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CELEBio

D.3.2 REGIONAL BIOECONOMY ACTION PLAN

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AUTHORS: CALLIOPE PANOUTSOU, LIYANA ADJAROVA, LORA JIBREEL, DINKO ĐURĐEVIĆ, ŽELJKA FIŠTREK, BILJANA KULIŠIĆ, ANA MANDARIĆ, MARKUS DETTENHOFER, ÉVA HUNYADI BORBÉLYNÉ, MÁRTA SZABÓ, MIHA KOPRIVNIKAR KRAJNC, STEFAN VRATNY, DOMINICA JENDRUSOVA, EMMANOUIL KARAMPINIS, DRAGOSLAVA STOJILJKOVIĆ. VLADIMIR JOVANOVIĆ, NEBOJŠA MANIĆ, PETAR M. GVERO.

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1. Introduction

The aim of the report is to provide advice for the development of a Regional Bioeconomy Action Plan in the CELEBIO countries[1] and has been prepared through a participatory process with project partners and national stakeholders in the twelve countries.

The analysis aims to inform future actions for bioeconomy in the region by focusing recommendations to domestic raw materials, regional challenges, infrastructure, and current state of biobased markets. The work builds on several meetings performed in the participating countries (combination of online and physical), online consultations and data from the project deliverable D.2.4: Summary report on the availability of biomass residues and biobased economy business opportunities for the CELEBIO region, and:

- narrows the analysis, based on the feedback received by national stakeholders, to a set of biobased value chains which entail innovation, are resource efficient and can be sourced with domestic raw materials,
- outlines policy related challenges for their valorisation and strategic benefits from their market uptake,
- recommends future actions and potential interventions, tailored to the individual value chains, that can steer the implementation of bioeconomy and the uptake of biobased products in the region,
- provides an overview of potential policy interventions for the relevant market segments related to agricultural, forest and biowaste value chains and further groups them to early and mature markets to allow for a broader mix of considerations and challenges that need to be addressed by future policy,
- highlights selected relevant policies (finished and ongoing) in other EU countries, and
- aggregates actions and interventions and outlines key actors that should be involved.

[1] Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Greece, Hungary, Montenegro, North Macedonia, Serbia, Slovakia, and Slovenia.

2. Opportunities, challenges, and domestically sourced value chains

This section briefly discusses the opportunities and challenges for the understudy countries. Following, it further narrows the analysis, based on consultations with national stakeholders, to a set of value chains from agriculture, forestry and biowastes which entail innovation, are resource efficient and can valorise domestic raw materials and natural resources which are currently unexploited.

Opportunities & challenges

The operational area of the CELEBIO project has significant natural resources and high presence of biomass raw materials. The economic development and infrastructures, however in most of the countries fall behind the EU average and significant advances are required to progress with biobased market development and facilitate the transition to production and use of biobased product by 2030.

