** is a furniture company that designs furniture according to a set of circular design principles, including design for durability—all their furniture comes with a five year warranty—, for repairability—through the use of replaceable components—and for recyclability—by designing furniture that can be disassembled into key materials that can then be re- or upcycled. Their flat-packing approach to packaging their furniture has also enabled them to reduce damage and reduce carbon emissions during transport by 56%. [639]

- Although not all **IKEA** furniture is currently designed according to circular principles, some of their products are already designed to serve multiple functions and can be useful throughout extended periods of time. For example, baby cots that transform into toddler beds, or modular products such as some of their storage solutions, or sofas whereby pieces can be added or taken away as needed. [640]

Industrial and technological infrastructure

In line with what was indicated in the previous opportunity (see 6.5a), the industrial and technological infrastructure of the Lithuanian furniture industry is already in place. Notably, production is high quality and flexible with up-to-date design solutions and responsive to new demand trends which further supports this opportunity. Moreover, as discussed in previous Sections (see 6.1, 6.3 and 6.4), there are a number of industries that could supply secondary feedstocks to the furniture industry, further strengthening the potential for Lithuanian industry to pursue this direction.

Innovation infrastructure

There is sufficient knowledge infrastructure and the innovation ecosystem is capable of implementing this opportunity. Particularly, the Lithuanian Design Cluster[641] and the Baltic Furniture Cluster can support the practical implementation of this opportunity by sharing and developing the necessary knowledge and skills.

[638] Ellen MacArthur Foundation. (n.d.). Redesigning medium-life bulky products from scratch. Retrieved from: EMF website
[639] Takt. (n.d.). Eco system design principles. Retrieved from: Takt website
[640] IKEA. (n.d.). Why the future of furniture is circular. Retrieved from: IKEA website
[641] Lithuanian Design Cluster. (n.d.). Cluster. Retrieved from: Lithuanian Design Cluster

Policy landscape

European Union and national policy landscape supporting this opportunity has been previously discussed (see opportunity 6.5a).

Impact potential

The environmental benefits associated with reuse are often similar to the benefits achieved from recycling, however much can depend on the specific application. It is estimated, for example, that about 1-2 tonnes of greenhouse gas emissions are saved on average for the reuse of one piece of furniture.[642] At the country level, an ambitious circular economy strategy for furniture could generate significant emissions reductions. In the UK, it is estimated that a well functioning circular furniture value chain could reduce over 850,000 tonnes of greenhouse gas emissions.[643] It is estimated that a circular European furniture sector could provide a potential increase in EU GVA of €4.9 billion, while reusing/recycling 3.3-5.7 million tonnes of material, avoiding 3.3.-5.7 million tonnes CO2 and creating 160,000 extra jobs.[644] Considering that Lithuania presents about 10% of total EU furniture production, that roughly translates to a €490 million opportunity to increase annual GVA. Individual consumers and repair businesses also experience economic benefits of participating in reuse systems. Households in the UK benefit by over £320 million per year as a result of sale of items through reuse exchange and avoiding purchase of new items. Each sofa reused can yield over £18 net revenue to reuse organisations.[645]

In terms of impacts to the labour market, several studies have given varying indications that recycling might result in additional job creation of anywhere between 2 - 80 jobs per 1,000 tonnes of processed furniture. This would equate to between 7,300 and 156,000 additional jobs created if an ambitious reuse policy package were deployed across Europe.

6.5c Use digital design systems to minimise input materials

This opportunity explores the role of digital design systems in the furniture manufacturing process to reduce total material inputs and to reduce waste and by-products. This opportunity would greatly enable the previous opportunities in this section (6.5a and 6.5b) by helping to streamline production processes to minimise raw material needs and waste, but potentially also to monitor and optimise decision making in furniture disassembly and remanufacturing when combined with circular business models.

[642] European Environmental Bureau (EEB). (2017). Circular Opportunities in the Furniture Sector. Retrieved from: EEB website
[643] Idem.
[644] Idem.
[645] WRAP. (2020). Domestic Furniture. Retrieved from: WRAP website

Feasibility and scalability

Digital design systems are becoming more commonplace, even for smaller manufacturers as a way to optimise manufacturing processes and reduce waste. Several innovative examples are already being applied within the furniture and textiles industry, which indicate that this opportunity would be feasible to implement.

- **Gispen** is a furniture company whose manufacturing process optimises 'intermediate products'—or components of final products—, such as metal tubes from which table legs are made. By including intermediate products in their production process, Gispen is able to reduce production waste when manufacturing new furniture and to save energy when remanufacturing products.[646]

- **Resale models** have proven widely successful in the apparel industry[647] and furniture retailers are following suit around the world, with digital platforms a key enabler of these business models[648]. For example, retailer Made.com partnered with online marketplace Geev on an initiative that makes it easier for customers to give away their used furniture and homewares, by providing customers purchasing goods on Made's website the option to post ads on Geev for any item of unwanted furniture or homeware they own. IKEA also launched a buyback scheme in May 2021, which will see used furniture stocked at stores across the United Kingdom[649], and in Lithuania, Ofisas Prabangiai is already tapping into the resale opportunity in the office furniture sector, where they renovate and give a second life to used furniture.[650]

- **DesignConcept**[651] is a 3D upholstered furniture development software developed by Lectra that allows to create virtual prototypes and preliminary cost budgets. Many are the benefits provided by the software, including a lower number of physical prototype iterations by up to 50%, decreasing the amount of fabric and leather needed early in the furniture development process.

