Project: 101081833 – BIOTRANSFORM – HORIZON - CSA

Ref. Ares(2024)4320093 - 14/06/2024

BIOTRANSFORM

TRANSITION PATHWAYS TO CIRCULAR BIO-ECONOMY

Circular BIOeconomy TRANSFORMation for regions by enabling resource and governance networks

D1.2: Report on current status of development of EU regional circular bioeconomies

PROJECT ACRONYM: BIOTRANSFORM

PROGRAMME: HORIZON Europe

Grant Agreement: No 101081833

TYPE OF ACTION: HORIZON-CSA

START DATE: 1 October 2022

DURATION: 30 months

Funded by the European Union

Document Information

Issued by:	BIOEAST HUB CZ
Issue date:	29/06/2023
Due date:	31/05/2023
Work package leader:	HUB
Start date:	1/10/2022
Dissemination level:	Public

Document History

Version	Date	Modifications made by
V0.1	31/05/2023	Document shared with partners for comments and feedback
V0.2	14/06/2023	Document shared to quality reviewers for feedback
V0.3	26/06/2023	Final Deliverable shared with Coordinator
V2.0	06/06/2024	Revised and quality reviewed version shared with Coordinator
V3.0	13/06/2024	Revised and sent to coordinator for re-submision

Authors

Contributors of D1.2

First Name	Last Name	Organization
Anastasia	Perouli	BIOEAST HUB CZ
Marie	Kubankova	BIOEAST HUB CZ
George	Sakellaris	BIOEAST HUB CZ

In case you want any additional information, or you want to consult with the authors of this document, please send your inquiries to: Perouli.anastasia10@gmail.com

Quality Reviewers

First Name	Last Name	Beneficiary	Remarks
Anna	Chrysafi	Q-PLAN INTERNATIONAL	Quality reviewer in 2023 and 2024
Jussi	Lahtinen	VTT	Quality reviewer in 2023
Kirsi	Kataja	VTT	Quality reviewer in 2024

Disclaimer

Funded by the European Union under GA no. 101081833. Views and opinions expressed are however those of the authors only and do not necessarily reflect those of the European Union or REA. Neither the European Union nor the granting authority can be held responsible for them.

Contents

Figures

List of Tables

List of Terms and Definitions

Table 1: List of Terms and Definitions

ABBREVIATION	FULL NAME
ACBS	Andalusian Circular Bioeoconomy Strategy
ALCN	Alchemia Nova
ANDALTEC	Plastic Technological Centre
CBE	Circular Bioeconomy
CEFIC	Cefic is the European Chemical Industry Council
CETAQUA	Water Technology Centre
CIRCE	CIRCE Technology Center
CLIB	Club Industrielle Biotechnologie
CluBE	CluBE-Cluster of Bioeconomy and Environment of Western Macedonia
CTA	Technological Corporation of Andalusia
CSIC	Spanish National Research Council
DEI	Public Power Corporation
ECCSEL ERIC	European Carbon Dioxide Capture and Storage Laboratory Infrastructure
ELY Center	Centre for Economic Development, Transport and the Environment
EMPHASIS	The European Infrastructure for Multi-scale Plant Phenomics and Simulation
ERDF	European Regional Development Fund
EU	European Union
EU IBISBA	European Industrial Biotechnology Innovation and Synthetic Biology Accelerator
GDP	Gross Domestic Product
HUB	Historically Underutilized Business
HUB	BIOEAST HUB

IFAPA	Andalusian Institute for Research and Training in Agriculture, Fisheries, Foods and Organic Production
JTF OP	Just Transition Fund Operational Program
KARP	Business Development Agency
LAG	Local Action Group
LEADER	Liaisons among actors in the rural economy
MSW	Municipal Solid Waste
MSWOF	Municipal Solid Waste Organic Fraction
NGO	Non-governmental Organizations
NRW	North Rhine-Westphalia
OP	Operational Program
PEF	polyethylene furanoate
PET	Polyethylene terephthalate
PNO	PNO Group
R&D	Research & Development
RDI	Research, Development & Innovation
RES	Renewable Energy Sources
RIS3	Regional Innovation Strategy
SDGs	Sustainable Development Goals
SMEs	Small and medium-sized enterprises
TECNOVA	Research Centre related to agribusiness
TM	Transition Management
UN	United Nations
VTT	VTT Technical Research Centre of Finland
WP	Working Package
ZRR	Zukunftsagentur Rheinisches Revier

Executive Summary

The current report (Deliverable 1.2. of the BIOTRANSFORM project), provides a map of the current status of circular Bioeconomy (hereinafter referred as “CBE”) as long as the challenges and potential for 6 European case study regions with different levels of CBE integration. This is a substantial element in indicating pathways for CBE transformation by comparing regions facing similar challenges with successful examples from the EU area always by taking into consideration the local limitations. Further on, this report establishes steps on how this information will be evaluated and includes key steps and considerations for setting up: effective screenings of current and potential policy measures, and investigations on measures aiding the circular bio-based transition growth and influence in each region, and steps to include the citizenry both in knowledge (awareness) and in co-development of solutions.

The methodology for the conduction of this analysis was based on executive studies in six different regions of Europe. For each region were considered policy, environmental, social and economic criteria as well as the specific attitudes for the related stakeholders. To understand the regional contexts, it is imperative to gather information on the regions that have an impact on the transition to the circular operations as well as collection and assessment of good practices and case studies in these practices and in governance and policies in general. As it was expected a substantial diversification was detected amongst the examined regions, reflecting a wide spectrum of needs and priorities. Additionally, to the regional analysis, the opinion of policy makers and related stakeholders for each region were collected through organized info-days. During these events, key issues were identified, considering local capacities, opportunities, barriers, potentials, responsiveness, reflecting specific characteristics for each region and highlighting elements for actions and possible mitigations.

Further on, information for circular Bioeconomy transformation were searched in literature (in particular peer reviewed journal such as Sustainability, Sustainable Production and Consumption, New Biotechnology, or Journal of Clean Production) and transferred into the following criteria for regional analysis: (i) policy measures assisting circular Bioeconomy transition (ii) existing technologies, (iii) biomass residues and (iv) existing gaps (you may refer to Chapter 1 for more details). These topics were first analyzed using a desk research method, the preliminary results were consequently discussed and completed on the info days (Task 1.5.).

The chapters 3 & 4 of this deliverable is summarizing the results of the desk research analysis. The feedback of the info-days is provided in the Chapter 5, Chapter 6 contains the conclusions. Literature research brought several interesting examples of Bioeconomy transformation from other EU regions, the findings are provided in Chapter 3. The primary data from desk research results provided by project partners are summarized in D1.2 Annex.

The overall information of this document will serve as the basis for the comparative analysis of the benefits of a transition from linear fossil-based economies to circular bio-based systems and consequently help to: assess the impact of the Bioeconomy transition in WP2, and enhance the participatory approach to co-design the transition with stakeholders.

This deliverable, focusing on the analysis and the evaluation of circular bio-based transition pathways across regions in Europe substantially contributes to the strategic objective of the BIOTRANSFORM project, which is to support policymakers in enabling the transition from linear fossil-based value

chains to circular bio-based systems across the EU. Consequently, this approach will contribute to the establishment of the innovative governance models. A key factor in this perspective is a well informed and documented decision-making processes, social engagement of all actors and uptake of sustainable innovations in Bioeconomy. Co-creation and a systemic approach are key to ensure this collaboration between the various actors involved to reach a tailor-made pathway of transition that is effective in a particular region.

1. Introduction

The present report aims to establish steps on circular bioeconomy information collection and evaluation, under certain KPIs. Furthermore, it will include important steps and factors to take into consideration for achieving: effective investigation of existing and potential strategies and policy measures at regional, national and local levels, pathways and conversion rates from biomass or residues to final products, identification of measures assisting and influencing the circular bio-based transition growth in each region, ways to enhance peer-to-peer learning across Europe, to raise citizens awareness and to enhance stakeholder inclusion in co-development of solutions. The information acquired will become the basis for the comparative analysis that will showcase the transition benefits from linear fossil-based economies to circular bio-based systems.

Starting to build steps for information collection according to literature, in the context of sustainable development, transitions are defined as a shift in socio-technical systems that requires a fundamental re-orientation of societal development, which involve a wide set of changes and interlinked transformations in markets, state, society, science, and technology. and their relations[1]. The theoretical frameworks frequently originate from the research field of innovation studies. According to Smith et al. 2010[2], the perspective of innovation research helps us to understand the emergence of more sustainable production and consumption practices and formulate recommendations for a shift away from unsustainable alternatives. Biological resources currently play an indispensable role in addressing global challenges and are part of many sectors of the economy (Efken et al., 2016)[3], advances in industrial biotechnology offer the potential for new materials, chemicals and new sources of energy to replace fossil resources (Bracco et al., 2018)[4]. The Bioeconomy Strategy was introduced by the European Commission a decade ago. Through the revision in 2018 it was updated, putting more emphasis on food sustainability and security, reducing dependence on non-renewable resources and the need for sustainable management of natural resources. Considering the current challenges these measures seem to be of importance as the war in Europe and the interconnected

[1] Grin, J.; Rotmans, J.; Schot, J. *Transitions to Sustainable Development. New Directions in the Study of Long Term Transformative Change*, 1st ed.; Routledge: New York, NY, USA; London, UK, 2010.
[2] Smith, A.; Voß, J.P.; Grin, J. Innovation studies and sustainability transitions. The allure of the multi-level perspective and its challenges. *Res. Policy* 2010, *39*, 435–448
[3] Efken, Josef & Dirksmeyer, Walter & Kreins, Peter & Knecht, Marius. (2016). Measuring the importance of the bioeconomy in Germany: Concept and illustration. NJAS - Wageningen Journal of Life Sciences. 77. 10.1016/j.njas.2016.03.008.
[4] Bracco, S.; Calicioglu, O.; Gomez San Juan, M.; Flammini, A. Assessing the Contribution of Bioeconomy to the Total Economy: A Review of National Frameworks. Sustainability 2018, 10, 1698. https://doi.org/10.3390/su10061698

security, energy and food crises, COVID-19 and also the climate crisis. The need to transform Europe's economy into a more sustainable, safer and less environmentally damaging system is emphasized in most of the new European strategies; bioeconomy is generally understood as a tool to enable this transition. However, when addressing a sustainability transition, there is a need to extend this perspective of innovation studies. The technological knowledge must be accompanied by instruction in other types of knowledge, particularly the transformative knowledge necessary to equip the protagonists of a bioeconomy transformation. In general, research into sustainable development requires a change in the objective of studies from a focus on the successful emergence of cleaner technologies to a rather far-reaching change to the entire production and consumption system. Such contributions often follow the objective to promote the applicability of conceptual approaches to assess policies or identify possible interventions by analyzing system dynamics and related barriers to system transformation as a basis for identifying ways of overcoming these barriers. For this purpose, a reflection on the conceptualization of problems is especially important, as different classifications of problems could lead to confusion among political decision-makers.[5]

Kemp et al., 1998[6] observed transitions through Multi-Level Perspectives emphasize the three analytical levels: niches, regimes, and landscapes. Regimes are considered structures that account for the stability of an existing system and “refers to the semi-coherent set of rules that orient and coordinate the activities of the social groups that reproduce the various elements of socio-technical systems". It is argued that the influence of structures varies depending on their degree of institutionalization. The concept of path-dependency often serves as a conceptual basis for understanding barriers. Regarding carbon-saving technologies, it is argued that “industrial economies have become locked into fossil fuel-based technological systems through a path-dependent process driven by technological and institutional increasing returns to scale”[7]. However, to analyze transition failures in relation to regime stability, studies go beyond the observation of the corporate aspects of path dependency by emphasizing mechanisms, such as barriers linked to the existence of dominant business models. Strategic Niche Management (emphasizes so-called socio-technical niches that serve as “local breeding spaces for new technologies, in which they get a chance to develop and grow”. Important elements for niche development are expectations and visions, social networks, and learning processes. In this perspective, scholars observe various interacting factors that could impede transitions, such as barriers related to production, demand, government policy and regulatory frameworks, culture, or infrastructure[8].

Transition Management (hereinafter refer as “TM”, Rothams et al., 2001[9]) is used to better coordinate and legitimize policy and mobilize capacities to solve problems. Transition Management experts focus on a transition arena and all stakeholders within this area and strongly emphasize visions affecting change. From a TM perspective, they result advantages of an operational model called transition management cycle, which includes the capacity to (i) structure the problem and establish the transition

[5] Alexandra Gottinger, Luana Ladu & Rainer Quitzow (2021): Studying the Transition towards a Circular Bioeconomy—A Systematic Literature Review on Transition Studies and Existing Barriers: Sustainability, 10(21) 17-27

[6] Rip, A.; Kemp, R. (Eds.) *Technological Change*; Battelle Press: Columbus, OH, Canada, 1998.

[7] Unruh, G.C. Understanding carbon lock-in. *Energy Policy* 2000, *28*, 817–830.

[8] Kemp, R.; Schot, J.; Hoogma, R. Regime shifts to sustainability through processes of niche formation. The approach of strategic niche management. *Technol. Anal. Strateg. Manag.* 1998, *10*, 175–198.

[9] Rotmans, J.; Kemp, R.; Van Asselt, M. More evolution than revolution. Transition management in public policy. *Foresight* **2001**, *3*, 15–31.

arena, (ii) develop a transition agenda and images, (iii) carry out transition experiments, and (iv) evaluate the experiment, Lovec & Juvančič (2021)[10]; Van de Brugge & van Raak (2007)[11].

Based on the above scientific studies, the report follows the logic sequence of problem structuring and identification for each region (based on the findings of regional desk research conducted by the project partners), building the transition arena based on the strengths and weaknesses of each region based on specific KPIs [(i) policy strategies and measures assisting circular Bioeconomy transitions to (ii) existing technologies, (iii) biomass residues and (iv) existing gaps]. The analysis provides characteristic findings about the status quo that enhance peer-to-peer learning across different European regions while the involvement of local actors during the conducted info days and interviews set an example of including the citizenry both in knowledge (awareness) and in co-development of solutions. The information obtained will serve as the basis for the comparative analysis of the benefits of a transition from linear fossil-based economies to circular bio-based systems that will be addressed in following working packages in more detail. It is worth highlighting that due to each region's specificities, an effective comparison of the strategic plans is difficult to be conducted. The local strategies address different issues and needs for each region which are already in different stages of their transition. The differences in the regions work exactly as a representative display of how transition looks like in practice: from the EU and UN directions, to the national strategies and how these translate or apply to the regional level. Therefore, this document approaches each region through its unique perspective in order to provide guidance for the following WPs, on the strengths, weaknesses and opportunities offered by each region. In terms of comparison, this is only used in a qualitative way to highlight similarities and differences when these are identified between the regions.

2.Methodology

The methodology that was followed targeted the wider strategic objective of the BIOTRANSFORM project; to support policymakers in enabling the transition from linear fossil-based value chains to circular bio-based systems across the EU. The results will provide a comprehensive methodology towards an EU-wide transition, tailored to policymakers. This approach should contribute to the establishment of innovative governance models. A key factor in this perspective is a well informed and documented decision-making processes, social engagement of all actors and uptake of sustainable innovations in Bioeconomy. Co-creation and a systemic approach are key to ensure this collaboration between the various actors involved to reach a tailor-made pathway of transition that is effective in a particular region.

Key Methodology steps

The methodology followed to conduct the current analysis consists of three steps:

First, enables for circular bioeconomy transformation were selected based on literature (in particular peer reviewed journal such as *Sustainability, Sustainable Production and Consumption*, *New*

[10] Loorbach, D. Transition management. In *New Mode of Governance for Sustainable Development: Nieuwe Vorm Van Governance Voor Duurzame Ontwikkeling = Transitiemanagement*; Erasmus University Rotterdam: Rotterdam, The Netherlands, 2007.
[11] Van der Brugge, R.; van Raak, R. Facing the adaptive management challenge: Insights from transition management. *Ecol. Soc.* **2007**, *12*, 33.

Biotechnology, or *Journal of Clean Production*) to gather information about local circular bioeconomy status, enablers and existing gaps. These enablers were then transferred into the four following criteria used for regional analysis: (i) policy measures assisting circular Bioeconomy transitions to (ii) existing technologies, (iii) biomass residues and (iv) existing gaps (please refer to Chapter 4 for more details).

Second, based on these criteria the desk research methodology was followed by responsible project partners (i.e., regional representatives) to gather information on the current status of the circular bio-based transitions in 6 EU regions that will provide the baseline references to draft transition routes in WP3. Chapter 4 summarizes the results of the desk research analysis. The primary data from desk research results provided by project partners are summarized in D1.2 Annex.

Third, for each of the 6 case-study regions, responsible partners organized dedicated Info Days and semi-structured interviews with relevant key policymakers and other stakeholders like experts, regional authorities, etc. (Task 1.5.). The purpose of the conduction of these interviews and surveys was to involve key regional stakeholders in the identification of major policy challenges and solutions and to have a better understanding of the needs and level of detail that politicians and public officers need to design effective transition Policies. Stakeholders' feedback is summarized in Chapter 5.

The above three-step approach that was used for the comparative analysis was also enriched with additional case studies and scientific literature to reach solid conclusions. Further literature research revealed several interesting examples of bioeconomy transformation from other EU regions, these findings are provided in Chapter 4.7.

The information acquired in the present report (Chapter 6) is providing the conclusions) will serve as the basis for the comparative analysis of the benefits of a transition from linear fossil-based economies to circular bio-based systems and consequently help to: assess the impact of the Bioeconomy transition in WP2, and enhance the participatory approach to co-design the transition with stakeholders.