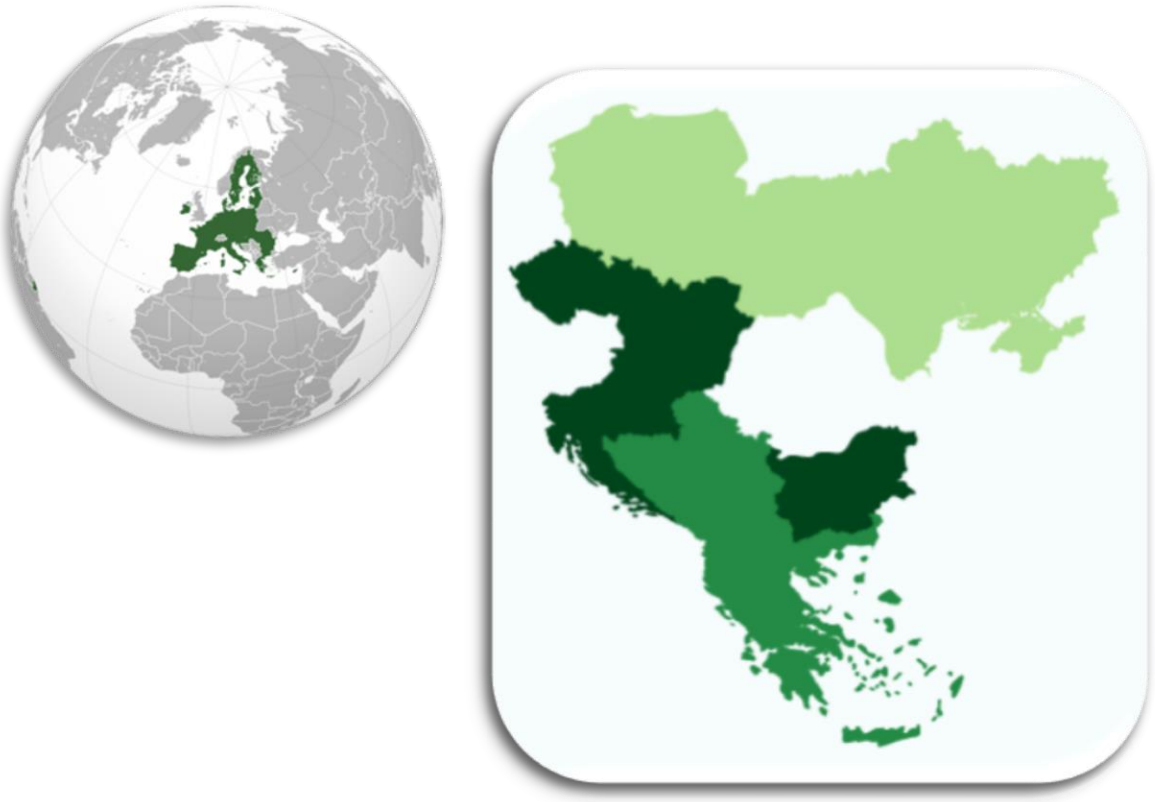

Figure 1 CELEBIO operational area [2]

[2] Source for global European Union map: https://commons.wikimedia.org/wiki/File:Global_European_Union.svg

Table 1 opportunities and challenges for biobased industries in the CELEBIO countries[3]

	Opportunities	Challenges
AL	Increase the added value of Albanian exports through sustainable biobased products.	Absence of state policies and support. Limited funds for establishing new bio-based value chains. Small internal market. Lack of knowledge on establishing bio-based value chains. Limited interactions and participations in European R&I actions.
BiH	Companies with certain bio-based interests / state-of-the-art chemicals or plastic production. Strengthening support for food industry to source inputs from domestic producers. Improved production quality, standards, and reliability of supply to the food industry. Strengthened value chain integration. Job creation. Increased competitiveness of the country.	Lack of knowledge among the stakeholders in whole levels. Lack of incentives and support from governmental side. Low-level of promotion of bio-based industries. Lack of investments in bio-refinery projects. Non-compliance with market standards and inability to export.
BG	Underexploited potential of agricultural residues. Pilot projects to connect the research community and private investors. EU funding for innovative bio-based initiatives. EC vision to mandatory inclusion of bioeconomy development in the National Strategic Plans for Agricultural Development - the basis of the reformed Common Agricultural Policy (CAP).	Lack of projects related to rural development for bioeconomy. Lack of R&D and innovations infrastructure outside universities and outside of the capital. Lack of HiTech institutions for innovations in some of the largest cities. Lack of cooperation between academia, public and the private sector. Low interest in science among young people. Low level of internationalisation of SMEs.
CZ	Engineering new tools and machines for the automation of processes of bioeconomic sectors. The "bioplastics"/alternative packaging market can be further developed. The availability of used cooking oil may be a good source of unused biomass. The use of residual wood can be used for any novel business ideas, as this resource seems under-utilized. Abandoned mining lands offer the opportunity to reclaim such lands through remediation crops.	Soil erosion and contamination of soil through increased chemical fertilizers and pesticide use. Overall land contamination, without remediation will reduce the overall output of biomass in agricultural lands. The water stress and lack of adequate management of the bark beetle, will significantly reduce forestry stocks. Low development of innovative solutions and willingness to try new concepts.