Industrial and technological infrastructure

As described in previous opportunities (see 6.5a and 6.5b), it is apparent that Lithuania has both the industrial and technological infrastructure to introduce new manufacturing and design solutions to advance this opportunity.

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[646] Gispen. (n.d.). New circular furniture. Retrieved from: Gispen website
[647] thredUP. (2020). Resale report. Retrieved from: thredUP website
[648] Circle Economy. (2020). The future of garment technology in circular fashion. Retrieved from: Circle Economy website
[649] Keating, C. (2021). A partnership in furniture brings the circular economy to consumers. Retrieved from: GreenBiz website
[650] Ofisasprabangiai. (n.d.). Furniture purchase. Retrieved from: Ofisasprabangiai website
[651] Lectra. (n.d.). DesignConcept furniture: virtual prototyping and product development software. Retrieved from: Lectra website

Innovation infrastructure

It is clear that the knowledge and innovation infrastructure to further advance a circular furniture industry is largely present and active in Lithuania (see 6.5a and 6.5b). Furthermore, the Lithuanian Design Cluster[652] and the Baltic Furniture cluster, together with other clusters focused on digital solutions, such as the Digital technology cluster, can support the practical application and strengthen the absorption capacity by the furniture industry of this opportunity.

Policy landscape

European Union policy landscape supporting this opportunity has been previously discussed (see 5.1). Additionally, on a national level, key priority number two ('New production processes, materials and technologies') and three ('ICT') of the S3, even though not directly related, given their horizontal nature can support the opportunity. The Industry Digitisation Roadmap also identifies 'timber and furniture' as one of the five value chains to implement digital and new technologies.[653] The National Skills Strategy can also support this opportunity by focusing on the development and integration of the necessary skills.[654]

Impact potential

The utilisation of digital design systems primarily produce benefits of waste reduction in production chains, however the associated resource extraction and emissions savings can be significant when widely adopted across an entire industry.[655] Waste reductions in the design process can be significant, ranging from 30% to 100%.[656] Lithuanian furniture industries represent about 1.5% of total domestic material consumption and produce nearly 90 thousand tonnes of wood waste annually, illustrating that there is quite a large opportunity for material savings and the associated environmental and economic benefits. While there are no specific studies on the influence of digital design systems in the furniture industry, studies that do exist indicate small changes to employment numbers, and emphasize the importance of higher skills and education levels.[657]

[652] Lithuanian Design Cluster. (n.d.). Retrieved from: Lithuanian Design Cluster
[653] Lithuanian Innovation Centre (LIC). (2020). Lithuanian Industry Digitisation Roadmap 2020-2030. REVISED DRAFT updated within a framework of the "Follow up" project. Retrieved from: EIMIN website
[654] STRATA. (2020). National skills strategy. Retrieved from: STRATA website
[655] European Environmental Bureau (EEB). (2017). Circular Opportunities in the Furniture Sector. Retrieved from: EEB website
[656] Koo, B. et al. (n.d.). Towards Zero-Waste Furniture Design. Retrieved from: Texelmancy website
[657] European Environmental Bureau (EEB). (2017). Circular Opportunities in the Furniture Sector. Retrieved from: EEB website

7. The way forward: Recommendations for Lithuania's industrial transition to a circular economy

Taking into account the barriers identified for Lithuania, as well as other EU Member States, and building on the best practices of each of the countries, the following are recommendations that could shape the policy landscape so that it supports a just and circular transition for industries.

7.1 Regulatory Framework

The lack of a comprehensive legal and regulatory framework for the circular economy, that integrates and aligns vision and targets set currently across a variety of national policy strategies and action plans hinders the sound implementation of these strategies in an industrial setting. Outdated regulation that is not fit-for-purpose and maintains the status quo hinders the effective advancement of circularity. This means that updating the regulatory system, while adapting European regulation to the local context, may incentivise the financing of technological and social innovation, and structure investments to boost competitiveness. It is therefore recommended to:

- **Introduce clear standards for waste classification and align schemes for collection and treatment in collaboration with industries.** To improve valorisation of waste materials and other residues, better standards for reporting waste and by-products are needed. These will enable better insight into the actual valorisation of materials and potential opportunities for improvement. Similarly, standardised guidelines for waste collection and sorting, as well as subsequent treatment, are needed to ensure improved quality in secondary materials and facilitate the accurate disposal of waste. Better insight is also needed on the processing of domestically produced, imported and exported waste streams, as only reporting aggregated recycling rates may distort reality. This is exemplified by the current reporting on Lithuania's plastics recycling.

- **Adapt overarching circular economy directives to the different regions** and counties throughout the country, as the budget will be also allocated by region. Having a regional perspective when implementing circular strategies will allow for better implementation in the real-life contexts of each region, for example in critical areas such as innovation clusters and industrial symbiosis.

- **Expand Extended Producer Responsibility (EPR) schemes** to mandate that manufacturers and importers increase reuse, repair and recycling rates in as many sectors as possible (for instance, healthcare equipment, textiles, etcetera). Because the ultimate aim of EPR schemes

is to foster improved product (eco-)design to reduce waste and facilitate recovery after disposal, a closer connection to circularity-driven innovation and research and development (R&D) are yet to be established, especially for currently unregulated waste streams.