3.Circular bio-based transition

Bioeconomy is based on new, more efficient ways of using biomass and new biological processes and innovations (McCormick and Kautto, 2013)[12]. Bioeconomy can enable economic growth that does not lead to environmental degradation (Schmid et al., 2012)[13] and can be circular and sustainable (Ronzon and Sanjuan, 2019)[14]. Bioeconomy can therefore make an important contribution to a

[12] Mccormick, Kes & Kautto, Niina. (2013). The Bioeconomy in Europe: An Overview. Sustainability. 5. 2589-2608. 10.3390/su5062589.
[13] Schmidt, O., Padel, S., & Levidow, L. (2012). The Bio-Economy Concept and Knowledge Base in a Public Goods and Farmer Perspective. Bio-Based and Applied Economics, 1(1), 47–63. https://doi.org/10.13128/BAE-10770
[14] Ronzon, Tévécia & Sanjuán, Ana. (2019). Friends or foes? A compatibility assessment of bioeconomy-related Sustainable Development Goals for European policy coherence. Journal of Cleaner Production. 254. 119832. 10.1016/j.jclepro.2019.119832.

sustainable, climate-neutral economy. Bioeconomy is also an important part of a circular economy, providing a non-fossil source for carbon. The transition towards a sustainable CBE does require specific conditions; the transition should be enabled by sustainable development principles and political willingness to adopt those principles in regional policies.

3.1 Transitional pathways towards bioeconomy

To project the potential transition in a schematic and comprehensive way, Lovec & Juvančič (2018)[15] built upon and upgraded Dietz et al. (2018)[16] and described five interrelated, yet distinct transitional pathways towards bioeconomy. (Figure 1).

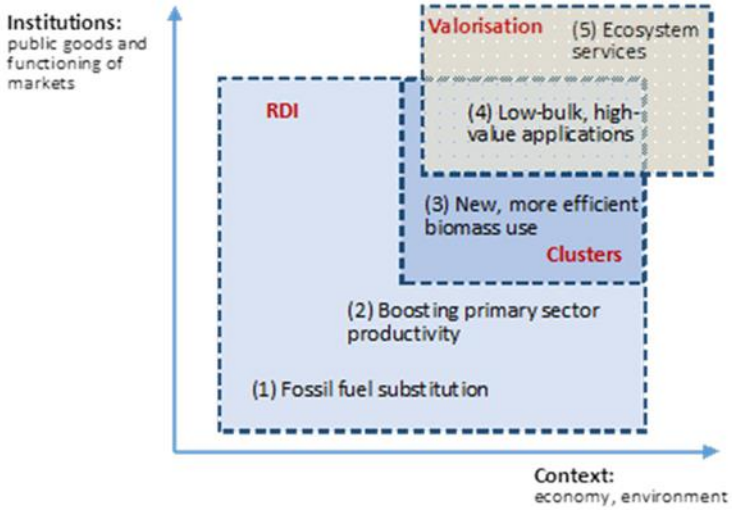

Figure 1: Contexts (axes), specific drives (in bold), and transition pathways (1-5)

The first way (1) involves the substitution of non-renewables as a source of energy. The second, (2) is related to primary sector growth which, in developing countries, is often related to transitioning, monocultures, extreme natural resource extraction, modernization resulting in environmental degradation. The third pathway (3) involves more effective, alternative uses of biomass that include side streams and waste, both in conservative and new bioindustries, supply side mobilization and innovation downstream, biorefining, new cost-efficient technologies, and increases in added value through bioindustry, including through market demand. The fourth way (4) is the development of low-bulk, high-value applications and processes based on biological values independent of biomass streams, such as cheaper and environmentally friendlier methods and processes, new products, products with improved functionality, advanced solutions, the broad application of biological principles, and the complex interface of value chains (e.g., between food and health). To this, we add

[15] Lovec,M.;Juvančič ,L.The Role of Industrial Revival in Untapping the Bioeconomy's Potential in Central and Eastern Europe. Energies 2021, 14, 8405. https://doi.org/10.3390/en14248405
[16] Dietz, T.; Börner, J.; Förster, J.J.; von Braun, J. Governance of the Bioeconomy: A Global Comparative Study of National Bioeconomy Strategies. Sustainability 2018, 10, 3190.

the fifth (5) pathway based on the valorization of non- commodity aspects such as ecosystem services through public and private activity Brouwer et al (2018)[17].

3.2 Transformation Enablers

Gottiger et. al. (2021) [18] named enablers for transformation, that can form an "upper layer" of the coding system – in other words, broader categories as indicated in Table 2 - and indicate clusters of thematic sub-categories, specifically:

1. policy and governance
2. biomass
3. technology
4. human factor

Salvador et al. (2022)[19] specified enablers for regional CBE systems in Europe in more detail, such as governmental support through financial incentives for R&D, taxes as penalty on fossil-based resources compared to waste streams or standardization for environmental assessment of circular products. Circular Bioeconomy is considered an early-stage economic development model which needs innovation to strengthen its resolve and increase its value. Experts therefore call for increased investment in R&D or policy incentives to increase the competitiveness of bioeconomy (Philp, 2018; Popescu, 2014[20]; Schütte, 2018[21]). Bioeconomy innovations are often mentioned and considered as one of the most important drivers of the transformation to sustainable development. The role of the fourth layer human capital is essential in extending the biomass processing chain, highly educated farmers will be more willing to invest and participate in innovations of biomass processing technology (Jiang et al., 2018)[22], there is a need for raising awareness for farmers to recognize these innovations as being beneficial not only for the environment, but also for themselves Mikielewicz et al. (2020)[23] .

[17] Brouwer, F.; Mantino, F.; Polman, N.; Short, C.; Sterly, S.; Rac, I. Private Sector Actions to Valorise Public Benefits from Agriculture and Forestry. EuroChoices 2018, 17, 16–22

[18] Alexandra Gottinger, Luana Ladu & Rainer Quitzow (2021): Studying the Transition towards a Circular Bioeconomy—A Systematic Literature Review on Transition Studies and Existing Barriers: Sustainability, 10(21) 17-27

[19] Rodrigo Salvador, Murillo Vetroni Barros, Mechthild Donner, Paulo Brito, Anthony Halog, Antonio C. De Francisco, How to advance regional circular bioeconomy systems? Identifying barriers, challenges, drivers, and opportunities, Sustainable Production and Consumption,Vol. 32, 2022, 248-269, ISSN 2352-5509, https://doi.org/10.1016/j.spc.2022.04.025.

[20] Popescu, I., 2014. Industrial biotechnology in the European union: identifying the best pathways to boost growth of the bioeconomy. Industrial Biotechnology 10, 376e378. https://doi.org/10.1089/ind.2014.1537.

[21] Schütte, G. (2018) What kind of innovation policy does the bioeconomy need? New Biotechnology, 40, 82–86.
Philp, J., 2018. The bioeconomy, the challenge of the century for policy makers. N. Biotechnol., 40, 11-19. https://doi.org/10.1016/j.nbt.2017.04.004

[22] Jiang, L.; Zhang, J.; Wang, H.H.; Zhang, L.; He, K. The impact of psychological factors on farmers' intentions to reuse agricultural biomass waste for carbon emission abatement. J. Clean. Prod. 2018, 189, 797–804.

[23] Mikielewicz, D.; Dąbrowski, P.; Bochniak, R.; Gołąbek, A. Current Status, Barriers and Development Perspectives for Circular Bioeconomy in Polish South Baltic Area. Sustainability 2020, 12, 9155. https://doi.org/10.3390/su12219155

Likewise Andersen et al. (2022)[24] highlighted the need for alignment between resources for innovation and upscaling and the positive climate for innovation and willingness of stakeholders to get involved; the regional innovation paradox, '*the mismatch between the large need for innovation in structurally weak regions and their low absorptive capacity to use innovation funds'* is also articulated in the EU *Bioeconomy Development in EU* Regions study[25]

Price-conscious customers may not be willing to pay a premium for switching to circular bio-based products such as refurbished, recycled, or remanufactured products, which are perceived to have lower quality and face value when compared to brand-new products Roy et al. (2022)[26]; this could be explained by low awareness but also as a lack of standardization in the adoption of circular bioeconomy practices regarding processes, activities, and materials across industries and sectors (Salvator et al., 2002)[27].

The following table summarizes enablers and clusters them thematically according to the above indicated upper layers.

Table 2: Transition enablers

Information retrieved by Gottiger et. al. (2021) 28, Mikielewicz et al. (2020)29, Salvador et al. (2022)30 and adapted.

Upper layer	Sub categories
Policy and Governance	-Favorable public policies, financial incentives,

[24] Andersen, M.S.; Christensen, L.D.; Donner-Amnell, J.; Eikeland, P.O.; Hedeler, B.; Hildingsson, R.; Johansson, B.; Khan, J.; Kronsell, A.; Inderberg, T.H.J.; et al. To facilitate a fair bioeconomy transition, stronger regional-level linkages are needed. Bio-fuels, Bioprod. Biorefining 2022, 16, 929–941. https://doi.org/10.1002/bbb.2363 .

[25] European Commission, Bioeconomy Development in EU Regions. European Commission, Brussels (2017).
[26] Tarun Roy, Jose Arturo Garza-Reyes, Vikas Kumar, Anil Kumar, Rohit Agrawal, Redesigning traditional linear supply chains into circular supply chains–A study into its challenges, Sustainable Production and Consumption, Volume 31, 2022, Pages 113-126, ISSN 2352-5509, https://doi.org/10.1016/j.spc.2022.02.004.

[27] Rodrigo Salvador, Murillo Vetroni Barros, Mechthild Donner, Paulo Brito, Anthony Halog, Antonio C. De Francisco, How to advance regional circular bioeconomy systems? Identifying barriers, challenges, drivers, and opportunities, Sustainable Production and Consumption,Vol. 32, 2022, 248-269, ISSN 2352-5509, https://doi.org/10.1016/j.spc.2022.04.025 Furthermore, existing indicators such as gross domestic product and industrial production will focus on the level of production and consumption based on a linear economy.
[28] Alexandra Gottinger, Luana Ladu & Rainer Quitzow (2021): Studying the Transition towards a Circular Bioeconomy—A Systematic Literature Review on Transition Studies and Existing Barriers: Sustainability, 10(21) 17-27
[29] Mikielewicz, D.; Dąbrowski, P.; Bochniak, R.; Gołąbek, A. Current Status, Barriers and Development Perspectives for Circular Bioeconomy in Polish South Baltic Area. Sustainability 2020, 12, 9155. https://doi.org/10.3390/su12219155
[30] Rodrigo Salvador, Murillo Vetroni Barros, Mechthild Donner, Paulo Brito, Anthony Halog, Antonio C. De Francisco, How to advance regional circular bioeconomy systems? Identifying barriers, challenges, drivers, and opportunities, Sustainable Production and Consumption,Vol. 32, 2022, 248-269, ISSN 2352-5509, https://doi.org/10.1016/j.spc.2022.04.025.

	-Regulation favoring environmental protection and regulatory bans -Standardization for environmental assessment of circular products
Biomass	-Competition for resources -Competition nonfood v. food sector -Availability (volume, price)
Technology	- Availability and reliability of technology - R&D capacities, knowledge transfer, eco innovation system - Infrastructure and economic barrier (fix cost)
Human Factor	-Networks -Social Perception and Acceptance -Knowledge and Education -Linear mindset

3.3. Framework for Analysis

The above identified enablers were used as basis for the BIOTRANSFORM regional case analysis for the CBE transition. The information obtained will serve as the basis for the comparative analysis of the benefits of a transition from linear fossil-based economies to circular bio-based systems. The following criteria were considered.

1) **Policy measures assisting circular bioeconomy transition** at regional and local levels - existing strategies & stakeholder networks (NGOs focused on circular bioeconomy – HUBs, clusters, platforms, synergies, associations etc.); measures assisting the circular bio-based transition growth and influence, regional plans or documents of such kind (if any exists)
2) **Existing technologies in place**, i.e.: conversion pathways including conversion rates from biomass or residues to all necessary commodities (existing network of biogas plants, composting units, renewable energy plants), a list of existing technologies.
    a. It will also be valuable to list the not-realized plans and projects of the above activities.
3) **Biomass residues** that are currently not being used to their full potential (exported from the region before being processed, biomass that can be utilized at a higher level of the biomass utilization hierarchy, geographical distribution)

4) **Existing gaps** in technology, logistics, finance, governance, regulatory constraints etc.

4.Regional Potential for CBE

The regional case studies analyzed in this document are Charles Spa Region (Czech Republic), Western Macedonia (Greece), Northern Burgenland (Austria), Finland, Andalusia (Spain), North Rhine-Westphalia (Germany). The findings were based on desk research conducted by the project partners responsible for each region as presented in the table below. The complete desk research for each region can be found in Deliverable 1.2 Annex. Regional Case Studies – Desk Research. Links leading to each respective region are also included in the table.

Table 3: Case study regions

COUNTRY	REGION	MAIN BIOECONOMY TOPICS	LEADER
Austria	Northern Burgenland	vineyards, vegetation & sludge from lake, agribusinesses	ALCN
Czech Republic	Charles Spa Region	hot springs & associated spa tourism, beverages & food production	HUB
Finland	Country level	forestry	VTT
Germany	North Rhine-Westphalia	chemical industry / biogenic side & residue streams	CLIB
Greece	Western Macedonia	decarbonisation of energy production, agriculture, mining, fur & leather	CLUBE
Spain	Andalusia	tourism, retail, transportation, underdeveloped industry, agriculture,	CTA

4.1 Case Regions

Northern Burgenland (Austria)

Northern Burgenland is located in the Eastern part of Austria and combines both mountainous forelands and few plain areas with the climatic conditions tending towards being dry and warm. Forestry is rather limited due to the low land capacity. There is a large agricultural sector, but compared to the added value of other sectors, it plays a minor role in the economy. The main economic sectors are services, tourism (strong around Lake Neusiedl), manufacturing, trade, transportation, food supply, and communication and information. The economy is characterized by a high dependence on fossil resources though there have been efforts to use renewable resources in the energy sector mostly. There is, however, a need to identify more biological resources for further exploitation with the more promising ones being household waste and lake resources, sludge. The case of Northern Burgenland is interesting because there have been great advancements to catch up with circular and sustainability solutions (indicating that there's already some relative infrastructure) although there are many limiting factors to take into consideration such as groundwater contamination, non-existing stakeholder networks and low R&D comparatively to other Austrian regions.

Charles Spa Region (Czech Republic)

Charles Spa Region is located in the Northern West part of the Czech Republic and shares the major part of its border with Germany. The area is mostly mountainous with mineral resources, mineral springs and medicinal wealth as the main assets of the region. Depending on the district, the spa and tourism industry can be a key economic activity while other districts are heavily mining and manufacturing dependent. Traditional products are glass and porcelain manufacture, building materials, textiles, and musical instruments manufacture. However, these have been slowly decreasing during the last 25 years, mainly due to their high energy demand, high demand of raw materials and human resources with the local population suffering aging, low birth rates and brain drain of young people.

Agriculture, on the other hand, is not favored neither by the geomorphology of the ground nor by the soil consistency. Only 2% of the total workforce are employed in agriculture production. Potatoes, oilseed rape and cereals (wheat, barley) are produced in the region. The livestock production segment is represented by dairy and beef cattle, poultry, and pigs.

Tracking the CBE status of the Charles Spa Region is important because it is an indicative example of a region undergoing structural economic shift from a declining non-circular, natural resource-based economy. The main challenge is to create new circular bioeconomy inspired opportunities for a region with minimum biomass potential.

Finland

Finland's forests represent the country's most significant renewable natural resource. Forests are a major source of both economic and social wellbeing for Finland. As the demand for natural resources rises, in the future Finland's timber reserves are sure to become an even more important asset.

The analysis in this report is focused on the whole country rather than a single region since Finland, as a case study, has extensively invested in developing forest biomass within the circularity framework. The country has a concrete circular bioeconomy strategy in accordance with the EU regulations, strong stakeholder engagement and is now targeting to achieve better technological innovation.

Examining the Finnish case study is interesting because it can work as an example for other regions to follow.

North Rhine-Westphalia (Germany)

North Rhine-Westphalia (NRW) is the largest and most populated state in Germany, sharing borders with The Netherlands and Belgium in the west. NRW had guidelines towards a bioeconomy strategy already in 2010, but is currently developing a roadmap towards a full bioeconomy strategy, including a state bioeconomy council. The area has a significant amount of agricultural activity, although it is not Germany's main producer. Other sources of biomass are forestry, food & feed production, waste collection, and their circular reuse today focuses largely on energy. The region is characterized by heavy mining, manufacturing and chemical activities. While mining activities are being phased out, manufacturing and the chemical sector are still strong economical drivers in the region. The transformation of the former lignite mining region, as well as transformations towards the decarbonization of other sectors will have to keep social and environmental aspects in mind.

The case study of North Rhine-Westphalia is interesting because it represents a transitioning region, with much potential and supporting mechanisms that still needs strategic improvements to manage the new CBE scenery.

Western Macedonia (Greece)

Western Macedonia is located in the northern part of Greece and is a mountainous, rural region with few urban centers and has one of the lowest GDPs in Greece. It is endowed with rich natural resources, as well as natural beauty, although the former has traditionally worked to the detriment of the latter. Major lignite deposits have turned it into the heart of Greek electricity production since the mid-20th century, causing environmental degradation and health issues to the local population.