[3] Detailed country analysis is included in the CELEBIO individual country reports.

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	Opportunities	Challenges
GR	New companies (often start-ups) offering bio-based products. Re-start of the national sugar production, possibly integrating bioethanol production.	Lack of commercial medium/large scale biorefineries. Limited capacity of internal market. No major large-scale consumer movement to embrace bio-based products beyond certain sectors.
HR	Pilot projects to connect the academy community and private investors. The underexploited potential of agricultural residues. Connection with the tourism sector Programmes to keep the young people in the country (decrease "brain drain"). PPP expanding to other sectors. Expansion of food and processing industry, pharmaceutical and cosmetic industry into bio-based products and markets. Financing from EU funding, aligned with financing of waste management system (waste management centres).	insufficient connection and research projects between academia, public and the private sector. A small rate of high TRL (6-9) research/development infrastructure The loss of engineers (scientists, engineers, doctors, …) due to "brain drain". No PPP in other sectors except construction Development based on individual approach. The loss of experts (and young people) due to rising competitiveness in other countries. The loss of start-up companies due to lack of recognition of the legislative framework.
HU	Public support for the use of biomass. Stable internal market. There are official regulations for productions and the market. Contributes to biodiversity More employment opportunities. Clarified legal and ownership system Low interest rates for loans related to biobased initiatives. The amount of available raw material is often higher than the capacity of the processing.	Problematic mobilization in mountain areas regarding heavy weight transport. High-cost demand for upgrade the equipment and machinery regarding recirculation of energy sources. Not enough capacity for grid feeding – there is a need for grid development. The fragmented ownership of the distribution network makes complicated the further developments.
MN	Expanding the capacity for processing agricultural products. Organic farming. Development of agriculture through tourism, additional food consumption.	Non-sustainable and material and energy non-efficient production. Much of the production is not competitively priced. Unfavourable age and social structure in rural areas. Administrative implementation. Low productivity, agricultural production, lack of modern technology and knowledge. Lack of planning and land use regulation. Lack of network infrastructure.

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	Opportunities	Challenges
MK	Companies with strong bio-based interests / state-of-the-art chemicals or plastic production. Energy analysis in the municipalities. Creation of teams that are trained to l lead the overall process. Preparation of Feasibility Study and identification of possible sources for financing for development of such industries.	Lack of support (institutional and financial). Unreadiness of the producers and market. Loss of competitive market advantage.
RS	Restructuring of exports in the direction of increasing the share of products with high domestic added value. Successful international positioning in the market of high quality industrial products and services. Increasing energy efficiency and the degree of resource reuse in industrial production. Encouraging effective interactions between university and research institutions and companies. Forming effective public-private partnerships. Additional harmonization of quality standards and other regulations of the industry of the Republic of Serbia with the EU. Developing financial markets and providing access to alternative sources of financing. Strengthening the awareness of domestic consumers about the advantages of products made of biomass in relation to similar or the same products from other (artificial) materials and thus creating conditions for the growth of demand in the domestic market. Determination of the Government for the introduction of green procurement in the public procurement system of Serbia.	Small number of alternative sources of financing and underdeveloped financial markets. Insufficient development of clusters and other forms of association. Low level of cooperation between domestic industrial economic entities. Infrastructure differences.
SI	Companies with strong bio-based interests / stateof-the-art chemicals or plastic production.	Middle of bio-chemicals/materials value chain missing / very high-CAPEX technologies. Loss of competitive market advantage / not developing own bio-based processes (buying them).

	Opportunities	Challenges
SK	Large space for investments in food processing Possibilities for investments in furniture industry. Opportunities in investments in pulp and paper industry Space for investments in biochemical production.	Insufficient industrial capacities for agricultural products processing. Lack of food processing industry. Obsolete food processing technologies. Lack of investment means Insufficient systems of subsidies for food processing. Extreme high dependency on foreign food selling chains. Low interest of the government for bioeconomy development and high preferences for the automotive. Insufficient subsidy system for bioeconomy development. Absence of capital market Strong financial superiority of foreign competition. Risk adversity of domestic entrepreneurs.