Outdated regulation that is not fit-for-purpose and maintains the status quo hinders a smooth circular transition. Updating the regulatory system will therefore incentivise the financing of technological and social innovation, and structure investments to boost competitiveness. It is therefore recommended to:

- Update and adjust regulation that supports preparation for reuse for diverse waste streams, recognising the priorities given by the EU Waste Hierarchy. Overall, Lithuania is not doing poorly compared to countries selected for comparison in this study. However, special attention needs to be afforded to, for example, the recycling rate of e-waste, wooden packaging, and overall packaging, where Lithuania is well below the EU average. Additionally, the separate collection and preparation for reuse and recycling of waste streams that are yet to be regulated, should be done in accordance with and alignment to EU strategies and directives (such as the upcoming EU *Textiles Strategy* and the 2025 directive requiring the separate collection of textiles).

- Use 'green taxation' more aggressively and effectively. Taxation is complex and there are always trade-offs with winners and losers. Fiscal implementation problems may arise, and in some cases expected outcomes become unrealistic, for example, due to external circumstances. The key is to ensure the right combination in the tax structure that effectively sends price signals and steers companies and markets. To this end, the introduction of more disruptive tax instruments than those already in place and those being considered[658] is recommended. For example:
    - A Virgin Materials Tax (VMT) can have positive effects across different levels: it encourages material productivity, efficiency and substitution, and supports and increases the secondary materials market, building its competitiveness. On a more macroeconomic level, as part of a broader redesign of the tax structure, it can be instrumental in moving away from income taxation and towards the taxation of resources, consumption and pollution.
    - A reasonable but effective CO2 floor tax for industrial production can encourage decarbonisation and material efficiency in industry, as well as further support energy efficiency and the electrification of industrial processes (where possible).
    - Bolder steps, such as introducing a special levy, to address the excessive cost-competitiveness of incineration plants and 'level the playing field' can ensure that more

[658] This includes actions already being taken by the Lithuanian government to increase environmental taxes and expand the 'polluter pays' principle in 2021. The EU taxonomy already excludes waste-to-energy plants from its classification of 'green activities', and Lithuania is increasing taxes for incineration plants.

desirable waste management alternatives, such as mechanical recycling plants, can compete.

- **Introduce sound fiscal incentives** that send clear market signals to industrial actors and encourage sustainability, circularity and environmental protection. This could include: 1) cost deduction for clearly defined environmental investments and eco-innovation activities; 2) a reduced VAT for second-hand goods and repair services; 3) industry subsidies and/or tax benefits for organisations participating in industrial symbiosis interventions[659], resource efficiency activities and circular business models; 4) tariffs for products from resource-intensive industries or a CO2 floor tax; and 5) financial support for feasibility studies, for example for 'brown investments'.

- **Expand the offer to environmentally-sound measures in grant funds**, as for instance, the National Rural Development Programme funding currently dedicates less than 15% of its funding to agri-environmental measures and organic farming practices. This could include, for example, developing and investing in opportunities for regenerative forestry and smart and organic farming.

7.2 Market

Lack of clear and effective regulation, incentives and measures foils the adoption and implementation of, (eco-)innovation initiatives and the uptake of secondary raw materials. It is therefore recommended to:

- **Warrant specific attention to Green Public Procurement (GPP)**, as it can create a significant market pull for sustainable and circular products. Although efficiency has been significantly low up to date, the targets for GPP have been recently updated to the ambitious aim of 100% GPP by 2023 in Lithuania. Furthermore, environmental criteria and guidelines for its implementation have been reviewed this year: the updated GPP criteria for food expands the opportunities for organic and local food procurement. However, **adding clear circular criteria and guidelines** for the procurement of circular, service/performance-based business models, as well as criteria that promotes industrial symbiosis and circular ecosystems has not been done yet. Additional focus should be placed on **capacity building, knowledge sharing and professionalisation** of GPP agencies and entities, to ensure effective implementation.[660] Capacity building initiatives could capitalise on EU-level and international initiatives.
- **Refine directives and targets established for material recovery**. For example, to meet packaging waste targets, there is a heavy reliance on industrial, commercial and institutional packaging waste, which is easier to collect. However, this may misdirect the focus from the largest share of

[659] World Bank (WB). (2021). Circular Economy in Industrial Parks: Technologies for Competitiveness. Retrieved from: WB website

[660] OECD. (n.d.). Public procurement reform in Lithuania. Retrieved from: OECD website

packaging waste—post-consumer packaging—and therefore weaken the sector's ability to achieve high recovery rates.[661] Regulation and investment should enhance waste management infrastructure for key waste streams such as packaging and textiles.

- **Promote the development of circular business models.** Businesses are key actors in operationalising the transition to a more circular economy. But for this they need to also transform their business and revenue models. For example, servitisation and performance-based models, as well as repair, refurbishment and remanufacturing services, are key.

- **Invest and encourage investment in infrastructure that increases material recovery for effective industrial reuse.** Lithuania's waste management infrastructure has substantially improved over the previous decades; however, it still requires substantial investment to expand, upgrade and modernise its capacities, particularly for recycling. Pursuing higher value recovery of materials other than for energy generation, should constitute an area of focus for future infrastructure development. Investment in areas of material recovery for effective industrial reuse, thereby fostering an active market for secondary resources, should be an area of focus.