Other manufacturing activities include traditional sectors such as marble, saffron, fruits, local wines, furs and leather manufacturing and specialized arts and crafts. In the services sector, retail and wholesale trade, tourism and public administration services are the most important value-added sectors.

Western Macedonia has participated in multiple sustainability initiatives mainly pushed by the damage caused to the natural environment throughout years of lignite mining activities and by political decisions that support transition to carbon neutral energy. The area is another interesting example of exploring alternative economic models after a violent shift from linear, lignite-based activities.

Andalusia (Spain)

Andalusia is the largest region in Spain and the most populated one. The greatest part of its economic activity stems from the service sector while agriculture is also an important economic driver for the region. Forestry, fishing, food, and paper production are also present. The energy sector is also quite strong with 51% originating from renewable resources (wind and solar energy mostly). Its intense agriculture creates opportunities for circular bioeconomy development.

The Andalusian case study is important because it’s indicative of a region with large capacities that, however, needs to make improvements on an administrative, financing and technological level to reach its full potential.

4.2 Policy Measures

Policy measures is the first criteria used to examine the regions regarding the transition to circular bioeconomy. At first, the existence and application of policy measures dedicated to bioeconomy at a regional level was examined. In particular the governance structure, existing stakeholder networks, access to funding, local assistance measures. Project partners map the (non) existence of the (macro) regional strategy (i.e., Danube, Baltic, Adriatic, Just Transition Fund, regional RIS3 strategy etc.), the (non) existence of the regional circular resp. circular bioeconomy to name a few examples. Consequently, the strategies were scrutinized to see whether and to what extent they reflect the Green Deal goals, UN SDGs, EU bioeconomy strategy or providing measures of the circular bio-based transition growth. Apart from specified regional and national strategies, this parameter seeks for specific measures that can help the transition to circular bioeconomy and that can also be replicated by other regions.

4.2.1 Governance

The Governance criteria analyze the decision-making structure for the advancement of bioeconomy in the case study regions along with the existence of established local or national circular bioeconomy strategies. All of the regions do indeed get affected or motivated to a certain extent from national and local sustainability related policies within the EU and United Nations clearly showing the desired direction. What differs, however, is the amount of proper implementation and support each region receives into making the desired transition based on the local differences and of course, the existence of well-structured and targeted circular bioeconomy policies.

Northern Burgenland (Austria)

The Austrian Bioeconomy Strategy was adopted in 2019 in alignment with UN's SDGs and the 2030 Agenda According to Europa.eu (https://knowledge4policy.ec.europa.eu/bioeconomy/bioeconomy-strategy_en), key objective was the identification of robust measures to further support growth for bio-based products, bioenergy and related technologies and services. The targeted areas are:

- Achieving the Climate Goals
- Reducing Dependence on Non-renewable Resources
- Promoting Innovation
- Promoting Economic Development
- Securing and Creating Jobs
- Promoting Sustainable Societal Transformation

The implementation of the national strategy is embedded in the government programme 2020-2024 (BKA) where in a co-creation process involving stakeholders, more than 100 measure were adopted.

Projects related to bioeconomy were grouped in several categories under the name "Flagships of the Bioeconomy".[31] (Under this categorization, current actions to achieve climate neutrality are brought to the spotlight. The Flagships are:

- Sustainable Bio-based Consumption Patterns
- Promoting and demanding the bioeconomy
- Regional value creation through the bioeconomy
- Driving innovation in renewable resource use
- Biobased circular economy
- Austrian Timber Initiative
- Understanding Ecological Guardrails of the Bioeconomy
- Awareness Raising - Knowledge Management Bioeconomy

Apart from the national directions, each region responds to the national goals differently. The province of Burgenland is divided into seven political districts and two independent cities and is governed by a

[31] https://www.bmk.gv.at/en/topics/climate-environment/climate-protection/bioeconomy/flagship-projects.html)

system of parliamentary democracy – each district being governed by an elected district assembly. The sub region of Northern Burgenland does not have its own official regional governance structure – a regional governing body is non-existent. It is, though, governed by five individual district commissions ("Bezirkshauptmannschaften"). Namely, those are (i) Eisenstadt, (ii) Eisenstadt-Umgebung, (iii) Neusiedl am See, (iv) Mattersburg and (v) Rust.

There is also a dedicated Local Action Group (LAG) specifically for Northern Burgenland that is responsible for the implementation of the LEADER funding program in the region (see more on "Funding" below). LAGs are private-public partnerships between the various socio-economic sectors of the respective region and are intended to represent the population of the region. The region of Nordburgenland has its own LAG.

In Burgenland 3 main strategy plans address sustainability (rather than bioeconomy):

- Energy Concept 2020+ (Targets: 2013: Autonomy with electric power, 2020: 50 % plus of the total energy consumption is produced renewable in Burgenland, 2050: Complete energy self-sufficiency is the goal)
- Climate and Energy Strategy 2050 (Target: reducing greenhouse gas emissions by 2050 through specific measures)
- Mobility Strategy (Target: reorganization of the region's public transport)

The above, work as tools to achieve climate neutrality and resource efficiency.

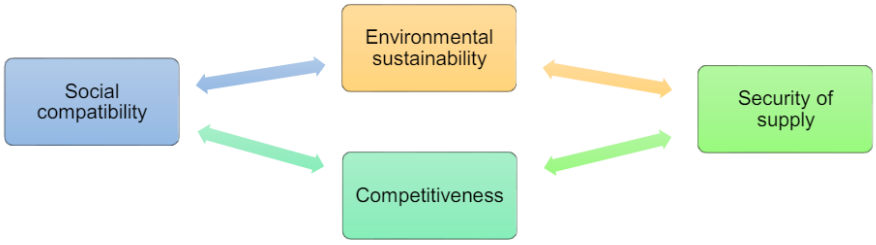

Figure 2: Main objectives of Burgenland (Burgenlandische Klima- und Energiestrategie 2050, 2020)

Figure 2 visually represents the 4 main objectives tackled in the strategy, also indicating the interlinkages. This shows that all objectives impact the business economy, for instance "environmental sustainability" includes mobility, energy, or buildings as an integral part of business resource efficiency.[32]

In Burgenland most assisting measures concern energy, greenhouse gas emissions and agriculture. Through a specified program for the region, 'Bioland Burgenland' (a smart growth programme using organic farming practices), political incentives and laws to promote the development of organic agriculture are offered (new stables can only be built when being certified organic and all municipal kitchens shall serve 100 % organic food by 2024). This 12-step program adopted in 2019 supports

[32] https://projects2014-2020.interregeurope.eu/fileadmin/user_upload/tx_tevprojects/library/file_1643379877.pdf

responsible production and consumption patterns setting a target to increase the organic production from the current (2020) 31 % to 50 % by 2027. The plans to increase the proportion of organically produced food in public kitchens, nurseries and state schools aim to support local farmers' income opportunities. In a holistic approach, the program also references the goals regarding public health, clean quality water and climate protections actions.

Charles Spa Region (Czech Republic)

According to Europa.eu The Czech Republic's National Bioeconomy Strategy is under development and aims at:

- Ensuring management of the implementation of the Bioeconomy Concept at national level
- Supporting the development of bioeconomy in the Czech Republic using international cooperation
- Strengthening technological development and innovation

There is not a dedicated ministry at a national level in the Czech Republic yet. So far, the BIOEAST HUB CZ is the only actor in the macro regional level to support bioeconomy implementation, stakeholder participation, international projects, interministerial cooperation. Therefore, the country and consecutively the Charles Spa Region do not have a dedicated Circular Bioeconomy Strategy.

The region is gradually recovering from coal mining activities while its tourism & spa industry has suffered major losses after the pandemic. A Just Transition Plan[33] is in place with the main purpose to improve the economic performance of the region, the quality of life of its residents, and to improve the environment. The plan indicates infrastructure activities, short and long term, investments in the territory and development of people's potential. The document introduces the European Green Deal, outlining national strategies (Strategic Framework, Climate Protection Policy, Innovation Strategy, National Energy and Climate Plan, Regional Development Strategy) and the regional context (Innovation Strategy, Regional Development Programme, Territorial Energy Concept, Karlovy Vary Agglomeration Strategy). The Development Program of the Region (PR KK2021-2027)[34], a mid-term document, targets among others the topic Environment, agriculture, energy with specific measures like:

- Introducing the principles of circular economy and improving waste management
- Restructuring of large combustion sources: aims to restructure the energy base, including shutting down lignite-fired sources and replacing them with natural gas, biomass or renewable sources. A sub-measure "Energy" states that the region does not have the potential to significantly employ renewable energy sources with the most promising one being biomass.
- Use of renewable and secondary energy sources, for heat and electricity when applicable

Both the Just Transition Plan and PR KK 2021-2027 are setting the frame for the transition and introduce the financial mechanism to implement this transition.

[33] https://dotaceeu.cz/getmedia/70636969-9d91-49ae-b41d-af4b5027234e/PSUT-dokument_2.pdf.aspx
[34] https://www.dataplan.info/img_upload/7bdb1584e3b8a53d337518d988763f8d/prkk21_strategicka.pdf

Despite the lack of a dedicated bioeconomy strategy thought, the Charles Spa Region has also developed a long-term regional development strategy, a strategic document that guides the development of the statutory town Charles Spa (Karlovy Vary), energy, climate, waste management and innovation related documents and plans as well as some cross border corporations on R&D with Bavaria and Saxony.

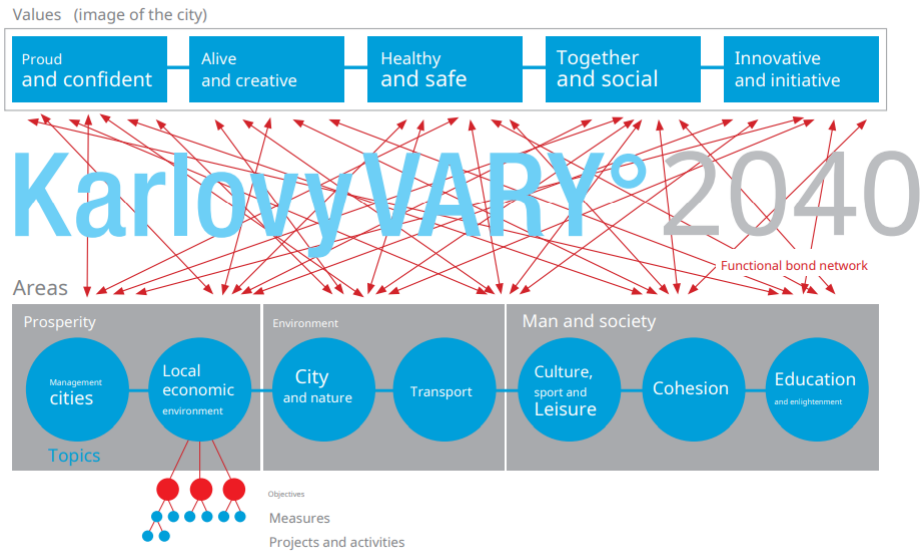

Figure 3: Figure 3 Regional Goal development for Karlovy Vary (Charles Spa)

Figure 3, retrieved from the regional development plan "KarlovyVARY°2040" showcases how the regional values translate into 3 main goal categories: Prosperity, Environment, Mankind and society. A big highlight of the development plan is social cohesion, education and innovation as means to create an attractive and prosperous economic and social environment. This is to face an aging population and brain drain. Tourism and Spa industry is also tackled as a key economic activity. The topics that are more relevant to bioeconomy and their respective targets -in parenthesis- as retrieved from the strategic document are:

Prosperity

1) City administration (Effective office/ City management/ Image of the city)
2) Local economic environment (The cooperation of the town hall and entrepreneurs/ Spa/ New challenges/ Tourism)

Environment

1) City and nature (Urbanism and architecture/ Environment, nature and landscape)
2) Transport (Public transport/ Transport and public space/ Transport connections)

Mankind and society

1) Education and awareness (School and community/ Educated and active citizens)

As for the Karlovy Vary Energy Strategy 2017-2042, it plans a gradual reduction of coal mining while increasing an energy mix for heating and electricity prioritizing efficiency throughout the production

and distribution system. More specifically, by 2020, the maximum possible deviation from the use of coal in household consumption should be ensured. Among the long-term target are identified:

Alternative resources: biomass, other renewable and secondary sources, waste in combination with other fuels for heat supply systems, nuclear power plants to heat larger agglomeration units (The localities of Brno, Jihlava, Dukovan, České Budějovice, or others in the horizon until 2030), natural gas.

Heating methods: heat pumps and solar systems to replace heating with solid fuels in households.

Air quality: In accordance with the current wording of the Air Protection Act, ensure the replacement of non-compliant boilers with manual fueling, low efficiency and high emissions, enabling the burning of waste and low-quality fuels with modern wood-gasification boilers or automatic pellet boilers.

Prioritize efficiency: Support the restructuring of energetically and economically inefficient heat supply systems wherever there is a prerequisite for achieving higher energy efficiency, higher flexibility in the use of fuels and better parameters in terms of sustainable development. Limit low-efficiency condensing electricity generation. Fully exploit special planning to increase interconnection, and make construction more efficient to facilitate processes. Support, when possible, territorial development of heat distribution to use surpluses more efficiently.

As for assisting measures, only “The Smart accelerator project” is mentioned and it alone can’t be classified as a bio-based favoring measure. The Smart accelerator project can work as a tool to enhance innovation, local business awareness, cooperation between academia and private sectors, provide incentives for local businesses, and provide a skilled workforce. Education can play a crucial role in this case, and, although no specific education related measures are mentioned, it is important to raise awareness to local decision makers to support research infrastructure, educational programs along with international vocational training to enhance cooperation and specific bioeconomy related skills.

Finland

Among the examined regions, the Finnish case is closer to a more centralized monitoring of the transition. Finland has a clear CBE strategy for its massive forestry industry taking into consideration the risks and sustainability, cascading residuals into production and always involving the local stakeholder actors in the decision making. Finland presents a rather complete strategy with a special interest to help finance and R&D innovation activities related to forestry.

More specifically, Finland’s Bioeconomy Strategy 2022–2035 aims to sustainably double the value added by the bioeconomy in ecological, social, and economic terms. It targets achieving climate neutrality by 2035 by incorporating bioeconomy practices and resource efficiency within the framework of a circular economy. Supporting green transition, the strategy is reflected on several forestry oriented strategic documents, both EU and national.

The EU Forest Strategy for 2030, part of the European Green Deal, aims to meet biodiversity objectives, reduce greenhouse gas emissions by 55% by 2030, and achieve climate neutrality by 2050. It emphasizes the multifunctional role of forests and the forest-based value chain in creating a sustainable economy and vibrant rural areas.

Finland's National Forest Strategy 2035, approved in December 2022, will be implemented from early 2024. It addresses the evolving forest sector environment and incorporates sustainable development and climate change mitigation. Developed through extensive collaboration, it aligns with various national and international strategies and focuses on the UN 2030 Sustainable Development Goals (SDGs) relevant to forestry, particularly Goals 12 (Responsible Consumption and Production), 13 (Climate Action), and 15 (Life on Land).

The Finnish Forest policy is guided by the National Forest Strategy, involving NGOs and stakeholders, and includes regional objectives through Regional Forest Programmes. The METSO programme complements this strategy by focusing on ecological sustainability in Southern Finland. The Finnish Bioeconomy. Additionally, Finland's strategic programme for a circular economy, adopted in April 2021, aims to transition the economy to circular principles by 2035, supporting the country's carbon neutrality goal.

Further information can be found at [Nordic Bioeconomy] (https://www.norden.org/en/bioeconomy) and [BSR Bioeconomy][35]

North Rhine-Westphalia (Germany)

Germany's North Rhine-Westphalia (NRW) monitors the transition on the state level. It had established the guidelines of bioeconomy strategy early in the year of 2010, which has since been rendered obsolete. A new strategy is in the process of being drafted as a multistakeholder process led by the Ministry of Economics (MWIKE). Under the new federal government, NRW's bioeconomy strategy is being updated, and a state bioeconomy council will be established.

A National Biomass Strategy (Nationale Biomassestrategie), is also soon to be published by the federal government to outline goals for sustainable biomass utilization, focusing on material use rather than bioenergy/biofuels.[36.]

On a regional level, NRW also has other strategies related to innovation, carbon management, sustainability, and local bioeconomy regions. NRW's Regional Innovation Strategy, published by the Ministry of Economy, Innovation, Digitalization, and Energy (MWIDE) in 2021, aims to solidify its status as an innovation leader.[37] While this strategy covers various aspects beyond the bioeconomy, it includes the "environmental economy and circular economy" as key areas. This involves improving resource management practices, enhancing material efficiency, recycling, and promoting closed-loop resource streams. The strategy emphasizes innovative processes, eco-design, and scaling up developed processes to facilitate industry transition and societal acceptance.[38]

In 2016, NRW developed a Sustainability Strategy, updated in 2020,[39] monitored by the state statistics office using indicators to measure success and significant changes[40] in line with the SDGs.

[35] https://s3platform.jrc.ec.europa.eu/en/w/baltic-sea-region-interregional-cooperation-on-circular-bio-economy
[36] Eckpunkte für eine Nationale Biomassestrategie (NABIS)
[37] regional Innovation Scoreboard 2019 –Publications Office of the EU (europa.eu)
[38] regionale_innovationsstrategie_des_landes_nrw, p.41; p.65. https://www.wirtschaft.nrw/sites/default/files/documents/21-0924_mwide_broschuere_regionale_innovationsstrategie_des_landes_nrw-web2.pdf
[39] https://nachhaltigkeit.nrw.de/
[40] https://www.klimaatlas.nrw.de/klima-nrw-monitoring/alle-indikatoren

Additionally, the Carbon Management Strategy (Carbon Management Strategy NRW) acts as a guideline to manage the supply and use of carbon for the local industry. The strategy includes reduction of fossil feedstocks, carbon capture solutions (CCX) and the exploitation of alternative carbon feedstocks. [41.]