Domestic biobased value chains

Table 2 Agricultural value chains selected by stakeholders in the CELEBIO regionpresents the agricultural value chains that stakeholders in the CELEBIO region selected as most important to focus activities for developing the bioeconomy markets in the 2020- 2030 timeframe.

Table 2 Agricultural value chains selected by stakeholders in the CELEBIO region.

Value chain	AL	BiH	BG	CZ	GR	HR	HU	MN	MK	RS	SI	SK
Field crop & animal residues												
Straw & prunnings for biobased materials & energy			√		√		√			√		
Medicinal and aromatic plants			√				√			√		
Manure for biogas & fertilisers					√					√	√	√
Corn stover for biofuel (HU)							√					
Agro-industrial residues												
Slaughter houses & meat industry for oleochemical industry, cosmetics, proteins, animal feed, biogas, heat & electricity, organic fertilisers			√								√	
Distilleries for biogas			√									
Food and beverage industries for bioactive components, fibrous materials, fertilisers, biogas, heat & electricity			√									
Dairy industries for food additives, bioactive components, biogas, heat & electricity			√								√	√
Cereal processing for food & feed additives, bioactive compounds, platform chemicals, bioplastics, bio-composites, heat & electricity											√	√
Polutry meat side-streams (HR)						√						
Industrial crops in unused, abandoned land	√	√	√	√		√		√	√	√		

Table 3 presents the forest value chains that stakeholders in the CELEBIO region selected as most important to focus activities for developing the bioeconomy markets in the 2020- 2030 timeframe.

Table 3 Forest value chains selected by stakeholders in the CELEBIO region.

Value chain	AL	BiH	BG	CZ	GR	HR	HU	MN	MK	RS	SI	SK
Primary forest residues for eco-innovation, construction, fertilizers, and bio-degradable packaging materials	√	√	√	√	√		√	√	√	√		
Secondary forest residues (lignin, hemicellulose, cellulose) for advanced biofuels, bioplastics, biopolymers, fibres and chemicals	√	√		√	√	√		√		√	√	√
Forest biomass for energy	√	√	√		√		√			√		
Lower quality wood assortments (industrial processing eg. plywood / pulp & paper industry) for platform chemicals											√	√

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Table 4 presents the biowaste value chains that stakeholders in the CELEBIO region selected as most important to focus activities for developing the bioeconomy markets in the 2020- 2030 timeframe.

Table 4 Biowaste value chains selected by stakeholders in the CELEBIO region.

Value chain	AL	BiH	BG	CZ	GR	HR	HU	MN	MK	RS	SI	SK
Biowastes from different flows (households, industrial wastes, waste waters of food industry, etc) in anaerobic digestions installations			√		√		√			√		
Recovery of nutrients from wastewater treatment plants - sewage sludge					√					√	√	√
Secondary residues from food processing → electricity and heat (anaerobic digestion process) → digestate → biorefinery → bioplastic, pharmaceutical industry, construction industry			√		√	√						
Municipal sludge to biogas for heat & electricity	√	√		√			√			√		
Municipal waste for recycling plants	√	√								√		
Municipal waste for electricity and heat	√	√						√	√	√		
Paper industry effluents (primary sludge, in particular) for biofuels, fertilisers (in case of primary sludge with high carbohydrate contents) and/ or construction materials (in case of primary sludge with prevailing inorganic fraction)			√								√	
Food waste for animal consumption and biogas for heat & electricity			√	√						√	√	

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Table 5 a) Domestically sourced value chains from agriculture: understanding challenges for their valorisation and strategic benefits from their market uptake. is based on consultations with local stakeholders and outlines challenges for the valorisation of domestic biomass raw materials and strategic benefits from their market uptake.

Table 5 a) Domestically sourced value chains from agriculture: understanding challenges for their valorisation and strategic benefits from their market uptake.