- **Explore the role of the government as a market designer, not only as a market regulator.** The national government should begin using policymaking to shape and design markets from a market co-creation approach.[662] This particularly applies to innovation policy and governance. This shift can be made possible by implementing mission-oriented policies and investments, for example, targets for the reduction of overall material consumption and/or environmental pressures, that change the mentality and focus towards a productive, proactive agenda. This role as a market designer could also foster the production and processing of secondary raw materials as well as promote their use in the production of new products, by gradually increasing their quantities through economic measures, such as the development of national end-of-waste criteria, the development of design guidelines for secondary raw materials incorporated in final products procured by both public and private entities, or through providing tax incentives for products made from secondary raw materials.

- **Support the development and scaling of digital technology platforms**, which can play a significant role, for example, in developing a digital secondary materials market. Lithuania already gives strong example with the secondary textiles platform 'Vinted'[663]. Applying learnings and best practices to other industries and extending platforms to the business-to-business context may

[661] EUROPEN. (2013). Position on Extended Producer Responsibility for post-consumer packaging in the EU. Retrieved from: Municipal waste Europe website

[662] Mazzucato, M. (2016). From market fixing to market-creating: a new framework for innovation policy. doi:10.1080/13662716.2016.1146124

[663] Vinted. (n.d.) Ready to declutter your closet? Retrieved from: Vinted website

hold significant potential for Lithuania to grow as a regional hub for secondary materials marketplaces.

7.3 Technological

Demonstrating the effectiveness of low-waste and closed-loop technologies and solutions is key to encouraging large-scale adoption. Infrastructure development for circular economy implementation is also limited and must be upgraded. Regional planning is not always aligned to structures and asset management needed in the circular economy. Sorting and processing infrastructure is not yet fully developed and well balanced across waste streams. Furthermore, recent investment in incineration infrastructure can result in overcapacity and ultimately thwart better waste management practices. It is therefore recommended to:

- **Foster the development of digital technologies and innovation.** Digitalisation and the circular economy are two of the main pillars of the EU's strategy to transform its productive model, making it more sustainable and strengthening its competitiveness. Digital technologies are fundamental for the development and implementation of digital production technologies that enable closed-loop production and more resource-efficient industrial production processes as well as new products and services. Digitalisation also enables business model innovations, for example in manufacturing (remanufacturing) and the agri-food sector (shorter supply chains and product traceability). Lithuanian industry's circular economy roadmap and policy approach must combine and reflect this double transformation.

- **Promote eco-design and zero waste production innovations.** Technological innovations, in line with those presented in the previous recommendation, are crucial to promote the eco-design of products and production innovations that minimise waste generation. For example, industry-specific support programmes can help bridge the knowledge and financial gaps between industry and academia.

- **Establish sector-based pilot projects that demonstrate the effectiveness of low-waste and closed-loop technologies and solutions on productivity and competitiveness.** Small-scale pilot projects implemented on SMEs can serve as effective examples that demonstrate to larger industrial players the economic benefits of investing in the acquisition and introduction of technological solutions that minimise waste and that enhance material and energy efficiency.

- **Encourage industrial symbiosis** as an alternative to closed-loop production when the latter is not possible. In line with the previous recommendation, there is also potential for circular opportunities to address and link diverse industrial sectors, minimising waste and increasing competitiveness. These activities would also increase the overall awareness of circularity solutions within the industry. This could be enabled by a deeper analysis of the complementarity of waste streams arising within different industry clusters, particularly in Kaunas and Vilnius, as well as the involvement of possible industry partners in open exchange forums on reusing waste streams within these clusters.

- **Incentivise and step-up operational support with the modernisation, upgrade and expansion of technologies and infrastructure for material and resource recovery.** Investing in advanced, higher-value treatment waste management facilities (for instance with plastics recycling plants), waste prevention points and reuse centres for textiles, furniture, clothes and biowaste is key to narrowing, slowing and closing industrial material, energy and waste flows.
- **Invest in increasing and upgrading recycling capacity and quality**. Investing in key waste management infrastructure is crucial to, among other things, increase the quality of recycled materials and thus also support the competitiveness of the secondary materials market. Large-scale investment in key waste management infrastructure (for example, RATCs), in combination with a fit-for-purpose regulatory framework that provides the necessary incentives and price signals to producers and consumers, can have a substantial impact on the Lithuanian (or even regional) secondary materials market.

- **Expand and enhance the circular use of public-owned assets** such as land, buildings, and infrastructure. Lithuania presents several unused or outdated industrial sites, which could be renovated for new industrial development to promote the set-up of 'green investments'.

- **Accelerate the transition towards clean, renewable energy.** Shifting the energy supply to renewable sources goes hand in hand with a shift to a circular economy and is essential for reducing Lithuania's material footprint. Lithuania has already improved its energy policies over recent years and is integrating its electricity grid into the synchronous grid of Continental Europe.[664] Recommendations in this area are the following:
    - Accelerate the introduction of additional policies and regulations necessary to develop off-shore wind energy capacity and electricity storage.
    - Grow, where possible, the already strong bio-based district heating system, as well as intensify the development of solar power plants and parks.
    - Enhance long-term strategies for energy independence and grid optimisation to allow for better integration and feed-in of diverse energy sources.
    - Scale up the integration of energy 'prosumers' and green energy purchases.
    - Increase the adoption of renewable electricity in end uses such as heating and transport.
    - Further support the curbing of energy consumption through increased efficiency by promoting more stringent industrial energy performance standards as well as energy taxation reforms.[665]
    - Expand and accelerate the Building Renovation Programme.