The NRW Ministry of Economics and several stakeholders of the Zukunftsagentur Rheinisches Revier (ZRR) agreed on the "Reviervertrag" as a common guideline for the transition of the former lignite mining region. This agreement aligns with the European Green Deal and emphasizes resource efficiency and circularity, considering ecological, economic, and social aspects.[42] The structural change in the Rhenish mining region is being addressed through various state and regional strategies, aiming to establish the area as a leading bioeconomy region. The transition is also partly monitored on a Germany-wide level, since a National Bioeconomy Strategy is in place for Germany.

Western Macedonia (Greece)

Western Macedonia, and specifically the municipality of Kozani aims to achieve climate neutrality by 2030, aligning with the European Green Deal and commitments under the Paris Agreement. This goal places the region at the center of various strategies and plans. It is worth mentioning, though, that the region does not have a clear Circular Bioeconomy Strategy on a regional level as well as that the National Bioeconomy Strategy is under development. The region is undergoing structural economic shifts away from the lignite mining for energy production and participates in the Just Transition Fund. In the Western Macedonia case, the regional authorities have adopted multiple international and local sustainability initiatives and agreements focusing on public transportation, energy & climate, waste management, circular economy, social integration, sustainable urban development, investment on local lakes in an effort to catch up with the major structural decarbonization change for the region. As for assisting local or central measures to support the bio-based transition of the region per se, they don't seem to exist. However, diving into the regional strategies and plans, these involve:

1. Operational Program of Western Macedonia 2014-2020: Focuses on clean energy, productivity, innovation, employability, and education. Key priorities include research, ICT access, SME competitiveness, low-carbon economy, climate adaptation, resource efficiency, sustainable transport, employment, social inclusion, and education. (JTSP, 2021), (Ministry for Economic Affairs, Labour and Energy, 2019).

2. City Council's Climate Action Plan: Targets climate neutrality by 2030, following the UN 2030 Agenda and EU regulations by setting the ambitious goal to achieve in 2030 at least 100% CO2 emissions' reduction, comparing to the base year 2010. Actions to achieve this include energy savings in buildings, street lighting, residential, agricultural, and transportation sectors, increasing renewable energy, and raising public awareness. (Municipality of Kozani, 2020b), (Municipality of Kozani, 2022a)

3. Sustainable Urban Mobility Plans (SUMPs): Promote sustainable mobility, focusing on citizens' accessibility rather than vehicles, developed with local community participation. Kozani's SUMP, finalized in 2020, outlines measures over 5, 10, and 15 years and was designed with active stakeholder participation (Municipality of Kozani, 2022b).

[41] MWIDE – Carbon Management Strategie NRW
[42] Reviervertrag - Perspektiven für das Rheinische Revier

4. Covenant of Mayors: Kozani joined in 2011, committing to increase energy efficiency and renewable energy use. The updated Sustainable Energy and Climate Action Plan (SECAP) aims for 100% CO2 emissions reduction by 2030 (Municipality of Kozani, 2022b).

5. Circular Economy Action Plan (CEAP): Financed by the Green Fund, it includes regulatory arrangements, transportation management, waste management, circular entrepreneurship, circular consumption, innovation, agricultural facilities, technology actions, and infrastructure. (Municipality of Kozani, 2021)

6. Green City Accord: The Mayor of Kozani signed this accord, committing to improve air quality, water quality, urban biodiversity, waste management, and noise reduction by 2030, supporting various SDGs. (Municipality of Kozani, 2022d)

7. Western Macedonia Regional Strategies:

- Smart Specialization Strategy: Focuses on energy transition, district heating, land decontamination, and diversified energy production directly referring to the previous lignite mining acativities. (JTSP, 2021).

- Waste Management Plan (PESDA): Emphasizes land decontamination and efficient resource use. (JTSP, 2021).

- Social Integration Strategy (PESKE): Aims at social welfare, unemployment reduction, and social cohesion. (JTSP, 2021).

- Sustainable Urban Development Strategy: Promotes entrepreneurship, job creation, social protection, green development, cultural heritage, and infrastructure. (JTSP, 2021).

- Integrated Spatial Investment: Focuses on environmental protection and local economic strengthening through lake utilization. (JTSP, 2021).

Andalusia (Spain)

Spain in general has a dedicated bioeconomy strategy with the goal of enhancing competitiveness and internationalization of Spanish companies, maintaining bioeconomy as a crucial economic activity and maximizing its potential by 2030, promoting bioeconomy development, fostering interaction between public, private, science, technology, and productive sectors. (Knowledge4policy)

On the regional level, Andalusia also has a dedicated regional bioeconomy strategy (ACBS) aiming to position itself as a leader in circular bioeconomy practices. The ACBS takes into consideration multiple bioeconomy fields like sustainable growth, availability of biomass resources & processing technologies, regional development and competitiveness (products, agriculture, forestry, fishing, food, and paper production, chemical, biotechnology, and energy industries), financing, communication & awareness, cooperation & collaboration, R&D and education, infrastructure and logistics. Launched in July 2016, approved in September 2018, with a framework extending to 2030, allocates a €1.4 billion to the cause. Various management bodies are to be assembled to monitor the ACBS implementation. Regarding the Regional Innovation Strategy (RIS3), however, the implementation has proven rather inefficient due to administrational changes and misinformation. The plan was also

incomplete, missing follow-up and evaluation with a next version (RIS4) undergoing stakeholder consultation.

The strategic lines indicated by ACBS concern:

1. Sustainable Production and Biomass Availability: Actions include identifying biomass resources, developing sustainability practices, and creating an inventory of biomass users.

2. Infrastructures and Logistic Management: Focus on efficient technologies for biomass collection, storage, and use, and improving logistical infrastructures.

3. Industrial Biomass Processing: Promoting eco-innovation, feasibility studies for bioindustries, and the establishment of bioindustries in rural areas.

4. Market Development for Bioproducts and Bioenergy: Conducting market studies, promoting bioproducts and bioenergy, and analyzing environmental footprints.

Regarding special assisting measures for bioeconomy transition, Andalusia declares the implementation of the strategy through a set of four instrumental programs of a transversal nature:

1. Communication and Awareness: Developing communication plans, promoting bioproducts and bioenergy, and increasing public awareness.

2. Promoting R&D and Education: identifying research needs, supporting innovation, and including circular bioeconomy in educational curricula.

3. Access to Financing: Providing guidance on financial instruments, promoting public support, and connecting projects with investors.

4. Cooperation and Monitoring: Establishing a Cluster for Circular Bioeconomy, creating an Observatory, and forming a Monitoring Committee. In total, 17 measures and 39 actions have been defined. However, a detailed action plan has not yet been developed, so the follow-up and evaluation procedure (including the creation of a Monitoring Committee which will periodically evaluate the degree of compliance with the strategic lines and measures) has not yet been established.

Additional Initiatives:

- Operational Groups: Includes the Andalusian Circular Bioeconomy Observatory (HortObserTIC) for horticulture and OLEOVALORIZA for the olive sector.

- Andalucía Agrotech Digital Innovation Hub: Tackles agri-food sector needs through technological services, innovation, and public support.

- S3P Partnership: Focuses on traceability and big data in the agrifood value chain.

- Campus of International Excellence in Agrifood (ceiA3): Offers a Master's in Circular Bioeconomy and Sustainability and contributes to the Spanish Bioeconomy Observatory.

Additional regulatory and strategic support for the ACBS implementation and circular bioeconomy development in the region is offered by the Regional Ministry through the:

- Strategic Plan (2020-2022): Aims to improve competitiveness in agriculture, livestock, fisheries, and agro-industry sectors.

- REINWASTE Project: Focuses on zero inorganic waste solutions in the agri-food sector.
- Regional Law for Circular Economy: Upcoming legislation to support circular economy practices.
- Andalusian Overall Plan for Waste: Approved in 2021, aims for a circular economy by 2030.

4.2.2 Stakeholder networks

The involvement of local stakeholders is crucial for the advancement of a regional circular bioeconomy since it promotes closer links, more effective decision making, ensures social acceptance and enhances cooperation in a highly demanding field. Among the regions examined, it seems that the most advanced ones are also the ones that showcase the most integrated and coherent transition. These are true in the cases of Finland, North Rhine-Westphalia and Andalusia.

Northern Burgenland (Austria)

In the Northern Burgenland case, while in a national level one can search actors in the field of bioeconomy as per branch and region at bioeconomy-austria.at, in Northern Burgenland itself, there's not a network connecting companies providing circular solutions or generally being connected to bioeconomy.

Charles Spa Region (Czech Republic)

In the Charles Spa Region there is no dedicated cluster, only a bottom-up interest for bioeconomy from local enterprises as well as from the Business Development Agency (KARP) that encourages innovation, education and cooperation.

Finland

Finland has already managed to include a large number of stakeholders like ministries, research institutes, businesses, industry groups, local governments, and a citizens' jury in the process of drafting the country's roadmap to circular economy.

North Rhine-Westphalia (Germany)

North Rhine-Westphalia has had a dedicated cluster strategy since 2007 and has managed to have multiple associations connecting academia, industry, investment and other stakeholders. Some of those associations active in the CBE transition are the North Rhine-Westphalia state clusters, BIO.NRW, Kunststoffland, and Chemie.NRW. Further actors relevant for the model region are e.g. In4Climate, Cluster Industrial Biotechnology (CLIB), ZRR, Bioökonomie.Revier, and In4Climate.RR. The national Chemical Industries Association (VCI) also has an NRW section, the VCI.NRW. For topics, including on new crops, bioenergy, and renewable biobased feedstock the Landwirtschaftskammer NRW is the locally active advisor that is well connected with the corresponding branches of other federal states. Beyond the borders the binational project RealiseBio focusses on the creation of new cross border networks and projects between certain regions in The Netherlands and NRW.

Western Macedonia (Greece)

Among Western Macedonia, Charles Spa Region and Northern Burgenland, only Western Macedonia has a dedicated energy cluster (CluBE) that cooperates with the agrifood sector. Western Macedonia local authorities also show a great interest in participation in international sustainability initiatives and forums.

Andalusia (Spain)

In Andalusia, there's a strong cooperation among stakeholders (biomass suppliers, transformers and users, as well as consumers of bioproducts and bioenergy). The agrifood sector is also strongly structured and articulated and has many relevant associations. The Andalusian Circular Bioeconomy Strategy led by the Regional Ministry for Agriculture, Fisheries and Rural Development of Andalusia is another authority contributing to the development of bioeconomy networking. Andalusia had been selected by the European Commission as a model demonstrator region to lead the way towards a chemical sustainable production in Europe which linked the region with the European Sustainable Chemicals Support Service and created intersectoral relations between the chemical industries and those which are involved in the processes that produce raw material.

4.2.3 Funding

Adequate access to funding is of high importance for aiding the bioeconomy transition of a region. This specially stands for small or recovering economies that need large investment in new infrastructure, training, R&D etc. In our analysis, Western Macedonia, the Charles Spa Region and Northern Burgenland are falling behind in funding resources in comparison to Finland and North Rhine-Westphalia.

Northern Burgenland (Austria)

Burgenland, is part of the LEADER Program, a funding measure for the development of rural regions. Through LEADER, funding is provided for projects that contribute to the goals and intended effects of local development strategies.

Charles Spa Region (Czech Republic)

The Charles Spa Region is in shortage of funding with the main sources stated being the Just Transition Fund, and the Business Development Agency (KARP) distributing innovation vouchers.

Finland

The national roadmap for RDI identifies three interlinked strategic development areas: competence, a new partnership model, and an innovative public sector. Finland's competitiveness and wellbeing are built on competence, research and innovations. Finland seems to provide a wide variety of funding options. The main funding instruments are Business Finland, Ministry of Agriculture and Forestry in Finland,The Academy of Finland and European Regional Development Fund (ERDF). Financing is not limited to dedicated instruments and funds but goes further with providing enterprises with assisted loans and tax support. There are also more than fifty Leader groups that grant funding to local projects of entrepreneurs, associations and other communities. This funding comes from EU, State and municipalities. (Leader 2023)

North Rhine-Westphalia (Germany)

North Rhine-Westphalia supports the transition with public funding coming from the state government, the federal government, and from multiple EU funds (ERDF, Just Transition Fund). Specifically, the "Model region Bioeconomy in the Rhenish mining region" (Modellregion Bioökonomie im Rheinischen Revier) receives funding from the Federal Ministry of Education and Research (BMBF). Three funding schemes support inventions from early stage to market entry: NRW-Patent-Validierung, GreenEconomy.IN.NRW and ZukunftBIO.NRW. At a binational level, the funding scheme INTERREG DE-NL connects regions in North Rhine-Westphalia and The Netherlands.

The North Rhine-Westphalia Ministry of Economics and several stakeholders of the Zukunftsagentur Rheinisches Revier (ZRR) agreed on the "Reviervertrag" as a common guideline for the transition of the former lignite mining region, a subregion of NRW. Funding projects that help the transition is part of the action plan "Strukturwandel" and led to the initiative "BioökonomieREVIER". The two bioeconomy flagship projects are "Kompetenzzentrum Bio4MatPro", a competence cluster including 23 subprojects and 50 partners and "Innovationscluster BioökonomieREVIER", an innovation cluster acting via 14 subprojects (innovation labs).

Western Macedonia (Greece)

In Western Macedonia the Green Fund is offering funding programs, while the region has also participated in the Horizon 2020 Program for Smart Cities and Societies and the Just Transition Fund.

Andalusia (Spain)

Andalusia has quite a few options for funding, both national and EU derived but on average, the fund flow in the region is significantly lower than other Spanish regions. Some of the referred funding resources concerns the development of the Andalusian Circular Bioeconomy Strategy development (Strategy Fund for ACBS) that will have the financial resources from different, administrative centers and instrumental bodies, European Regional Development Fund (ERDF), European Agricultural Fund for Rural Development (EAFRD) and European investment funds, Spanish Ministry for Economy and Business, the Regional Government of Andalusia.

4.3 Existing technologies

The second analyzed thematic topic is the volume of regional bioeconomy, existing technologies for biomass conversion, available innovation technologies or processes and finally research & development infrastructure. First, an introductory description of each region most important technologies and processes is initiated focusing among other Renewable Energy Sources (RES) in subchapter 4.3.1. In what concerns RES utilization, one common element among all regions is that diversification in order to achieve a higher RES percentage in each region's energy mix is pursued using the regional advantages and resources.

Then, specific information on technology categories and processes is provided in subchapter 4.3.2. The information presented were identified in D1.3 where one can find more detailed data about the technological processes. It is important to note that due to the regions being in different transition stages, addressing different feedstocks and having adopted different priorities, a comparative

analysis among them is difficult. This can only generally be conducted through the lens of a broad KPI categorization like:

- The focus on the largest quantities of side stream material / waste available in the region.
- Potential technologies/knowhow/willingness exist to utilize the stream
- Possible regional strategies/actions concerning the streams

Despite the differences in the regions the above KPIs can work as a guide for comparison. Overall, the goal of this chapter is to map information that will assist the development of the regional cases in following work packages.

4.3.1 Renewable Energy Sources (RES) Utilization

Northern Burgenland (Austria)

In Austria a well-established and functioning logistics system exists, in which separate collection and recycling is carried out to the greatest possible extent. Especially for the northern Burgenland wind energy and storage and sustainable quality of life are the two main areas of interest. Primary electricity production in 2020 was covered completely by renewable energy sources, 88.7 % alone through wind energy, Burgenland is investing in green hydrogen production through electrolysis. Burgenland Energie and VERBUND want to convert 300 MW of solar and wind energy to hydrogen in 2030; heat and energy production is based on debris from the silviculture, 10 % of the electricity production in 2016 was based on wood products.

Charles Spa Region (Czech Republic)

In the Charles Spa Region, there are currently 11 composting plants in operation (this does not include agricultural composting plants) disposing a total capacity of 51,100 t/year. 6 plants are operating under the Waste Act regime, 5 are mostly smaller community composting plants, where mainly compostable "waste" from municipal green maintenance is processed (there is no need to comply with the Waste Act regime). The capacity of composting plants in the region may seem sufficient at first sight, but the closer look of the entire territory shows that there is district where the composting units are missing (i.e., from the logistic point of view and transport costs it is not economically viable to transport wastes further than 30 km). Biogas plants, together with wastewater treatment plants are representing the potential for the development of a circular bioeconomy in the region, too. There are 14 biogas plants, and 103 wastewater treatment plants are in operation with a total capacity of 126 338 m3/day.

Finland

The energy used in the forest industry in Finland is mainly from renewable sources, arising from the side streams of production. The forest industry has reduced its primary energy use and increased the use of renewable wood fuels over the years. There are already several Biorefineries in Finland that are already using wood as raw material. In addition, there are some plans for new ones. Current biorefineries are built on existing pulp manufacturing units, where additional side stream utilization options are being studied, in addition to current use of energy.

North Rhine-Westphalia (Germany)

North Rhine-Westphalia has no direct technology roadmap for circular bioeconomy. Specialized incineration plants are active that use waste streams from the paper production, or hazardous waste for the generation of heat or electricity. Biomass plants are listed separately and use fuel in form of waste wood, saw dust, wood based bulk garbage and other woody biomass. In 2016 there were 620 biogas installations, 58 composting units (municipal waste), and 16 biorefineries (mostly sugar, starch, and oil crops) active in NRW.