Biomass raw material options		Challenges	Expected benefits
	Straw from cereals & oilseed crops	Maintenance of soil organic matter (SOM), competing markets for animal bedding and feeding, mushroom, flower bulbs, and strawberry production;	New markets for straw types that remain unexploited with respective income for farmers
	Prunnings from fruit trees, vineyards, etc.)	Possible loss of soil carbon; demand from traditional wood burners & stoves in rural areas; local practices must be considered to decide the amount of removals.	Improved regional infrastructure and new market opportunities for farmers.
	Manure (solid & liquid)	Low level of exploitation. Disperse raw material.	Use of manure as fertilizer to replace chemical ones and revitalize soil richness. Reduced soil pollution with nitrates.
	Industrial crops in unused, abandoned land	Many small producers but not well organised and linked to industrial actors.	Restore nutrient depleted lands, e.g. mining sites. Abundance of species that can provide raw materials for essential oils production, food additives and cosmetic products.
	Secondary residues from agri-food industries	Most countries in the region have high presence of small local and family agro-industrial enterprises which require more capital and extensive training. Specialised installation for management of side streams from agri-food industries, technologically advanced processing with relatively high added-value products.	Long tradition of food production and agri-food processing which offer great potential to integrate biobased activities. Less wastes from food-processing, use of side streams and reduction of negative impact on the environment. Untapped potentials in obtaining functional components and materials (bioactive components, fibrous materials).

Table 5 b) Domestically sourced value chains from forest biomass and biowastes: understanding challenges for their valorisation and strategic benefits from their market uptake.

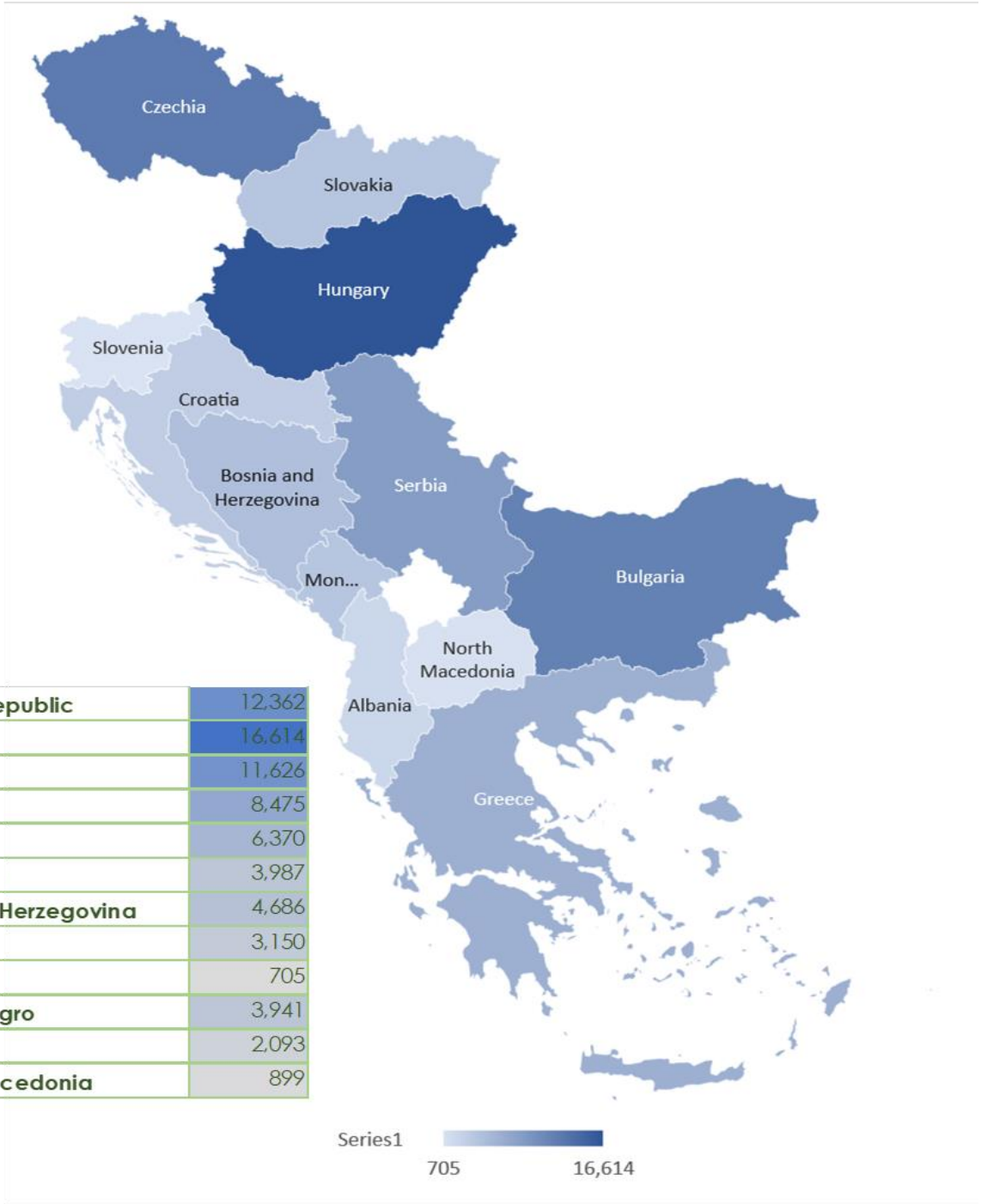
Biomass raw material options		Challenges	Expected benefits
	Primary forest residues from field operations	Low value-added of harvested timber. Fragmented ownership structure, which makes it difficult to establish efficient supply chains.	Forest restoration. Mobilisation of private forest owners and income increase through diversification of their markets. Increased eco- building activity.
	Secondary forest residues from sawmills & wood processing industries	Large quantities of secondary forest residues are exploited but the process technologies are not always efficient.	Upgrade lower quality wood to bio-based materials through biorefining. New market opportunities include dyes, resins, flavorings, and medicinal products.
	Biowastes	Waste management remains problematic in most countries and improvements are required in collecting, sorting and waste disposal procedures.	Enabling the collection of food waste through recycling in cities as an additional source for biogas. Increased efficiency of waste recovery methods in municipalities.