A lack of joint involvement in R&D activities generating products and services with commercial potential between businesses and the scientific community limits the potential of the Lithuanian innovation landscape. This is further exacerbated by poor institutional cross-cooperation, especially observed in financial support management and the limited possibilities it allows in practice for business and academia to collaborate in new research and developments. Additionally, a lack of specialists across businesses familiar with green technologies as well as a very small knowledge

[664] International Energy Agency (IEA). (2021). Energy Policy Review: Lithuania. Retrieved from: IEA website
[665] Idem.

intensive sector across the country, further limits innovation capacity. It is therefore recommended to:

- **Encourage specialisation of Vocational Education and Training (VET) and Universities in the circular economy**, recognising their position in developing a pool of knowledge experts and specialists to drive the circular transition of Lithuanian industry.[666] Mechanisms should be implemented for greater collaboration and knowledge transfer between academia and industry, including apprenticeships and firm-based learning. Furthermore, vocational education, training and adult learning can address demographic challenges in regions going through an industrial transition, as the population is likely to be older and require upskilling or reskilling through innovative pedagogical techniques.
- **Invest in increasing the availability of skills and technical expertise** in the local and regional market, which can unlock new eco-innovation opportunities for industry, for example, related to eco-design and industrial symbiosis. Investing in skills is key to helping overcome existing technological and capacity-based barriers.
- **Translate learnings** from Lithuania's participation in the EU Circle Learning Programme,[667] as well as embed those key insights derived from industrial changes within the educational system. Public knowledge investments in higher education and research and innovation (R&I) must guarantee the provision of adequate human capital to fulfil the new knowledge needs. In effect, investment in human competences, including soft and not only technical skills, is a crucial precondition for companies to better incorporate new technologies and rethink their business models.
- **Provide grants assessment and technical assistance** (*id est,* research and specific training) by specialised entities, which are instrumental in providing necessary resources for R&I. The terms for the application and implementation of grants and available funding for R&D and eco-innovation should also be reviewed, to ensure that the highest forms of business-scientific collaboration can be achieved in practice.
- **Fund the acquisition of patents and commercially viable cutting-edge technologies** through the establishment of public-private partnerships, through European or national level funding calls, to support their fast and efficient integration with circular practices at the industrial level.
- **Create joint research (open innovation) centres with foreign partners**, improve public relations to attract talent and investors, and make foreign direct investment (FDI) more selective to channel funding to industrial clusters with the most potential from environmental and social perspectives. These could be initiated by collaborations through EU funding calls,

[666] A.SPIRE. (2019). Hubs for Circularity – Process Industries, Regions and Cities Deploying Circular Economy at Scale. Retrieved from: A.SPIRE website

[667] Circle Learning. (n.d.). CIRCular Economy through Integrated LEarning in VET. Retrieved from: Circle Learning website

or they could be initiated, for example, by the already existing Digital Innovation Hubs (DIHs) and their partners in the European DIHs network.

For the industrial transition to circularity to succeed, however, there must be a shared understanding of circularity as an environmental necessity and an economically sound strategy with social and economic co-benefits throughout the country as a whole. Therefore, overarching governance and cultural barriers need to be addressed in order to secure structural, long-term and sustainable change.

7.4 Governance

An unclear institutional set-up and basis for inter-institutional collaboration prevents policy coherence and coordination between different institutions and actors, creates bottlenecks and misalignments, and hampers the harmonisation of efforts, regulations and definitions, ultimately hindering structural coherence and effectiveness. It is therefore recommended to:

- **Ensure that the transition to circularity has the necessary support at the highest political level.** The government is a key actor capable of steering and guiding the process as well as providing necessary momentum and initiative. To this end, the circular agenda, which depends directly on the Prime Minister and effective control and monitoring mechanisms, can help guarantee that the transition remains a top national priority and that implementation is advancing according to plan. It also allows for changes and adjustments along the road. However, to ensure effective coordination of systemic industrial change which can serve as the basis and engine for future, more holistic, systemic change, the Ministry of the Economy and Innovation must have a clear mandate and budget to guide and support the implementation of the industrial transition roadmap.

- **Guarantee clear division of tasks and responsibilities as well as necessary competences and funding.** Effective inter-institutional collaboration is fundamental to ensuring **practical within-government coordination** so that complementary public legislation, regulation, transfers of authority and infrastructure mutually align with and support one another. At the same time, the approach must be inclusive, transparent and democratic, with continuous involvement and engagement at all appropriate levels: local, regional, and national. Include specialised governmental agencies in this effort, for they play an essential ancillary role in specific policy development as well as in measuring and monitoring progress. For instance, strengthening policy interconnectivity and synergies help ensure that political commitment, technological development and social sensitivity align in the same direction. Experience from other countries has shown that this coordination could be led either by the Prime Minister's office, or by Ministries, including but not limited to the Ministry of Economy and Innovation; but the final aim should be to jointly involve as many ministries and relevant agencies as necessary in specific roles to tackle the industrial transition.