There are 620 biogas plants, 16 power plants running on renewable resources running on wood or waste from forestry in North Rhine-Westphalia Germany. More energy and industrial used crops have been produced every year from horticulture, forestry, and waste materials. For 2019 the share of waste burned for energy purposes was 5.2 %. In waste incineration plants in Germany roughly 18 % of the waste is burned and used for energy production. Energy production in North Rhine-Westphalia is being tracked by the LANUV in its “Energieatlas NRW”, primary energy production via renewables is higher than 23 % of the total production in North Rhine-Westphalia (wind, solar, biomass, water, renewable gas).

Western Macedonia (Greece)

Existing technologies in Western Macedonia include biomass boilers which can be used to produce heat from agro-wastes for public buildings or local district heating systems. This can include biomass from agricultural residues, tree pruning and other sources, which is dried and pelletized. The aGROWchain project (2019) has examined the necessary supply chains to utilize this technology and bring biomass producers in contact with transporters and consumers. For this purpose, the project has successfully tried a matchmaking application called Binter. In addition, the presence of the main facilities of the Public Power Corporation (DEI) in the region provides extra infrastructure and supports the prospects for further infrastructure. In the context of the region’s decarbonization, some of the heating systems fueled by hot water from the coal power plants have been replaced by biomass boilers.

Andalusia (Spain)

Renewable energies accounted for 52% of Andalusia's total electricity capacity at the end of 2021. Biogas production facilities are in operation (21), wind energy (the most important), 22 solar thermal power plants, Biomass electricity (17 installations), Biomass thermal production (28,049 biomass installations), Pellet (13 facilities). Electricity is produced by the anaerobic digestion of slurry, landfill gas and biogas production by anaerobic digestion of sludge from wastewater treatment plants. Solar energy is produced through tower technology, parabolic trough technology, and two experimental Stirling dish installations for research. Another innovation is called Ocean Thermal installation: this renewable installation uses residual energy (cold from the vaporization of liquefied natural gas) to generate electricity by exploiting the temperature differences between the liquefied natural gas stream and the environment, specifically in Atlantic Ocean mass. This installation uses tails cogeneration technology. As for olive biomass valorization for energy, Natac-Innova Leo (a collaboration between Oleícola El Tejar and Natac) has set up a biorefinery for olive oil waste streams, which produces nutraceuticals and some side-streams which could be used as input to produce other biobased products.

4.3.2 Existing technologies and processes

Utilizing the information gathered in D1.3, the table below (Table 4) summarizes technologies and processes existing in the regions that tackle the available feedstock according to the most prominent activities for each of them. Below a commentary on the similarities and differences based on the KPI categories mentioned at the beginning of the chapter is attempted.

The focus on the largest quantities of side stream material / waste available in the region

In the table the processes and technology used reflect the regions' economic activities and targets. Northern Burgenland (Austria) presents a mix of agriculture together with the production of bioenergy, bio-based materials and biochemicals. Charles Spa (Czech Republic) targets bioenergy, composting and wastewater treatment showcasing the effort to switch to more sustainable energy options. Finland shows a high specialization to the country's key forestry sector as does Andalusia (Spain) by clearly describing processes within the agri-food sector. NRW (Germany) on the other hand has technologies regarding the hydrocarbon processing industry, which despite its non-sustainable nature, testifies for the regions expertise and willingness to shift its chemical industry to a more sustainable direction. Finally, Western Macedonia (Greece) has a rather diversified portfolio of activities varying from energy production, agriculture and leather and fur manufacturing.

Potential technologies/knowhow/willingness exist to utilize the stream

The technologies dedicated to the described economic activities are in place, even if they can be optimized. The valorization of the waste deriving from these activities though might require different technologies, specialization or scale-up depending on the desired result and product. Technologies to turn waste into bioenergy and compost are quite mature and can be readily applied in more than one region, even if a certain scale-up and investment is required. As for more specialized technologies like biorefineries, green chemistry, biomaterials production, more elaborate skills, R&D, investment and expertise are necessary. Efforts in the direction of added value side stream valorization may be more demanding, but also, they correspond to an equally developed production model, as the Finish model proves. For regions that need to make improvement in this direction in order to fully valorize their biomass potential, like for example Northern Burgenland and Andalusia and NRW, this bottleneck can be addressed through funding on R&D and scale-up activities depending on the regional specificities.

Possible regional strategies/actions concerning the streams

A common target in all region's strategies, is the reduction of the carbon footprint. Among the regions, Finland is the only one to include a specific feedstock in a strategic document (forestry). In Burgenland, energy, greenhouse gas emissions and agriculture are mostly measure supported along with the target to reduce dependency on non-reusable resources and support renewable resource efficiency. In Charles Spa, the Karlovy Vary Energy Strategy 2017-2042 sets targets for a diversified renewable energy mix also mentioning waste as a resource among others. Finland's National Forest Strategy 2035 clearly targets the further development of the sector, while the need to invest more in innovation is long identified in strategic documents and by stakeholders. In NRW developed a Sustainability Strategy, updated in 2020 also highlights the need to reduction of fossil feedstocks, carbon capture solutions (CCX) and the exploitation of alternative carbon feedstocks. For Western

Macedonia, all regional documents revolve around decarbonization and also the Waste Management Plan calls for resource efficiency improvements, without focusing on a specific feedstock though. In Andalusia, ACBS takes into consideration multiple bioeconomy fields like sustainable growth, availability of biomass resources & processing technologies, regional development and competitiveness (agri-food sector) but the plan itself envisaged implementation issues.

Table 4: Technologies in the regions to process available biomass (information retrieved from D1.3 - BIOTRANSFORM)

Austria	Czech Republic	Finland	Germany	Greece	Spain
Agriculture	**Energy/ composting**	**Wood processing (different types of wood)**	**Hydrocarbon processing industry**	**Energy production**	**Food drink and milk**
Agriculture Phosphorus yielding Harvesting Dreding technologies Zero-tillage farming Precision agriculture Crop rotation Reed Harvesting & Reed management technologies (Rejuvenation Strategies)	**Energy/ composting** Energy & Heat production Composting	**Sandwood** Sorting & measuring Debarking Sawing Edging & trimming Sorting & stacking Drying Conditioning	Oil refining Pyrolysis	**Energy production**	**Materials reception and preparation** Materials handling and storage Sorting/screening, grading, dehulling, destemming/destalking and trimming Peeling Washing Thawing
Bioenergy production anaerobic digestion pyrolysis gasification	Waste water treatment	**Wood Boards** **Veneer/Plywood:** •Cut-off heads •Debarking •Veneer lathe •Clipping •Drying •Patching •Gluing •Pressing •Cutting •Sanding	**Basic petrochemical industry** Ethylene cracker Pyrolysis Ethylene/ Propylene separation Butadiene separation/ conversion Aromatics extraction & conversion Ammonia synthesis Methanol synthesis	**Winemaking**	**Size reduction, mixing and forming** Mixing/blending, homogenization and conching Cutting, slicing, chopping, mincing, pulping and pressing Grinding/milling and crushing Forming/molding and extruding
Bio-based materials		**Wood Boards** **Fiberboard:** •Drying •Gluing •Hot pressing •Cooling	**Polymer production** Polymerization Finishing Processing	**Leather & fur manufacturing**	**Separation techniques** Extraction Deionisation Fining Centrifugation and sedimentation Filtration Membrane separation

					Crystallisation Removal of free fatty acids by neutralisation Bleaching Deodorisation by stream stripping Decolourisation Distillation
Bio-based chemicals Fermentation Hydrogenation		**Pulping** **Mechanical:** Debarking Chipping Refining Grinding Screening Washing (Bleaching) Drying		**Agriculture**	**Product processing technology** Soaking Dissolving Solubilisation/alkalising Fermentation Coagulation Germination Brining/curing and pickling Smoking Hardening Sulphitation Carbonatation Carbonation Coating/spraying/enrobing/agglomeration/encapsulation Ageing
		Pulping **Chemi-Machanical:** Debarking Chipping Chemical impregnation Refining Washing Screening (Bleaching) Drying			**Heat processing** Melting Blanching Cooking and boiling Baking Roasting Frying Tempering Pasteurisation, sterilisation and UHT processing
		Pulping **Chemical:** Debarking Chipping			**Concentration by heat** Evaporation (liquid to liquid) Drying (liquid to solid) Dehydration (solid to solid)

		Cooking Washing Screening (Bleaching) Drying			
		Papermaking **Paper/Paperboard:** Pulping Forming Pressing Drying (Coating) Finishing			**Processing by removal of heat** Cooling chilling and cold stabilisation Freezing Freeze-drying/lyophilisation
		Paper Converting **Corrugated board:** Fluting Gluing Cutting Printing			**Post-processing operations** Packing and filling Gas flushing and storage under gas
		Textiles Regeneration Spinning Drying Yarning			**Utility processes** Cleaning and disinfection Energy generation and consumption Water treatment Vacuum generation Refrigeration Compressed air generation

4.3.3 R&D Infrastructure

As circular bioeconomy is a newly introduced economic model it needs innovation to support practical implementation. Therefore, it is of crucial importance to provide an overview of R&D capacities, opportunities and an effective system that can favor technology transfer and up-scaling of new technologies. R&D development goes hand in hand with educational opportunities for the local population especially education targeted on bioeconomy, biotechnology, the agri-sector, sustainability, business and other related fields. In some of the regions, the lack of education was highlighted as an important factor hindering innovation, which is also associated with demographic factors - like the aging population and brain drain – that hinder the dynamic of a region.

Northern Burgenland (Austria)

In comparison to the whole of Austria, Burgenland lacks behind in terms of R&D actors and investment. It has the lowest figures of all Austrian provinces in terms of the number of R&D actors (companies, research institutions, universities, etc.) and R&D expenditures. However, there are still a few R&D centers. Further investment on their activities could be a good start to advance the region's performance.

Charles Spa Region (Czech Republic)

R&D is very low in the region due to education reasons and lack of funding since the energy prices are a setback. As a result, there are low patent applications, no academic centers, no circular economy or bioeconomy projects in the region. The Charles Spa Regional Agency (KARP) is the only one supporting R&D and innovation in the region, The only municipality funded research institution (Institute of Spa and Balneology), The strategic project "Karlovy Vary Innovation Centre" (with the support of the JTF OP. Its primary focus is to provide a new public infrastructure that will provide support for entrepreneurship, start-ups and start-ups, innovation and R&D activities, knowledge transfer and cooperation with the education and private sector), there are also 3 very private business incubators.

Finland

Finland, being already established in the field of circular bioeconomy has realized that the only way to expand is through innovation. For this reason, Finland wants to expand R&D investment to achieve competitiveness in the forestry sector through innovation. The forest industry invests more than EUR 300 million every year in research, development and innovation activities. Many universities around Finland offer studies on forest sciences, papermaking technologies and biomass refining. The studies are often partly executed in co-operation with forestry companies, which drives both research and education forward (University of Helsinki 2021). In addition to the forest industry's own research and university research, VTT conducts significant technological research and development in the field.

Western Macedonia (Greece)

In the case of Western Macedonia, CluBE supports R&D through its activities. Other R&D institutions mentioned are the Centre for Research and Technology Hellas along with a few academic institutions.

North Rhine-Westphalia (Germany)

North Rhine-Westphalia showcases not only a large number of R&D contributors, but also a very diverse ecosystem including R&D centers, educational institutions, innovation hubs and systemic start-up support systems setting a very promising picture for the advancement of Bioeconomy through innovation in the region. This diverse ecosystem includes:

1. North Rhine-Westphalia has a large number of academic institutions, universities and technical universities. These focus on basic, but also applied research
2. Support for start-ups is provided state-wide
3. EMPHASIS: The European Infrastructure for Multi-scale Plant Phenomics and Simulation
4. ECCSEL ERIC (European Carbon Dioxide Capture and Storage Laboratory Infrastructure)
5. Six European Digital Innovation Hubs listed under the Smart Specialisation Platform
6. Nine Digital Innovation Hubs listed under the Smart Specialisation Platform
7. Five digital innovation hubs called DWNRW-Hubs (located in Aachen, Bonn, Düsseldorf/Rheinland, Münsterland, Ruhr-Area)
8. German Network for Bioinformatics Infrastructure den.bi
9. 19 R&D parks
10. A more detailed database of research centers is kept up-to-date by the state cluster BIO.NRW in its Wissenschaftsdatenbank

Andalusia (Spain)

In Andalusia, there is a notable foundation of factors that can actively contribute to the advancement of bioeconomy. Starting with education, The Agrifood Campus of International Excellence - comprising the universities of Jaén, Córdoba, Huelva, Cádiz, and Almería – focused on the valorization of agriculture by-products, biorefineries, and algae. Regarding research itself, there are a few centers like the IFAPA (Andalusian Institute for Research and Training in Agriculture, Fisheries, Foods and Organic Production), the CSIC (Spanish National Research Council), ANDALTEC (Plastic Technological Centre), TECNOVA (Research Centre related to agribusiness) and CETAQUA (Water Technology Centre). However, it's important to note that none of the above centers is specifically devoted to bioeconomy or circular bioeconomy as such. However, there are in total 12 technology parks, research, and innovation centers broadly related to the field that can promote circular bioeconomy.

4.4 Biomass Residues

The unexploited biomass residues, and local biomass resources were scrutinized to find whether they are currently being used to their full potential. The desk research aims to identify existing gaps in technology, logistics or finance.

Northern Burgenland (Austria)

Burgenland, not possessing a particularly strong agricultural sector but seeks for alternatives to expand its bio-resource base. The existing agricultural sector can provide some biogenic waste, residues and by-products that are worth further exploration. Crops that account for more than 1% of the total area and that are likely to offer interesting potential for various applications are: winter wheat (22%), soybeans (15%) and wine production (9%). The most promising alternative though, derives

from municipal waste. The cumulative volume of municipal waste amounts to 183,000 tons, to which 86,000 tons from other sources can be added.

Lake Neusiedl also presents a significant reed population as it is the second largest contiguous population in Europe. The lake can also be a great source of sludge.

Charles Spa Region (Czech Republic)

The region has a rather limited agricultural and forestry activity as it is transitioning from previous fossil-based activities. As a result, there's no quantifying data to assess residuals from such activities. However, as most of residuals are used for heat and energy purposes, alterations in this area, more specifically, an increase in a heat plant capacity, indicate that the forest biomass is sufficient but without specific data from agriculture and forestry. As for the local activities that could be a basis for transition, these are the forest areas (covering 45% of the region), the thermal waters, thus the spa and tourism industry, chemical and engineering production, and textile industry.

Finland

Finland's extensive forestry sector calls for further use of existing forestry related by-products, wastes and residues like green liquor dregs, lignin, hemi-celluloses, ash and bark. These by-products and residues can be further processed, increasing the country's significant environmental performance. More specifically, because of lignin's high presence in wood, this is the most researched residue. Extending R&D expenditures, as described in the region's goals for development, combined with economies of scale can result in advanced solutions for the existing by-products.

North Rhine-Westphalia (Germany)

North Rhine-Westphalia has biomass resources originating from the agricultural sector, the municipal waste and industrial waste. Part of the above is used for bioenergy production purposes (as indicated by most local studies) but there are references/ efforts for alternative use and added valorization.

A potential in municipal waste (collected from bio waste bins, gardens and public parks) is recognized. Sewage gas is being used for energy production, with 336 installations across North Rhine-Westphalia. 90 % of all sewage sludge is being incinerated, most of it in dedicated incineration plants to recover phosphorus, the rest in coal power plants, cement plants, or municipal waste incineration plants. Approximately 34% of all municipal solid waste (MSW) is the organic fraction (MSWOF). This can be used in anaerobic digestion, for biogas, but a number activities across the EU focus on a higher valorization. There are, however, some problems that inhibit the full valorization such as logistics and legal restrictions regarding the end-of-waste and transport of waste, as well as competing interests among waste management actors.

Regarding other types of urban waste, industrial waste accounts for more than 29% of urban waste but there's no data about the biogenic percentage in it. While its collection can be relatively easy, the often high amount of toxic substances (e.g. for post-consumer, treated wood), or its fast decomposition (e.g. industrial food waste) makes this a challenging feedstock.

As for the agricultural and forestry sector, wood waste from various sectors is a potential source of biomass. Manure from feedstock livestock is used as fertilizer on fields or as a substrate for biogas plants. According to studies, biomass potential of 1.17 million tons can be realized from agriculture processing. This particular feedstock is very promising since streams from processing of agricultural

products for food that can be valorized for high value applications (food-grade). At present, these are mainly used in feed partly due to legal restrictions regarding biomass characterization and its potential uses.

Flue gasses: There is also another source of carbon, though not of biogenic origin, and as a result not largely examined in this report. This concerns North Rhine-Westphalia's steel and cement plants, as well as a network of incineration plants, all of which emit CO/CO2 containing gas streams, a potential carbon source for the chemical industry adding to the total potential feedstock.

Western Macedonia (Greece)

Western Macedonia was largely dependent on lignite-based energy production, marble extraction but also presents a variety of bioresources originating from agriculture (like saffron, fruits, local wines) and arts and crafts such as furs and leather manufacturing. The biogenic resources of the region require better management within the principles of bioeconomy. Among those lie the municipal waste biomass, forestry production and residues, residuals from agriculture, and bio-waste. The above biomass resources seem to be redirected to energy purposes, more specifically to generate electricity and heat. However, the quantity of the above resource streams remains unknown. Quantifying such data requires a lot of resources and governmental support to fully map the potential of the region after its fossil transition, thus extending the suggestion to local policy makers.