3. Future actions and potential interventions

This section highlights key facts, suggests future actions and potential interventions in the timeframe 2020-2030 and outlines the value chains' performance within ecological boundaries related to climate change, biodiversity, soil, water and air quality. Following it provides:

- an overview of potential policy interventions for the relevant market segments related to agricultural, forest and biowaste value chains and further groups them to early and mature markets to allow for a broader mix of considerations and challenges that need to be addressed by future policy.
- Highlights selected relevant policies (closed and ongoing) in other EU countries.

Agricultural value chains from primary field residues, agri-food residues, manure, and industrial crops in unused, abandoned land



Czech Republic	12,362
Hungary	16,614
Bulgaria	11,626
Serbia	8,475
Greece	6,370
Slovakia	3,987
Bosnia & Herzegovina	4,686
Croatia	3,150
Slovenia	705
Montenegro	3,941
Albania	2,093
North Macedonia	899

Figure 2 Estimated agricultural biomass potentials (in million dry tonnes per year) in the CELEBIO countries

Straw from cereals & oilseed crops

Most countries in the region, except Czech Republic and Hungary, have lower cereal yields therefore improvements in farming practices can still be achieved.

Straw is a field residue with many uses which provide an additional source of income to the farmer. This is particularly the case in countries and regions where there is a large concentration of livestock and/or other straw using horticultural activities.

Straw removal from agricultural soils must follow maximum sustainable removal rates that ensure maintenance of nutrients and corban in the soil and provide enough food and shelter to biodiversity.

Straw markets exist. Cereal straw harvesting is common practice. Stover/stubbles are difficult to harvest and no common practice.

Limitation for the collection is that the biomass is spatially dispersed, with relatively low density.