- Address the rather fragmented governance for innovation. Mergers of agencies, clearer strategic planning and more decisive leadership are actions to be evaluated. Special attention must be placed on governance and the ownership of financial instruments for the development of R&I, which currently hinders the proper interaction between scientific/research institutions and businesses. A coordinated approach between the upcoming Innovation Agency and Research Agency of the Ministries of Economy and Education must ensure that financing serves the purpose of both boosting R&I and supporting those innovations to reach the market.
- Consolidate the Science, Technology and Innovation Council. It holds the mandate to coordinate efforts and is chaired and supervised by the Prime Minister. However, a lack of consistency prevents it from being more impactful. Making this Council an instrument for real commitment and strategic guidance, not only on paper, could really be of significance. For this, the practicalities have to improve since they currently lack the necessary drive. The Swedish, Finnish and Dutch National Innovation Councils are good examples of effective spaces to guide innovation.
- Promote a democratic, inclusive and transparent approach for governance and policy making. This is key to ensuring that the circular economy industrial transition agenda proactively engages (not only for the policy and strategy design but also the implementation phase) as many stakeholders and broad segments of society as possible, and thus also promotes a mindset shift: a transformation towards the circular economy as a new socioeconomic model. Engaging with stakeholders from the private sector is essential to 'bring them onboard' and ensure that they practically implement the necessary changes in industrial processes by securing the necessary investments in new technologies that, for example, increase material efficiency and productivity and minimise waste. From a public perspective, it is central to ensuring transparency and to avoiding political and/or regulatory capture.
- Introduce clear and transparent reporting and monitoring mechanisms to ensure that implementation can be monitored, reviewed and adjusted. This includes evaluating the strengths and weaknesses of current monitoring methods, such as the GPAIS waste accounting system and its potential for the improvement of digital platforms. Amplifying these accounting methods may also take product and material tracking into consideration to identify best potential end-of-use treatments for the disposed materials. Improved reporting is also needed in the context of bio-based materials and agriculture in order to gain better insight into ecological cycling. In particular, this should encompass the sustainable management of production ecosystems as well as information on carbon cycling and how nutrients from bio-based waste are cycled back into ecosystems. The activities for the investigation and definition of these systems should be taken forward in the form of private-public cooperation, so that organisations active industrially can take an active role in shaping the tools that they will later have to implement. The creation of an independent public-private Centre for Data Analytics, tasked with technical matters such as establishing indicators and an effective data collection system to monitor and evaluate progress, can help solve some of the aforementioned

constraints. This could also be an institution with the mandate to discuss difficulties and propose ways forward.

- **Develop an integrated National Circular Economy Strategic Roadmap.** The goal is that it can instigate broad joint mobilisation of actors and resources and make circularity mainstream. It can also function as a collective agreement on national goals regarding, for instance, resource use and pollution. It can also piece together the already existing policy focus regarding resource efficiency. Detailed and broken down sectoral agendas for the prioritised sectors can be derived from this main strategic document, however, this main document should also include horizontal strategies applicable to all Lithuanian sectors and value chains. Therefore, broad stakeholder participation (public sector representation at all levels of governance, private sector associations or representatives, academia and scientific institutions and civil society organisations) as well as an alignment in the development of the national circular economy strategy and roadmap is key for its later uptake. Furthermore, the tone of the strategic document should present circularity as a key path and stepping stone to strengthening competitiveness, innovation and a resilience, recognising resource scarcity and planetary boundaries.

The lack of social dialogue at a sectoral level needs to be addressed, particularly given that the circular economy will impact sectors differently. Engage civil society, businesses and the public sector via platforms and initiatives that act as forums for discussion, facilitate an exchange of ideas and lessons learned, and gather knowledge and expertise. It is therefore recommended to:

- **Implement mechanisms for proactive stakeholder engagement and participatory decision-making** at different levels beyond between policymakers and the traditional grouping of actors (government, academia, industry and civil society) to include other relevant stakeholders (for instance, trade unions, city councils, environmental agencies, consumer associations, social influencers, among others). Expand participatory governance mechanisms (such as online public consultations,[668] public dialogue spaces or sectoral policy councils[669]) into the development and implementation of a circular economy roadmap and action plan at a sectoral level. A comprehensive list of participatory governance mechanisms can be found in the toolkit developed by Civicus.[670] This will additionally strengthen the role played by the Tripartite Council of the Republic of Lithuania (LRTT) in the decision-making and implementation process.

- **Evaluate the possibility of establishing public-private partnerships** to achieve specific goals set up in the Roadmap, with strong conditions attached. However, these mechanisms ought to fulfil a mission and solve a specific problem.[671] In particular in the further development and

[668] Europa Nu. (2015). Public consultation on circular economy starts 'in few days'. Retrieved from: Europa Nu
[669] Gent. (n.d.). Food strategy Ghent: Gent en garde. Retrieved from: Stad Gent
[670] Civicus. (n.d.). Participatory Governance Toolkit. Retrieved from: Civicus.org
[671] Mazzucato, M. (2016). From market fixing to market-creating: a new framework for innovation policy. doi:10.1080/13662716.2016.1146124

(European) integration of waste management infrastructure, this may be a priority: besides the involvement of different governmental stakeholders and civil society, effective alignment of product design guidelines, collection schemes and treatment plans warrant the participation and collaboration of product manufacturers, municipalities, waste collectors and urban planners as well as operators of waste treatment facilities.

- **Expand collective agreement coverage**, which is still low. The Tripartite Council Lithuania plays a strong role at national level, but little social dialogue is observed at the sector level[672]. The Tripartite Council, active in Labour Code and related issues (such as security of labour regulation, labour exchange, minimum wage regulation, pension regulation, etcetera) can play an important role in increasing collective agreement coverage.