Andalusia (Spain)

Andalusia has an extensive and well organized agri-sector involving agriculture, algae production, forestry, olive production, livestock production, aquaculture and fishing. This is reflected in detailed statistical data for turnovers and businesses per sector indicating that the most influential activities are related to the Food and Beverage industries.

As a result, various resources can be potentially retrieved for further processing. Some of those are residual biomass from arable crops, biomass from pruning waste, livestock waste and by-products such as purines, manures, and parts of animals not intended for human consumption, discards and by-products from the agri-food and fishing industry, forest biomass, algal biomass, industrial CO2. Fruit and vegetables, sunflower and vineyard could serve as fibers for composites, rheology modifiers, pectin for gels and sugars for food or bioplastic applications. Pectin could also be the source of building blocks towards biobased PEF, a biobased alternative for PET. Regarding the forestry feedstocks, they now compete for the sustainable chemistry and energy sectors.

Special mention should be made on the olive production by-products (pomace, olive stone, olive pit, etc.). Olive production is substantially high in this region and its by-products are only partly used for bioenergy purposes (30%) due to logistics-related problems and insufficient processing facilities. However, there are many SMEs that could help create new value streams for olive by-products, some of them including nutraceuticals, lubricants, bioplastics, oleochemicals and food additives.

Currently, there is no official registry of biomass production that includes, for each of the producing sectors, the quantities of biomass generated. There are however estimates per sector made by PNO, CEFIC, CIRCE, 2016.

Other types of biomasses for potential use are biowaste at the local level and other organic waste including sludge and effluents from sewage systems.

Table 5: Biomass residues per region

Region	Biomass Residues
Northern Burgenland - Austria	-Municipal waste -Lake: reed & sludge -Agriculture
Charles Spa Region – Czech Republic	-Agriculture & Forestry
Finland	-Forestry
North Rhine-Westphalia – Germany	- Agricultural, agri-food/feed and forestry sector -Municipal waste -Industrial waste
Western Macedonia – Greece	-Fur and leather -Municipal waste biomass -Forestry -Agriculture
Andalusia – Spain	-Agriculture -Algae production -Forestry -Olive production -Livestock production -Aquaculture and fishing

4.5 Limitations and Existing Gaps

Identifying existing problems that inhibit the circular bioeconomy transition helps to better understand the specific characteristics of each region and to conduct tailor-made proposals. The effectiveness of the transition greatly depends on applying specific solutions.

Northern Burgenland (Austria)

Governance: There is not a dedicated local bioeconomy strategy, only a state strategy implemented by the local Government. The Local Action Group (LAG) is responsible for the implementation of LEADER (funding EU program to support rural areas) in the region. LAGs are private-public partnerships composed of partners from the various socio-economic sectors of the respective region

and are intended to represent the population of the region. Stakeholder networks are also non-existent, although there are bioeconomy actors listed.

Environmental: A major setback for the region is the little available land for cultivation resulting in little agriculture activity and biomass. Climate change also affects domestic soil quality and forests.

Education and R&D: Compared to other Austrian regions, Northern Burgenland has the lowest R&D both in factors and expenditures

Economic: The synthesis of the local economy is largely occupied by Services (46%). This is followed by Trade; Transportation; Accommodation and food service activities; Information and communication (22%), and then by Industry (17%), Construction (11%) and lastly, Agriculture and forestry (4%). A shift towards bioeconomy in this case requires careful planning taking into consideration existing waste streams rather than agricultural biomass.

Charles Spa Region (Czech Republic)

Education and R&D: Charles Spa region has a very low R&D infrastructure and expenditure (no mention to biotechnology). Education and a lack of entrepreneurial mentality is another factor that is lacking behind, especially for a high demand in technical skills sector like circular bioeconomy. As a result, there is low employability following the transition of the era.

Funding: There is low investment in innovation and new technologies too. Innovation vouchers are offered via calls that open every year (the managing authority is KAPR). These facilitate financial support for the development of innovation and R&D and between the limited entrepreneurs and the research/academia. More funding methods are currently under negotiation and are expected to facilitate the transition.

Resources: With the region being coal-mining-dependent for a long period, there are limited renewable energy sources. Limited land for agriculture doesn't allow for extensive energy use.

Innovation ecosystem: A dedicated cluster on bioeconomy is non-existent in the region no cluster and so is networking. The existence of a supporting hub could enhance and support local entrepreneurship.

Finland

Environmental: Finland is rather advanced in managing its resources with a policy that thinks ahead. However, some environmental limitations like loss of biodiversity should be seriously considered. This is important for every intensive economic activity exploiting natural resources.

North Rhine-Westphalia (Germany)

Available biomass: North Rhine-Westphalia will be challenged to source enough local biomass for its local industries. The region has very diverse biomass resources that can be difficult to sort and exploit. Depending on the type of biomass, there are some limiting factors. For example, municipal solid waste is under by strict end-of-waste and transport of waste limitations like logistics and legal handling restrictions. Post-consumer wood waste, or industrial wood waste can contain high amounts of toxic substances, while post-consumer or industrial food waste shows a high rate of decomposition, making both feedstock streams challenging in different ways.

Social: Regarding the municipal solid waste management, there are competing interests e.g., of waste management actors that make this valorization challenging. The structural change in the region, which has a long history of coal mining, steel production, and (automotive) manufacturing, is posing social challenges. An ageing and potentially shrinking workforce is in need of re-skilling and bioeconomy needs the education of a new labor force.

Legal: Legal issues related to biomass valorization, end-of-waste regulation and transportation could be re-examined to facilitate the transition and make biogenic feedstocks available

Western Macedonia (Greece)

Environment: Contaminated land due to lignite units and long exposure to air pollution is a remaining problem and a setback for the development of tourism and agricultural activities to the region.

Social: High level of unemployment and emerging social inequalities partly due to the structural economic change of the region that is violently shifting towards sustainable production. The age factor also plays a significantly big role in agricultural activities since only a small number of young farmers represent the sector.

Economy: The major issue for Western Macedonia is its great economic dependency on lignite mining. Lignite mining activities will be withdrawn by 2028 by order of the Greek Government. However, the region is left with low access to funding and financial support during this structural transition. Only the Funding instrument OP of the Region of Western Macedonia is mentioned as a current financing tool.

Governance: Apart from an inexistent transition plan on behalf of the Greek Government, there are also bureaucracy problems associated with clean energy.

Infrastructure: there is also poor digital infrastructure, a tool that is necessary to advance the already existing but in need of support in the tourism sector.

Education and R&D: Transitioning towards a circular bioeconomy model requires high skilled personnel and farmers to apply the latest technology advancements and embrace innovation. Unfortunately, this is not the case in this region. Low-skilled, mostly advanced age farmers along with poor business culture and few research centers and innovation hubs make transition difficult.

Andalusia (Spain)

Infrastructure: Proximity to processing facilities is crucial for biomass exploitation. The example of Andalusia regarding olive production shows that unfortunately, only 30% of this type of biomass is converted to electricity since if a region doesn't have an energy electricity plant, then it's not used for energy. Thus, there’s a need for more processing (biorefinery) facilities in olive production areas. The regional analysis highlights the need to have technological developments specifically adapted to every type of biological resource and industrial process and the need to make progress on the development of the integrated biorefineries.

Biomass nature problems: Logistic problems related to biomass’ nature are also present because transportation is not always favored by the land orography. Plus, the short harvesting periods and seasonality of the biomass, high humidity, low density result in high transport and handling costs. Regarding forest biomass, obtaining, extracting and transport costs towards centers of consumption.

As for livestock waste, its high polluting nature, low concentration and tech handling problems demand adequate infrastructure.

Legal: The extremely demanding criteria for the characterization of biomass as a by-product or waste are a setback for further valorization in many cases. So, there is a need for a favoring legal framework for the characterization of biomass as a by-product

4.6 Summary of Desk Research

The key conclusions of the desk research are provided in the table below.

Table 6: Overview desk research – Setting the scene

Country	Region	Main bioeconomy topics	Biomass Residues	Solutions
Austria	Northern Burgenland	-Vineyards -Vegetation -Sludge from lake -Agribusiness	-Lake and municipal waste biomass potential	- R&D enhancement - Establish networks - Promote education
Czech Republic	Charles Spa Region	-Hot springs & spa tourism -Beverages & food production	-Tourism and forestry potential	- Invest in R&D innovation - Education - Local strategy - Networks
Finland	Country level	-Forestry -Chemical production	-Forestry residues	- Need for innovation for added value - Focus on biodiversity sustainability
Germany	North Rhine Westphalia	-Chemical industry / biogenic side & residue streams	-Side-streams and waste (industrial, urban, agricultural etc.)	- Provide motives for cooperation and networking of bioeconomy actors - Enhance bioeconomy education - Invest in infrastructure, R&D, novel technologies

				- Wide and complex diversity of biomass resources - Improve end-of-waste and transportation legislation - Need to close the loops and scale-up
Greece	Western Macedonia	-Decarbonization of energy production -Agriculture -Mining -Fur & Leather	-Urban waste -Agriculture	-Government support in education -Investment in infrastructure -R&D -Innovation and entrepreneurship support -Mapping biomass potential -Create local networks -Focus on renewable energy -Agriculture and tourism infrastructure -Improve access to funding
Spain	Andalusia	-Agriculture -Tourism -Retail -Transportation -Underdeveloped industry	-Agricultural and food industry residues	-Invest in R&D and infrastructure of processing facilities -Improve the legal framework for biomass characterization -Improve access to funding -Create start-up supporting ecosystem

Table 6 is presenting the findings of the Desk Research showcases a rather diverse picture of the progress of CBE in each case study region.

It turns out that the adoption of a clear CBE strategy and the support of the transformation throughout are key contributing factors. A basic distinction among the examined regions is the adoption or not of an already existing strategy for the bioeconomy. Two of the examined regions belong to the countries already implementing a National Strategy (Germany & Finland) and this is rather reflected in the policy measures proposed, justified by examples and best practices. On the other hand, from the regions of Greece or Czech Republic such evidence is missing as there is neither regional (the first case) nor national bioeconomy strategy (the latter case). Western Macedonia, Burgenland and the Charles Spa regions don't seem to have any specific measures to support the bio-based transition either. What is also very important when building a regional strategy is the application plan and monitoring system. Andalusia, for example, is missing a detailed application plan for the local bioeconomy resulting in a difficulty to measure the results and make further improvements in the future.

The picture seems even more difficult for local economies recovering from chronic dependence on fossil-based activities. Western Macedonia (Greece), presents many similarities with the Charles Spa Region (Czech Republic) in terms of transitioning from previous fossil fuel activities (both are in the Just Transition Fund) with limited in natural resources, need for infrastructure, R&D and investment innovation and education as well as clustering and networking. As also indicated in the circular bio-based transition, a primary factor for support is forming local government bodies and engaging stakeholders to ensure participation. Clear strategies and practical support in the form of funding, alleviating bureaucracy levels and favorable legislation can strengthen the transition. Restructuring former lignite-based economies requires heavy state support and involvement and a more systemic approach to identify existing biomass potential, build infrastructure, re-train local workforce and create opportunities and invest in innovation to create entrepreneurial motives.

The example of North Rhine-Westphalia, being a heavy mining and manufacturing area itself, is closer to Western Macedonia and the Charles Spa Region. North Rhine-Westphalia, can build upon a national bioeconomy strategy and has built a good resource exploitation system. When it comes to valorizing challenging, diverse municipal biomass, the application of good monitoring systems as in North Rhine-Westphalia, can be a nice source of inspiration for the two regions. Sourcing material at the root can also be a good solution.

The R&D existing infrastructure and investment also seems to play an important role as it was mentioned as a real need in all regions, either already advanced, or in the transition process in the beginning. For example, in Northern Burgenland (as in Western Macedonia and the Charles Spa region) R&D performance is low. The agricultural activity is also rather low but there's promising potential on the waste acquiring (through well-organized separation systems), municipal waste and lake originated biomass. The valorization of the above biomass resources would be enhanced with further R&D investment. On the other hand, Finland teaches us that investment in innovation can make a key difference in competitiveness and government and local players know that and have already embedded this in their official agenda. In Finland, we see the state taking active action on innovation and R&D not only through funding accessibility but also with investment in public enterprises.

Energy from renewable resources was another important issue in all cases, with the use of biomass for energy purposes being a common practice. However, increasingly, biomass is recognized as too

valuable to use for energy production, and technologies are being developed and implemented for more added value applications. Burgenland. The region, though, presents some good signals of transitioning in the energy sector, though it needs to obtain a more focused local approach mainly by identifying the true potential through measuring specific biomass quantities. Andalusia also has an extensive renewable energy availability and Finland uses mostly forestry residuals, like bark, sawdust and waste liquors from pulp production for energy recovery.

Education, even though it was not exhaustively analyzed in this study, is another contributing factor since circular bioeconomy is mostly knowledge based and innovation led to overcome the limits set by biomass' fluctuant nature. The issue was particularly mentioned in the cases of Western Macedonia, the Charles Spa Region and Northern Burgenland. Education is a very important factor in the transition highly affected by the social tendencies like aging population and brain drain. The transition to Bioeconomy, as visible in Charles Spa Region, requires reskilling of the population which is very difficult to perform in an older population. Another interesting factor to secure equal access to opportunities presented by circular bioeconomy is the gender accessibility. In the current study, though, the gender factor was not identified as a factor hindering the transition during the regional desk research exercise. This is attributed to other factors, like the existence and support of regional strategies, being more influential to the transition.

Strong partnership building is another clear priority of the Finnish government that can benefit all of the regions analyzed in this document. Support through cooperation, availability of information, technology, data, resources and clustering can strengthen the transition. The Finnish example can indeed be a source of inspiration in terms of goal setting, recognition of local strengths and weaknesses, and a strategic approach and active participation of stakeholders. Andalusia also has a developed network of players in agriculture, technologies and R&D centers (not necessarily on bioeconomy) that can enrich innovation.

Funding is unanimously a big contributing factor aiding the transition. From the above regions, Western Macedonia, Northern Burgenland, Andalusia, the Charles Spa Region and North Rhine-Westphalia need further financial support. For example, in Andalusia funding is accessible but when compared to the state level, further funding opportunities should be offered. Funding can be redirected in special needs of Andalusia such as infrastructure development, specialized education on circular bioeconomy and a detailed monitoring system of the value streams and by-product generation. Problems related to biomass concentrations and transportation can also be tackled through funding infrastructure and R&D. This applies to all regions and not just Andalusia. Investment in in-situ processing infrastructure can be a solution.

The above regions may be in different stages of transition with distinct resources and difficulties; however, it is important to note that even the ones that have a longer distance to cover can present great growth opportunities if approached strategically and systemically.

4.7 Summarized work of other Circular Bioeconomy projects

To illustrate the transition to CBE a few case studies were carefully selected from the literature to show good practice from regions that are not included in the BIOTRANSFORM consortium (i.e.,

Lativa), show similarities with some region (Swedish focus of bioeconomy that resembles Finland), can show some specific type of biomass (the example from the BIOEAST macro-region) and also non-food biorefinery (brown, green and blue biomass utilization from Nordic countries).

Aizkraukle region (Latvia)

Mauizniece et al. (2019)[43] analyzed the transition to circular bioeconomy in a Latvian case study. Three main pointers were used to analyses livestock data – the number of animals showing which animals' rule in the areas of the research region, the number of animals per hectare of arable and agricultural land that characterize the intensity of farm animals, and the average amount of animals in a holding that show area-specific large farms or small backyard farms.

Table 7: Case Study for Aizkraukle Region Unused potential

Source	Unused potential, estimated volumes in the Aizkraukle region	Remarks
Unused agricultural land	13 810 ha (~ 13.1 % from total agricultural land in region)	Unused agricultural areas in the region in 2018
Former peat mining areas	12 216 ha with licensed peat extraction deposits [23]–[25]	Peat is not considered as a bioresource, but the former peat mining areas are treated as an additional place to produce bioresources
Biomass residues and waste form recycling	79 500 t/a digestate 24 800 t/a corn silage 18 800 t/a food waste 1 890 t/a sewage sludge 720 t/a wood ash and sand from cattle houses 80 t/a wastewater waste	The most frequently generated biowaste in major processing companies, wastewater treatment plants and boiler houses in the region
Municipal biomass waste	2 200 t/a	Share of biowaste collected in the region and deposited in landfills [26], [27]
Crop and livestock by-products	226 178 t/a manure 31 791 t/a residues form winter wheat 25 985 t/a residues from summer barley 21 452 t/a residues from summer wheat 14 265 t/a residues from oat 11 791 21 452 t/a residues from winter rapeseed 13 798 21 452 t/a residues from summer rapeseed 6 921 t/a balances from field beans 670 t/a balances of bucket wheat	Calculated on the basis of livestock production [6] and crop production [17] statistics in the region for 2018, crop yield indices [28]-[31] average crop yield (2015-2017) [32]

[43] Indra Muizniece, Lauma Zihare, Jelena Pubule, Dagnija Blumberga. This is an open access article licensed under the Creative Commons Attribution License, in the manner agreed with Sciendo.