In many of the regions the transport system, both the road network and the transport means are not optimally developed.

Future actions

- Optimise the efficient uses of straw.
- Promote the efficient, sustainable use of available natural resources within safe planetary boundaries.
- Stimulate the usage of agricultural residues.

Potential interventions

- Expansion of regulatory and funding instruments for rural areas to include bioeconomy.
- Development of technologies for the conversion of straw to higher added value products.
- Support for sustainable farming.
- Assist farmer cooperatives to apply for grants.

Table 6 Value chain performance for straw

Issue	Impact category	Value chain performance
Climate change	GHG reduction, compared to fossil reference	Reduced fossil inputs.
	GHG related to land use change	Residues, no land use change.
	Carbon stock change	Removal rates must be tailored to local ecology.
Biodiversity	Biodiversity conservation and management	Biodiversity loss when harvesting too many crop residues. This may also have adverse effect on soil biodiversity.
Soil	Erosion	Risk on erosion when removing stubbles.
	Soil organic carbon	Risk to lose soil organic carbon when overharvesting crop residues.
	Soil nutrient balance	Risk to lose nutrients when overharvesting.
Water	Water availability and regional water stress	Indirect link to water use.
	Water use efficiency	
	Water quality	
Air quality	Acidification (SO2-emissions)	Value chain specific measurements required.
	Particulate emissions (PM10)	Even in new stoves/boilers PM emissions are still higher than the fossil alternative. For straw this can be a particular problem.

Agricultural prunnings (from fruit trees, vineyards, etc.)

The countries in the region have significant fruit tree cultivations and prunnings form part of the annual regular activities for the farmers.

Prunnings, however, are also an important source of nutrients and carbon and should not be fully removed from the fields. Removal of part of the residues may still be possible without endangering the nutrient and carbon levels in the soil.

Overall, it is however clear that leaving part of the (shredded) pruning residues will enhance the maintenance of soil organic carbon levels. What these levels should be is case specific given the wide diversity in permanent crop types, soil, and climate.

Limitation for the collection is that the biomass is spatially dispersed, with relatively low density.

In many of the regions the transport system, both the road network and the transport means are not optimally developed.

Prunnings are commonly used for heat in rural areas.

Suggested future actions

- Promote the efficient, sustainable use of available natural resources within safe planetary boundaries.
- Carefully consider local practices and primarily aim to amend the organic levels in the soils, where required.
- Provide support for machinery and storage facilities for biomass harvesting.

Potential interventions

- Design financing mechanisms which will support the integration of food production with bioeconomy both at field (field residues) and within agro-industries (processing residues). These mechanisms can be combined with respective regulations that foster sustainable farming and renewable energy in agro-industries.
- Financing should favour the development and/ or upgrade of biomass logistics/ trade centres, etc. to facilitate the development of local capacities with high quality standards which will further trade un-mobilised indigenous biomass sources.
- Assist farmer cooperatives to apply for grants.

Table 7 Value chain performance for agricultural prunnings

Issue	Impact category	Value chain performance
Climate change	GHG reduction, compared to fossil reference	Low fossil input in the chain
	GHG related to land use change	Residues, no land use change
	Carbon stock change	Removal rates must be tailored to local ecology.
Biodiversity	Biodiversity conservation and management	Management of landscapes can improve biodiversity. Biodiversity loss when overharvesting and habitats disturbance when harvested regularly.
Soil	Erosion	Management of landscapes can improve soil conditions. Potential soil erosion caused during harvesting (depends on practice).
	Soil organic carbon	Removal of prunings from permanent crops may reduce soil carbon when overharvested.
	Soil nutrient balance	Particular risk of reduced soil fertility and soil structure when harvesting stumps.
Water	Water availability and regional water stress	No dedicated water use. If removal leads to increased fertilisation the leaching on N to water may increase.
	Water use efficiency	
	Water quality	
Air quality	Acidification (SO2-emissions)	Value chain specific measurements required.
	Particulate emissions (PM10)	PM emissions can be a serious pollution problem in older wood stoves. Even in new stoves/boilers PM emissions are still higher than the fossil alternative. There can be high savings when open fires of woody residues are avoided.