- **Build broad social consensus around circularity.** Transitioning to a circular economy model is a multidimensional, highly complex, long-term, and, at times, rocky process. It thus requires broad social engagement and consensus building to co-create a collective national vision with clear, bold targets and goals not only for industry, but for Lithuania as a whole. The transition of Lithuanian industry in line with the circular economy can be the cornerstone of a new economic model based on inclusive growth.

7.5 Cultural

Social behaviour, knowledge development and awareness raising regarding resource efficiency, circularity, and sustainable consumption amongst citizens and businesses is still deemed limited. It is therefore recommended to:

- **Introduce targeted education and training programmes for government and industry leaders.** The circular economy is increasingly gaining traction among academics and researchers; however, an industry transition to circularity also requires knowledge, awareness, and interest from political, industry, and business leaders. These types of programmes are essential to envision and implement new, different production and consumption processes and innovative business models. This can also increase businesses' demand for graduates with skills and competencies related specifically to the circular economy, and not those generally related to environmental protection. Moreover, these can also promote collaboration as a core guiding principle for advancing circularity across Lithuania's industry and all across the country.

- **Increase citizen engagement in the transition to reach set targets** to improve the uptake of proper disposal measures and better recovery volumes, for example, by expanding educational and awareness-raising programmes and supporting grassroots initiatives.

[672] Blažiene, I. & Gruževskis, B. (2017). Lithuanian trade unions: from survival skills to innovative solutions. Retrieved from: ETUI

Examples of these awareness raising measures could build on the Dutch example of their public awareness-raising campaign in January 2021 on the difference between 'use by' and 'best before' food labels, as part of their efforts to halve food waste by 2030;[673] or the Love Not Landfill campaign rolled out in the UK to recognise the value of properly separating textiles from household waste in order to retain their value in the second-hand and/or recycling markets.[674]

- **Develop and promote informational tools** to create and raise societal and business awareness and knowledge regarding circularity, sustainability and environmental protection across the country. Comprehensive and contextualised coverage across all regions can also strengthen education regarding these themes in rural and relatively isolated communities.
- **Review innovation policies to make sure they also tackle social and organisational dimensions**. Since sociocultural transformation is key to shaping and transforming personal habits, consumer choices and the cultural mindset, innovation policies ought to go beyond technological innovation and encompass broader social, organisational and cultural innovations.
- **Further support other forms of education such as workplace training or reskilling** and extra-curricular education via policies that facilitate the necessary adjustments and transition of roles for workers within the circular economy. This will be especially important for workers in legacy industries, as 85% of companies participating in the Emissions Trading Scheme (EU ETS) account for the largest share of emissions. These companies directly and indirectly create 25,000 jobs across Lithuania's regions. While some traditional industries have current technological ceilings to reduce their pollution levels, a shift to renewable and regenerative industries will also require reskilling of the workforce as they transition into different sectors and roles.

7.6 Who should take on these recommendations?

The policy recommendations given above tackle diverse competence areas that are materialised through the work of different ministries, government institutions and agencies. The Ministry of Economy and Innovation (EIMIN) has taken a leading role in coordinating the transformation of industry towards a circular economy, in the current absence of a national circular economy action plan and agenda for the country. Nevertheless, the responsibilities of EIMIN for policy implementation are related to competitiveness and productivity. Therefore, recommendations above tackling incentives and taxation measures that reduce market risks for industry, as well as the promotion and handling of green investments to promote the circular economy amongst private and public industry

[673] Food Tank. (2021). The Netherlands Launches Public Awareness Campaign to Reduce Food Waste. Retrieved from: Food Tank website
[674] Love Not Landfill. (n.d.). About us. Retrieved from: lovenotlandfill.org

partners will fall under the scope of EIMIN's work. Additionally, substantial focus should be placed by this ministry on the promotion and implementation of technologies and infrastructure that can support the work of the Ministry of Environment in terms of waste management and regulation, as well as the Ministry of Energy in terms of renewable and more efficient energy use.

Finally, as the leading actor in the coordination of the creation of the Roadmap for the Lithuanian industrial transition to circularity, and together with the National Industry Digitalisation Platform, *Pramonė 4.0* (Industry 4.0) stakeholders, these working groups will have a key role in building consensus towards the development and later implementation of the Roadmap and its key focus areas. This will include coordination, dialogue and alignment with additional ministries such as the Ministry of the Interior and the Ministry of Agriculture for the contextualisation of these policies, ensuring relevance across all Lithuanian regions. Dialogue with the private sector will be key to ensuring the receptivity of policies to embed any promoted innovations, as well as with scientific institutions, academia and civil society, to ensure a just industrial transition that takes existing local talent into account, as well as future skills and competencies development amongst current and future generations of workers.

7.7 Moving forward: from the recommendations to the roadmap

The challenge ahead—for Lithuania to create the Roadmap for Lithuania's industrial transition to a Circular Economy—presents a substantial opportunity for all the major stakeholders, representatives of the public sector, science and academia, as well as the business community, to commence a dialogue on the direction that the country will take for its future industrial policy. The *Pramonė 4.0* platform will provide a space for collective leadership to be practised and consensus to be built, utilising an inclusive and transparent approach to policy making. Nevertheless, building the Roadmap will require a phased approach, such as the one suggested below:

Phase one: Setting the goals

A definition of clear goals is agreed upon by all stakeholders. These goals are concise, tackle the core of the current issues for the industrial transformation, and have a defined timeline (and possibly intermediate milestones). They also present clear outcomes that show the benefits to society and nature, as well as identify underpinning parameters of change needed. An example of how these goals are set can be found in the *Dutch Transition Agendas* for the selected five key sectors of the economy in the Netherlands.[675]

Phase two: Deciding upon development directions to reach the goals

A decision is to be made upon the direction of the developments and focus sectors that will be covered within the Roadmap, that will make the most impact towards achieving the goals set. From the analysis

[675] Holland Circular Hotspot. (2018). All transition agendas now available in English. Retrieved from: HCH website

conducted by Circle Economy, relevant information on the current state of circularity of the Lithuanian Industry can be found throughout the report (for instance, in the Material Flow Analysis and Opportunity Analysis) that will support the dialogue surrounding the formation of the key development directions for Lithuania's industrial transformation.