Foresting residues	36 108 m^3/year non-useful part of the trunk 77 567 m^3/year twigs 8 913 m^3/year tops 6 238 m^3/year needle foliage 94 839 m^3/year strains	Calculated on the basis of annual harvesting volumes in major fellings (15]
Forest non-timber resources	11 700 t/a cranberries 5 500 t/a raspberries 24 700 t/a blueberries 17 500 t/a lingonberries 2 400 m^3/year tree needles from logging 80 thousands l/a of maple sap 245 000 thousands l/a of birch sap 2000 m^3/year pine needles from logging	The theoretical quantities of berries available have been calculated considering the forest types of the region [15] and the biological harvests of theoretical berries, depending on forest types [33]. In addition to the mentioned forest non-timber bioresources, there are others (e.g., forest mushrooms, cones, medical plants, game animals) the amounts of which cannot be determined. The theoretical quantities of tree sap to be obtained have been calculated on the basis of material factors of tree species, age [15], density [34], average quantities of sap [33], [35], nature protected areas [15], etc.

Table 7 clearly indicates the diverse resources and their volumes. These bioresources produce products at all levels, from low added-value energy products to high added-value products like pharmaceuticals, cosmetics and chemicals. At the same time, these results display the effectiveness or ineffectiveness of the use of existing resources and confirm the assumption that residues and waste are not primarily perceived and utilized as resources.

The case study highlighted the importance of forestry in the region, despite the sufficient land for agriculture. Bioresource processing is not as developed as primary production, which implies that there is no added value, and as a result no further development of the local economy and welfare levels. There is a substantial free labor force available for business development, which is not connected to the availability of resources, the primary production sector or the level of progress in the area. In its recommendations to fortify regional capacity through sustainable use of local bioresources, the emphasis is mainly on cooperation between organizations, business, and local inhabitants in the spheres of knowledge, education and training, research and innovation in the context of the bioeconomy and the circular economy.

The bioeconomy is a knowledge-based sector. Without it, there is little room for development. Therefore, the available bioresources are vital to the economic development of the Aizkraukle region, but knowhow is a roof that protects and makes the economy home everlasting. In the example of Aizkraukle the bioeconomy, the circular economy and economy development puzzle will not only be determined by the creation of one or more large capacity bioresource refineries. These issues should

be seen as a complex system so that, when established in one direction, there is no oversight or manipulation of other possibilities than the use of resources offered. Increasing your knowledge and raising awareness to deal with what is happening more broadly could lead to sensible decisions and take sustainable action.

Sweden

The Swedish bioeconomy is focused on the forest industry; both private participants and policy makers are closely cooperating on both national and regional level. Several professional networks and project-related events are being organized by regional participants in both Värmland and Västerbotten regions Andersson & Grundel (2021)[44] Academia represented by universities and research institutions participated in the development of the bioeconomy policies for both regions. Andersson & Grundel (2021) name the following good examples: study tours, plant visits as in input for dialog, basic technical specificities described in hand-out materials while key aspects of policies being concentrated on not the technical solutions and know-how, but rather on social organization through projects and networks and fostering regional traditions, cultures, and methods of communicating.

Melbourne & Malmö

Bolger & Doyon (2019)[45] portray two case studies to show that the sharing economy model may benefit local governments to achieve wider goals, including social coherence, better waste and resource management, and sustainable development. The worth of citizen participation through a dynamic and inclusive urban planning process articulated in the literature (UN Habitat, 2007) became apparent in both case studies that were investigated.

Untapped Biomass from the BIOEAST macro-region

Zeko-Pivač et al. (2022)[46] indicate brewer's spent grain as an important source of biomass as they account for approximately 85% of the total mass of solid by-products in the brewing industry and represents an important secondary raw material of future biorefineries. Countries located in the BIOEAST macro-region produce about 26% of the total EU27 beer production, the three biggest producers Poland with annual brewer's spent grain production of 816 kt, followed by Czech Republic (403 kt) and Romania (359 kt). The brewer's spent grain is indeed one of the underexploited biomasses that is not currently being properly utilized in the BIOEAST macro-region. However, the knowledge concerning the utilization of brewer's spent grain exist (i.e., the utilization in the biofuels

[44] Ida Andersson, Ida Grundel, Regional policy mobilities: Shaping and reshaping bioeconomy policies in Värmland and Västerbotten, Sweden, Geoforum, Vol. 121, 2021, Pages 142-151, ISSN 0016-7185, https://doi.org/10.1016/j.geoforum.2021.02.005

[45] Bogler, K. & Doyone, A. (2019) Circular cities: exploring local government strategies to facilitate a circular economy. EUROPEAN PLANNING STUDIES, VOL. 27, NO. 11, 2184–2205 https://doi.org/10.1080/09654313.2019.1642854

[46] Zeko-Pivač A, Tišma M, Žnidaršič-Plazl P, Kulisic B, Sakellaris G, Hao J and Planinić M (2022) The Potential of Brewer's Spent Grain in the Circular Bioeconomy: State of the Art and Future Perspectives. Front. Bioeng. Biotechnol. 10:870744. doi: 10.3389/fbioe.2022.870744

(biogas, bioethanol, biobutanol), biofertilizers production or the utilization of value-added products such as enzymes (mainly xylanase), lactic acid, ascorbic acid, citric acid, gibberellic acid, ferulic acid, xylitol, etc.). The existence of the biorefinery in the BIOEAST macro region is very scarce.

Non-food biorefinery

Andersen et al. (2022)[47] outline an example of brown, green and blue biomass utilization from Nordic countries; the case examples demonstrating non- food biorefinery concepts based on lignocellulosic, wet, and marine biomass (Table 8).

Table 8 [48]: Comparison of three bioeconomy value chains implemented in Nordic hinterland regions

Value chain	Brown	Green	Blue
Bioeconomy Resource	Lignocellulosic biomass	Wet biomass	Marine biomass
Productive Sector(s)	Forestry; biofuels	Agriculture; food	Fisheries and aquaculture
Products	Advanced biodiesel (HVO)	Green proteins	Raw seaweed or alginate
Technology	Forest biorefineries	Grass biorefining	Algae biomass harvesting
Technology readiness level (TRL)*	TRL9; commercial	TRL7-8; demonstration	TRL6-7; pilot
Innovation Type	Substitute product	Substitute product; new processes	New and substitute products
Operator(s)	Industries co-owned by government	Landowner with government support	Private fish farm entrepreneurs
Hinterland regions	Lappeenranta, South Karelia (Finland); Pitea, North Bothnia (Sweden)	Struer, West Jutland (Denmark)	Faroe Islands (North Atlantic; Realm of Denmark)

[47] Andersen, M.S.; Christensen, L.D.; Donner-Amnell, J.; Eikeland, P.O.; Hedeler, B.; Hildingsson, R.; Johansson, B.; Khan, J.; Kronsell, A.; Inderberg, T.H.J.; et al. To facilitate a fair bioeconomy transition, stronger regional-level linkages are needed. Bio-fuels, Bioprod. Biorefining 2022, 16, 929–941. https://doi.org/10.1002/bbb.2363 .

[48] Bioenergy IEA, Technical, Economic and Environmental Assessment of Biorefinery Concepts. International Energy Agency, Paris (2019).

Backwards linkages	Wood sourced from forest owners	Grass sourced from farmers	Integrated multi-trophic aquaculture with fish farming
Forwards linkages	Basic processing; use of existing refinery structure elsewhere	Cascading use of residuals for biogas plant and non-GMO fodder	Valuable extracts with operation at larger scale
Final demand linkages	Limited	Limited	Limited
Fiscal linkages	Weak despite tree harvest loyalties	Weak despite land value taxation	Weak despite small turnover tax on aquaculture
*TRL definitions of NASA: (6) technology demonstrated at relevant environment; (7) system prototype demonstration in operational environment; (8) system complete and qualified; and (9) actual system proven in operational environment			

5. Stakeholder validation

In order to validate the information gathered during the desk research and to search for additional information each partner responsible for a specific region organized dedicated Info Days where local actors and stakeholders from the industry, policy makers, etc. were invited to discuss local issues related to the transition of each region toward circular bioeconomy. Special questionnaires were also filled during the info days. (Task 1.5.) Separate interviews with local actors were also conducted. The purpose of these activities was both to engage local actors in discussion about the next steps of the transition, raise awareness about the project and new opportunities, to validate the findings of the desk research and to identify additional factors and issues that require attention while designing local future strategies. During the execution of the Task, the most important criterion for the selection of representatives of stakeholders was the person's competence and position in the value chain; gender and age were not the relevant selection criteria." Among social factors affecting the transition education was highlighted. While education in combination with age was identified as a key issue for the transition, other demographic factors like the gender representation were not highlighted as a per se bottleneck for bioeconomy transition.

The findings both from the info days questionnaires and the interviews were summarized for each region and are presented below.

Northern Burgenland (Austria)

During the Info Days, stakeholders discussed what is important to them in a shift towards a circular bioeconomy, what are the most important social, technical, and structural barriers to achieving sustainable development and where should the first steps be taken. The results that came out were:

Environment: Lake Neusiedler is important for the region; emotional connection to environmental problems connected to Lake Neusiedler and flagships are important for local stakeholder

engagement. The lake was also identified as a potential biomass source all while it faces environmental challenges like draining which is difficult to address since the salt water is a special environment.

- Depleting ground water levels
- Excessive use of petrochemical fertilizers requiring filters
- Water conservation awareness among farmers is low
- Insecticide usage has also resulted in a decline in insect diversity disrupting the entire food chain. Many winegrowers struggle to obtain organic certification due to the narrow strips of land they cultivate, which makes them susceptible to pesticide drift.
- High rate of surface sealing connected with animal farming and intense transportation. The reduced flow of rainwater from surface waters, due to increased surface sealing, contributes to the declining water levels in the lake.

The drying up of Lake Neusiedl poses economic risks, and experiments with alternative crops and vine varieties are being conducted to adapt to the changing conditions. The region would benefit from innovative stakeholders, such as urban career changers, to revitalize fallow land and sustain the local economy. **More incentives for public agreement:** better communication between the communities and the involvement of the population, along with political opponents, are needed.

Road and public transport infrastructure: There is a lack of public transport and bicycle infrastructure that makes everyday life difficult (25 bicycle lanes) and enhances energy consumption. The not so extensive road network cannot service the big local population, plus, transportation infrastructure is important for the development of bioeconomy. Political parties' dispute makes progress even more difficult in regards to the discussed new cycle lane.

Brain drain: A big challenge for the region is that while there's a high rate of high school graduates, there's also a severe brain drain. Thus, leading to a vicious circle in which structural barriers change only slowly. For example, a common misconception is that the wind turbines blow the water out of Lake Neusiedl.

Education: Lack of knowledge and awareness of the local population starts even from school. It is believed that more focus should be given at earlier stages of education.

Funding: Stakeholders stressed the importance of providing more incentives for sustainable agriculture and practices in general as it is crucial for the regional environmental issues. There's also a need for governmental motivational measures, competitions, procurement policies, and ecological procurement practices in the public sector.

Local actors: KEM (Climate and Energy Model Region) was identified as an actor to support sustainable practices in the region. KEM's activities include connecting local stakeholder groups, promoting the creation of a biomass network with focus on biogas development and prioritizing of the CHP (combined heat and power) utilization of biogenic residues.

Charles Spa Region (Czech Republic)

The potential of circular bioeconomy transition, gaps and regional challenges were discussed. The Info days validated the desk research:

Declining economic activities: stakeholders discussed the challenge in transformation as both the mining and manufacturing industry have a very long tradition. There were also mentioned other traditional industries such as glass and porcelain manufacture, building materials, textiles and musical instruments manufacture. However nowadays these industries have been slowly losing importance. Participants highlighted the low level of R&D&I activities and non-existence of any research centers.

Funding – The financial resources are limited while the implementation of the circular economy is rather expensive especially for regions such as The Charles Spa since serious infrastructure investment is requested.

Specialized education & technology: Lack of knowledge, possibilities and potential of the bioeconomy in the region, there is a lack of knowledge and training, the entrepreneurs do not dispose of modern technical equipment that limit the possibilities to go circular.

Finland

The Finnish Info Days and interviews shed light to the current situation of the local CBE along with a few more challenges and enablers for the transition. The topics that were discussed were:

Added value: Pulp production represents a significant part of the Finnish forest industry and there was a discussion on whether this is an optimal situation. Given that there are great new circular economy initiatives, and a great demand for added value, the participants thought that there should be a larger profit margin. Now the value of the final product is quite low, so it limits the possibilities. In the interviews was also mentioned that local hackathons are organised to boost bioeconomy and find partners for innovations. Students are also taking part of these events.

Energy: Finland produces renewable energy mainly from forest sector side streams. However, it is believed that the renewable energy issue needs to be rethought. This could be achieved by reforming the energy policy.

Regulations: Regulations are a challenge for extensive valorisations as they are rather restrictive. There should be a permit process to allow the development of new solutions. Standards should also be adapted to include current processes and products. Another difficulty is changing the legal waste status. Correcting the regulation regarding waste thinking can create a positive impact.

Market based incentives/ fossil competition: The cheapness of fossil-based raw materials, and their highly developed production processes and strong economic mechanisms make more sustainable solutions hard to compete. The development of market mechanisms can help favor these solutions.

Underutilized side streams: Forestry production side-streams that haven't yet been utilised to their full potential were identified. Those include green liquor dregs in particular go underutilized, ash, lignin, useful chemicals should be recovered from the wood chips and bark before energy recovery, and hemicelluloses, Side streams more visible with the help of digitisation

Funding: It was pointed out that state funding for ecosystems must be utilised more comprehensively, as the current level of funding is low. As for research funds (National and EU) Business Finland is financing and awarding new businesses. Fundings are granted via Sustainable Growth Programme for Finland while the RRF funding (Funding from EU Recovery and Resilience Facility) is granted only if receiver is targeting the goals of green transition. The JTF (Just Transition Fund) that is financing

to compensate financial losses of green transition was also mentioned as an option without clarifying whether currently the region is receiving support. Funding for maintenance of transportation infrastructure was also pointed out as a necessity during the interviews.

Material Availability: Currently there's shortage of wood due to freezing import from Russia (about 10% was imported, mostly from Russia). Certain varieties like birch are hard to import while it was observed that the main shortage is on the energy sector and not the materials. In the long run, forest regeneration can help.

Social: Forest owners are more and more of them are expected to live in the cities in the future. The restructuring of forest owners is considered essential by stakeholders. Previously, private owners owned large forest areas, but with the generational change, the forest areas are fragmented. This causes e.g. raw material availability becomes more difficult as the forest owners are further away and more numerous than before.

North Rhine-Westphalia (Germany)

In North Rhine-Westphalia's Info Day, local stakeholders with different interests focused on the chemical industry and the defossilisation of its feedstock. After an introductory session, participants collected best-practice examples of transitions in NRW and beyond, as well as unused potentials for future transformation developments. They then identified several existing barriers to a successful transformation towards a circular bioeconomy and focused on four of them:

Competitiveness: on price against existing technologies and established economies of scale is a serious challenge for the circular bioeconomy. Some solutions proposed were the pricing of external factors, tax breaks, and the preference of public procurement for biobased solutions.

Regulatory issues can hinder the introduction of new technologies, especially when a range of agencies are involved. These issues should be considered, and planning projects along existing regulations can help ensure alignment with current regulations.

Goal-setting: the diverse aims of the transformational processes towards a circular bioeconomy can make the transition harder.

Lack of scale-up infrastructure in NRW and beyond means that innovators find it difficult to advance their technology to scale. There's a need for stronger investments in scale-up facilities, both from the public and private sectors.

In the interviews, these points were largely confirmed, with only few additional points raised, such as regulation surrounding the increased valorisation of municipal waste, the lock-in effects of existing fossil-based infrastructure, the difficulty of collecting and analyzing robust data on feedstock availability, or the strong influence of EU regulations.

Western Macedonia (Greece)

The feedback from the info day in Western Macedonia confirmed the findings of the desk research:

Bioeconomy education must be funded: It was noted that, in Cyprus, businesses that have proof of training in bioeconomy principles, are already being funded.

Circular mentality to be cultivated: Stakeholders should understand that with the implementation of bioeconomy the economic benefit will come as a result. There is a need to change mentality in the management and the methods regarding bioeconomy.

Biomass potential: Regarding bioeconomy in the wood-furniture sector, a variety of materials could be used together. More opportunities with other materials should be explored e.g., blood and biogas can have a future together, and also there's a need to find out which are the bioeconomy good practices that exist in every country. Agriculture deriving biomass potential was also pointed out during the interviews. However, the exact amounts that can be retrieved are not known. OPEKEPE (the Greek Payment Authority of Common Agricultural Policy (C.A.P.) Aid Schemes) has records for all the crops produced and can convert it into biomass quantity by mathematical formula. Thus, it can be a good start to investigate the potential, though not completely accurate.

Access to funding: The financial incentive is also essential so it must be taken into account. The stakeholders of the region should look for proposals with EU funding, for example CluBE as a regional cluster could have an active role in that. The interviews revealed that there are some related funding options like the "Green Transition" program of the NSRF and the action "Skills upgrading and retraining programs in high-demand industries with an emphasis on digital and green skills". The latest is implemented within the framework of the National Recovery and Resilience Plan "Greece 2.0" with funding from the European Union – NextGenerationEU and the National Action Plan for the promotion of Green Public Procurement (2020 – 2023).

Bioeconomy awareness: The survey among participants showed that many are informed about bioeconomy and already active in it. The people that were less informed or inactive came from SMEs, and not from authorities or academia. Almost everyone recognizes the need for a transition to bioeconomy in the region, and many are aware that some progress has been made towards this goal.

R&D: Some R&D centers and actors were identified during the interviews namely; CERTH which is the Centre for Research and Technology Hellas. It is a leading research centre in Greece and in the EU, based in Western Macedonia. Also, there is the University of Western Macedonia which conducts a lot of research and has a technology transfer office as well as some spin-offs, such as Metamind Innovations I.K.E., Sure A.E., Energy Capability Center, Innovative Research Applications – Innora I.K.E., Private Equity Company for Regional Development Studies–Red Consulting I.K.E., Industry4forEnergy I.K.E., Activecode I.K.E., Omega Innovations , Innovative Network and Systems I.K.E – Insys I.K.E., Social Cooperative Enterprise for Public Utility and Development Initiatives–Helix 4. Also, three flagship projects have been set for implementation. The Technology Park, the Innovation Hub for hydrogen and energy storage and the Green Data Center under the supervision of the Just Transition Observatory.

Andalusia (Spain)

The participants were asked to vote for the main challenges and opportunities for Andalusia to step into a circular bioeconomy model. Most findings were also supported by the desk research.

The main challenges according to the attendees are: the bureaucracy, the lack of consumer information, the absence of industrial symbiosis, and the legislation and standards. On the opportunities side, the most prominent have been: waste recovery, support for the Andalusian Public Administration, new market opportunities, industrial symbiosis, and administrative streamlining.

R&D: The existence of R&D infrastructure according to the interviewees is not sufficient despite the adequate amount of biomass residues that present many opportunities. Semi-industrial testing is done outside Andalusia. Some centers were identified though like Lifewatch ERIC, JRC (Joint Research Centre), Andalusia Agrotech DIH (EDIH), and Junta de Andalusia.

Funding: Funding is not sufficient especially in the field of development of new solutions and R&D. Although sustainability is a strong financing factor for local actors to participate in funded projects, there's clearly a need for further financial support and accessing for this specific region of Spain.

The following table summarizes the findings from the local info days & interviews.

Table 9: Info days & Interviews feedback / summary

Country	Region	Topics	Details
Austria	Northern Burgenland	Environment:	-Biomass from lake but with environmental challenges -Agricultural practices
		Public Agreement:	- Need for stakeholder and political alignment
		Transportation:	- Limited road & public transport system
		Brain drain:	- Many high school graduates, many leave - Early school awareness needed
		Funding:	Funding incentives required for R&D and sustainable agriculture
Czech Republic	Charles Spa Region	Declining economic activities:	- Deeply rooted traditional activities that are on decline
		Funding:	- Need to access financial resources
		Specialized education & technology:	- Lack of training, knowledge and modern equipment

Finland	Country level	Added value:	-Need for added value solutions, now the product is low cost
		Energy:	-Reform energy policy, renewable energy from side streams to be reconsidered
		Regulations:	-Need for flexibility for new solutions and for the legal status of waste
		Market incentives:	-Market mechanisms to tackle fossil competitors
		Underutilised side streams:	-Green liquor dregs, ash, lignin, useful chemicals to be recovered from the wood chips and bark before energy recovery, hemicelluloses
		Funding:	- Funding for ecosystems to be utilized more comprehensively, the current level of funding is low - Funding for infrastructure maintenance
		Material availability:	-Imported material from Russia makes production difficult. Forest regeneration helps in the long run
Germany	North Rhine-Westphalia	Scale-up challenges:	-Insufficient availability of scale-up facilities, need for more investment
		Competitiveness:	-New processes and products can't compete on price alone, compared to established technologies, regulation/removal of subsidies/externality pricing necessary
		Regulations:	-Often hinder new technology advancement, new projects should be planned keeping existing regulations in mind
		Goal-setting:	- Need for coordination of existing strategies and definition of trade-offs - Difficulty due to diverse aims of transformational processes
Greece	Western Macedonia	Education:	-Must be funded
		Circular mentality:	-In CBE profit follows good management

		Biomass potential:	- Wood, furniture, blood for biogas, search good practices - Agriculture residuals should be researched more
		Funding:	-Funding is an incentive, EU opportunities to be examined
		CBE awareness:	-Political awareness exists, need for more SME involvement
		R&D:	-Some research centers are available but this sector needs development & funding
Spain	Andalusia	Challenges:	-Bureaucracy -Consumer misinformation -Absence of industrial symbiosis -Legislation and standards
		Opportunities:	-Waste recovery -Support for the Andalusian Public Administration -New market opportunities -Industrial symbiosis -Administrative streamlining
		Funding:	-The region needs better access to funding opportunities
		R&D:	-More research centers needed for industrial testing

6. Conclusions

The BIOTRANSFORM regions were examined in the perspective of potential transition pathways to circular bioeconomy under several KPI's like current and potential policy measures at regional, national and local levels, residues to all necessary commodities, investigations on measures aiding the circular bio-based transition growth and influence in each region, stakeholder networks, funding sources, technologies and R&D development. The involvement of stakeholders in the report findings was also a part of the co-designing and awareness process.

The presented regions have on one hand some similarities, but they also differ in particularities. There are regions where a regional strategy was accepted and implemented, regions without political commitment. Some have existing networks, advanced technological infrastructure and sufficient biomass resources while others lack behind. Additionally, there are regions that are supported by the EU as they participate to the Just Transition Funding scheme.

In developing the transition to a circular bioeconomy, a regions' specific background, infrastructure, feedstock provision, and existing stakeholders must be taken into account. Transition to a circular bioeconomy must be mostly based on the existing infrastructure dedicated to biomass processing, regional CBE technologies and utilize the existing network of primary producers, bio-waste business and energy suppliers. Each region has its own strengths and weaknesses which should always be taken into consideration. For instance, in the Charles Spa region in Czech Republic, almost 45% of the region is covered by forest. The utilization of forestry biomass can therefore be an input for the circular bioeconomy transition. Similar alternatives are observed in other regions as well. This means that even if the local economy's traditional activities are in decline, there are always opportunities for valorization.

Strong networks, as well as the alignment of policy makers and stakeholder involvement are of great importance. In studying the case regions of Burgenland and North Rhine-Westphalia, it was highlighted that different political bodies and stakeholders may have a different visions of the CBE transition and prioritize the potential benefits and challenges (environmental, ecological, economic, social, health, etc.) from different viewpoints. The broad aspect of CBE might necessitate cooperation incentives and opportunities for constructive dialogue between stakeholders from the private sector to help align different interests. It was suggested to base the transition to a circular bioeconomy on the existing infrastructure relevant to CBE and utilize the existing network of primary producers, bio-waste business and energy suppliers. Supporting local stakeholders can bring profits for the local economy and create fertile ground for advancement. The transition, however, might require new players who have additional demands on infrastructure. For example, North Rhine-Westphalia, with a lignite mining region in transition, will require heavy investing on new infrastructure to support a circular bioeconomy economic model.

The absence of R&D facilities and education is another very important key factor that holds back the CBE transition progress. Western Macedonia, the Charles Spa region, and Burgenland face this problem rather intensively. Lack of proper know-how, especially in the field of bioeconomy, inadequate R&D infrastructure and lack of innovation activity limits the potential to create sustainable added value solutions; educating the local workforce may be seen as a long-term investment but will inevitably return the investment and bring yields.

Favorable legislation that supports both fair competitions yet allows introducing new technologies, solutions and biomass valorisation opportunities, also needs careful design and open dialogue between policy makers and CBE local actors is vital. Spain, Finland and Germany are strong advocates for this need since they have very promising biomass resources but are rather restricted by regulations. Clear goals and alignment in public strategies can enhance and speed up circular bioeconomy transition. Both Finland and Germany are showing good examples for regions (f.e. the Charles Spa Region) that only now investigate local opportunities for biomass valorization and build their national/or local CBE strategies.

To conclude, all the examined factors (strategy, measures, governance and stakeholder involvement, existing technologies, R&D infrastructure, biomass residues, and access to funding) play a very important role in the advancement of local circular bioeconomy transition. Each region is different and has different needs that need to be addressed in the transition. The good examples of the more advanced regions can support and speed up the transition in other regions indicating areas that are vital for the successful transition toward CBE. This document provided effective screenings of current and potential policy measures, discuss unexploited biomass and technology equipment for the efficient biomass utilisation to support the circular bio-based transition. The findings acquired by this report establish the basis for comparing the benefits of a transition from linear fossil-based economies to circular bio-based systems taking into consideration regional characteristics.

References

1. Alexandra Gottinger, Luana Ladu & Rainer Quitzow (2021): Studying the Transition towards a Circular Bioeconomy—A Systematic Literature Review on Transition Studies and Existing Barriers: Sustainability, 10(21) 17-27
2. Andersen, M.S.; Christensen, L.D.; Donner-Amnell, J.; Eikeland, P.O.; Hedeler, B.; Hildingsson, R.; Johansson, B.; Khan, J.; Kronsell, A.; Inderberg, T.H.J.; et al. To facilitate a fair bioeconomy transition, stronger regional-level linkages are needed. Bio-fuels, Bioprod. Biorefining 2022, 16, 929–941. https://doi.org/10.1002/bbb.2363.
3. Bergek, A. Shaping and Exploiting Technological Opportunities: The Case of Renewable Energy Technology in Sweden. Ph.D. Thesis, Chalmers University of Technology, Gothenburg, Sweden, 2002
4. Bioenergy IEA, Technical, Economic and Environmental Assessment of Biorefinery Concepts. International Energy Agency, Paris (2019).
5. Bogler, K. & Doyone, A. (2019) Circular cities: exploring local government strategies to facilitate a circular economy. EUROPEAN PLANNING STUDIES, VOL. 27, NO. 11, 2184–2205 https://doi.org/10.1080/09654313.2019.1642854
6. Bracco, S.; Calicioglu, O.; Gomez San Juan, M.; Flammini, A. Assessing the Contribution of Bioeconomy to the Total Economy: A Review of National Frameworks. Sustainability 2018, 10, 1698. https://doi.org/10.3390/su10061698
7. Brouwer, F.; Mantino, F.; Polman, N.; Short, C.; Sterly, S.; Rac, I. Private Sector Actions to Valorise Public Benefits from Agriculture and Forestry. EuroChoices 2018, 17, 16–22
8. Dietz, T.; Börner, J.; Förster, J.J.; von Braun, J. Governance of the Bioeconomy: A Global Comparative Study of National Bioeconomy Strategies. Sustainability 2018, 10, 3190.
9. Efken, Josef & Dirksmeyer, Walter & Kreins, Peter & Knecht, Marius. (2016). Measuring the importance of the bioeconomy in Germany: Concept and illustration. NJAS - Wageningen Journal of Life Sciences. 77. 10.1016/j.njas.2016.03.008.
10. European Commission, Bioeconomy Development in EU Regions. European Commission, Brussels (2017).
11. Grin, J.; Rotmans, J.; Schot, J. *Transitions to Sustainable Development. New Directions in the Study of Long Term Transformative Change*, 1st ed.; Routledge: New York, NY, USA; London, UK, 2010.
12. http://www.kr-karlovarsky.cz/samosprava/dokumenty/Documents/koncepce/OZZ_uzemne_energeticka_koncepce.pdf
13. http://www.kr-karlovarsky.cz/samosprava/dokumenty/Documents/koncepce/ODPADY_POH_KVK_analyticka_cast_26_10_2015.pdf
14. http://www.kr-karlovarsky.cz/samosprava/dokumenty/Stranky/koncepce/oblast-zivotni-prostredi/Plan_odpady.asp
15. http://www.vary2040.cz/_files/ugd/bd1b76_ad4f93efbf0a4f788812936c4fe8770d.pdf
16. http://www.vary2040.cz/_files/ugd/bd1b76_ad4f93efbf0a4f788812936c4fe8770d.pdf
17. https://dotaceeu.cz/getmedia/70636969-9d91-49ae-b41d-af4b5027234e/PSUT-dokument_2.pdf.aspx
18. https://www.by-cz.eu/fileadmin/user_upload/interreg/downloads/downloads_21-27/Dokumente_zur_Programmgenehmigung/Programovy_dokument_BY-CZ_1.verze-17.03.2022.pdf
19. https://www.czso.cz/csu/czso/bd003d6c71
20. https://www.mattoni.com
21. https://www.ris3kvk.cz/download/documents/preshranicni-regionalni-inovacni-strategie-karlovarskeho-kraje-a-svobodneho-statu-bavorsko.pdf
22. https://www.ris3kvk.cz/download/documents/preshranicni-regionalni-inovacni-strategie-karlovarskeho-kraje-a-svobodneho-statu-sasko.pdf

23. Ida Andersson, Ida Grundel, Regional policy mobilities: Shaping and reshaping bioeconomy policies in Värmland and Västerbotten, Sweden, Geoforum, Vol. 121, 2021, Pages 142-151, ISSN 0016-7185, https://doi.org/10.1016/j.geoforum.2021.02.005.
24. Indra Muizniece, Lauma Zihare, Jelena Pubule, Dagnija Blumberga. This is an open access article licensed under the Creative Commons Attribution License (http://creativecommons.org/ licenses/by/4.0), in the manner agreed with Sciendo.
25. Jiang, L.; Zhang, J.; Wang, H.H.; Zhang, L.; He, K. The impact of psychological factors on farmers' intentions to reuse agricultural biomass waste for carbon emission abatement. J. Clean. Prod. 2018, 189, 797–804.
26. Kemp, R.; Schot, J.; Hoogma, R. Regime shifts to sustainability through processes of niche formation. The approach of strategic niche management. *Technol. Anal. Strateg. Manag.* 1998, *10*, 175–198.
27. Loorbach, D. Transition management. In *New Mode of Governance for Sustainable Development: Nieuwe Vorm Van Governance Voor Duurzame Ontwikkeling = Transitiemanagement*; Erasmus University Rotterdam: Rotterdam, The Netherlands, 2007.
28. Lovec,M.;Juvancˇicˇ,L.The Role of Industrial Revival in Untapping the Bioeconomy's Potential in Central and Eastern Europe. Energies 2021, 14, 8405. https://doi.org/10.3390/en14248405
29. Mccormick, Kes & Kautto, Niina. (2013). The Bioeconomy in Europe: An Overview. Sustainability. 5. 2589-2608. 10.3390/su5062589.
30. Metodika identifikace a faktické dostupnosti konkrétního druhu biomasy, 2020… https://agronavigator.cz/sites/default/files/users/user291/Nmet-dostupnost-biomasy-B2G-web.pdf
31. Mikielewicz, D.; Dąbrowski, P.; Bochniak, R.; Gołąbek, A. Current Status, Barriers and Development Perspectives for Circular Bioeconomy in Polish South Baltic Area. Sustainability 2020, 12, 9155. https://doi.org/10.3390/su12219155
32. Philp, J., 2018. The bioeconomy, the challenge of the century for policy makers. N. Biotechnol., 40, 11-19. https://doi.org/10.1016/j.nbt.2017.04.004
33. Popescu, I., 2014. Industrial biotechnology in the European union: identifying the best pathways to boost growth of the bioeconomy. Industrial Biotechnology 10, 376e378. https://doi.org/10.1089/ind.2014.1537 .
34. Rip, A.; Kemp, R. (Eds.) *Technological Change*; Battelle Press: Columbus, OH, Canada, 1998.
35. Rodrigo Salvador, Murillo Vetroni Barros, Mechthild Donner, Paulo Brito, Anthony Halog, Antonio C. De Francisco, How to advance regional circular bioeconomy systems? Identifying barriers, challenges, drivers, and opportunities, Sustainable Production and Consumption,Vol. 32, 2022, 248-269, ISSN 2352-5509, https://doi.org/10.1016/j.spc.2022.04.025.
36. Ronzon, Tévécia & Sanjuán, Ana. (2019). Friends or foes? A compatibility assessment of bioeconomy-related Sustainable Development Goals for European policy coherence. Journal of Cleaner Production. 254. 119832. 10.1016/j.jclepro.2019.119832.
37. Rotmans, J.; Kemp, R.; Van Asselt, M. More evolution than revolution. Transition management in public policy. *Foresight* **2001**, *3*, 15–31.
38. Schmidt, O., Padel, S., & Levidow, L. (2012). The Bio-Economy Concept and Knowledge Base in a Public Goods and Farmer Perspective. Bio-Based and Applied Economics, 1(1), 47–63. https://doi.org/10.13128/BAE-10770
39. Schütte, G. (2018) What kind of innovation policy does the bioeconomy need? New Biotechnology, 40, 82–86.
40. Smith, A.; Voß, J.P.; Grin, J. Innovation studies and sustainability transitions. The allure of the multi-level perspective and its challenges. *Res. Policy* 2010, *39*, 435–448
41. Tarun Roy, Jose Arturo Garza-Reyes, Vikas Kumar, Anil Kumar, Rohit Agrawal, Redesigning traditional linear supply chains into circular supply chains–A study into its challenges, Sustainable Production and Consumption, Volume 31, 2022, Pages 113-126, ISSN 2352-5509, https://doi.org/10.1016/j.spc.2022.02.004.
42. Unruh, G.C. Understanding carbon lock-in. *Energy Policy* 2000, *28*, 817–830.
43. Van der Brugge, R.; van Raak, R. Facing the adaptive management challenge: Insights from transition management. *Ecol. Soc.* **2007**, *12*, 33.
44. Wells, P.; Nieuwenhuis, P. Transition failure. Understanding continuity in the automotive industry. *Technol. Forecast. Soc. Chang.* 2012, *79*, 1681–1692.
45. www.bio-hub.cz

46. Zeko-Pivač A, Tišma M, Žnidaršič-Plazl P, Kulisic B, Sakellaris G, Hao J and Planinić M (2022) The Potential of Brewer's Spent Grain in the Circular Bioeconomy: State of the Art and Future Perspectives. Front. Bioeng. Biotechnol. 10:870744. doi: 10.3389/fbioe.2022.870744