Phase three: Assigning clear tasks and responsibilities

To lead the implementation of the Roadmap in the different focus areas or development directions agreed upon, it is essential that the different Ministries, government agencies and supporting organisations take up clear responsibilities for the diverse activities and commitments foreseen in the Roadmap, including implementation and funding, as well as monitoring responsibilities. An example of the assignment of responsibilities per commitment in a circular economy roadmap can be found in the recently launched *Finish Strategic Programme for Circular Economy* where key responsible actors as well as supporting actors are assigned to each commitment.[676]

[676] Ministry of the Environment of Finland. (2021). Government resolution on the strategic programme for circular economy. Retrieved from: ym.fi

8. Conclusion

Lithuania's power to transform its economy through industry. Lithuania's economy is just 3.3% circular—but the nation has the potential for transformation: fulfilling its needs and wants while ensuring materials are kept in use for as long as possible and cycled at the end of their functional lifetimes. This study provides a first approximation of how resource use is allocated across Lithuania's economy, complemented by an analysis of the policy landscape across the EU supporting its transition, and a deep-dive into 15 industry-based opportunities for circularity.

Lithuania, with a small, mostly urban population of 2.8 million, has a fast-growing and largely linear economy: it is characterised by a high level of imports and is export-oriented, specialising in low-mid value industrial processes, especially for manufacturing. While its material footprint—30 tonnes per capita—is relatively high, the nation is well poised to join the EU in its circular efforts and redirect its trajectory, beginning with the prominent hotspot of industry.

Focusing on key sectors, this report applies a diagnostic lens to identify where the most fruitful opportunities for circularity lie: from the metabolism analysis, five sectors with tangible potential for impact were determined: food and agriculture, construction, textiles, plastics and packaging, and furniture. By applying strategies across these sectors, Lithuanian industry can overhaul its practices, taking steps toward a more resource-efficient, circular future.

From opportunity to reality: tangible recommendations moving forward. The potential for transformation of the Lithuanian economy is there—but it will require multi-level engagement from government, business and society to realise. Taking into account country- and Europe-specific barriers, our recommendations span the realms of governance, law, culture, the economy and technology. A focus on shifting production practices through increasing industrial symbiosis and fiscal (dis)incentives is paramount, coupled with demand-driving actions that will create a market pull for circularity, including Green Public Procurement and Extended Producer Responsibility.

Countries are critical change agents: Lithuania is ready to be a European circularity leader. While the country has a ways to go in closing its Circularity Gap, it is well poised to take on this task: it is cited as a recycling champion in Europe and has the right infrastructure and impetus to take on the new challenges circularity poses. Lithuania is operating in a world that is only 8.6% circular—but has huge potential for impact: our *Circularity Gap Report 2021*[677] found that circular interventions could reduce emissions by nearly ten billion tonnes applied across high-income, high-consumption nations like Lithuania. As an export-oriented economy, dependent on trade, the country has the opportunity to ensure the resources and goods it produces are managed in a circular manner—contributing to the journey towards a circular Europe.

[677] Circle Economy. (2021). The circularity gap report 2021. Amsterdam. Retrieved from: CGRi Website

Appendix: Survey Respondents

Summary of Participants

In total we had 75 participants across our chosen sectors. A third or participants didn't indicate their sector, we have 17% from Construction and 10% from Food, Water. Otherwise we had a range of survey responses across the other sectors, with very few responses from BioPharmaceuticals and Electronics sectors.

1.1 Which sector do you operate in?	Count	*Proportion*
Forestry and Wood Products	3	*4%*
Textiles and Apparel	6	*8%*
Furniture	6	*8%*
Construction and Construction Materials	13	*17%*
Chemicals (including Plastic and Plastic Packaging)	6	*8%*
BioPharmaceuticals	2	*3%*
Electronics and Electrotechnics	1	*1%*
Food, Water and Nutrients	10	*13%*
Batteries and Vehicles, and Disassembly of Vehicles	4	*5%*
Unspecified	24	*32%*
	75	*100%*

The participants surveyed represented 45% microenterprises, 41% from SMEs, with 10 responses from large companies.

1.2 What size is your company??	Count	*Proportion*
Small and Microenterprise: less than 50 employees	34	*45%*
Medium: from 50 but less than 250 employees	31	*41%*
Large: greater than 250 employees	10	*13%*
	75	*100%*

The majority of participants (76%) indicate a moderate to above average knowledge of circular economy.

1.3 Please rate your own knowledge of circular economy (self assessment)	Count	Proportion
very low - 1	7	*9%*
2	11	*15%*
3	28	*37%*
4	24	*32%*
very high -5	5	*7%*
Average	3.12	
Count responses	**75**	