Manure (solid & liquid)


Heat


Electricity


Fertilisers


gas

Except for Montenegro and North Macedonia, manure potential in the region is significant.

Czech Republic, Hungary, Greece, and Serbia also produce interesting quantities of manure which can and are sometimes already used in biogas.

In most countries in the region there are already many established anaerobic digestion plants. Most of these are located on farmlands.

Reducing the existing manure surplus is desirable and could be combined with solving environmental issues like GHG emissions and soil pollution.

A limitation for the collection is that manure is mostly spatially dispersed, with relatively low density.

Suggested future actions.

- Establishment of smaller biogas installations on larger agricultural holdings, or in cooperation with other users (e.g local communities) in collective investments.

Potential interventions

- Introduce standards and premiums for manure.
- Future policy for manure should reward anaerobic digestion installations not only as a renewable energy installation but also as a solution for environmental issues (avoid methane emissions) and as a producer of valuable products like soil fertilizer, meaning that an anaerobic digestion installation becomes a decentral biobased refinery.

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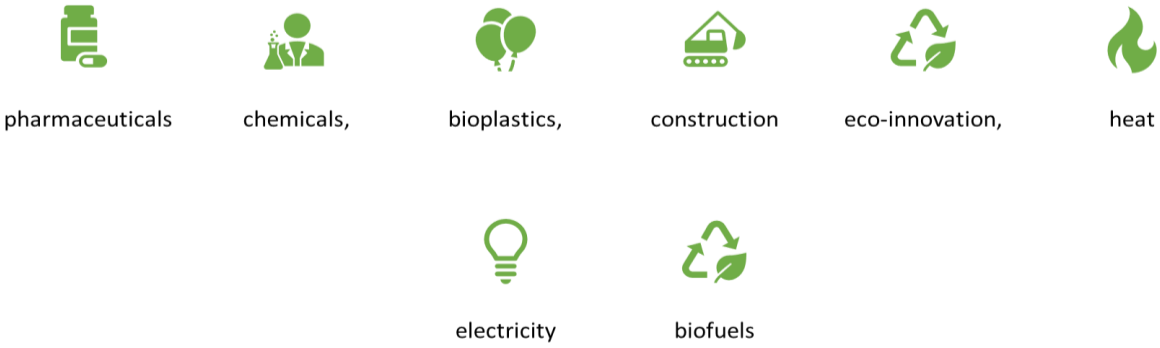
Table 8 Value chain performance for manure

Issue	Impact category	Value chain performance
Climate change	GHG reduction, compared to fossil reference	Next to replacing fossil fuels, methane emissions of manure storage avoided. Potential methane slip.
	GHG related to land use change	No land use change
	Carbon stock change	Removal rates must be tailored to local ecology.
Biodiversity	Biodiversity conservation and management	Extracting energy from manure has no direct impact on biodiversity. (In general the use of manure as fertiliser can have impact on biodiversity)
Soil	Erosion	No link to erosion
	Soil organic carbon	When digestate is used as fertiliser instead of liquid manure, the carbon content is reduced.
	Soil nutrient balance	Digestate can still be used as fertiliser.
Water	Water availability and regional water stress	No link to water use
	Water use efficiency	
	Water quality	May reduce N-surplus and N-leaching if manure/dried digestate is exported.
Air quality	Acidification (SO2-emissions)	Value chain specific measurements required.

Industrial crops in unused, abandoned land



The potential of unused and abandoned land potential is quite large in some countries due to a large collective or state farms being in the process of land privatisation and rehabilitation.

Much land has been abandoned due to lack of lack of start-up capital for agricultural investments. Such lack of capital forces landowners to leave part of their land outside agricultural use.

Suggested future actions

- Increase the cultivation of industrial (medicinal, aromatic, perennial grasses, Short Rotation Coppice) plants, particularly in unused and abandoned land in rural areas.
- Establish local co-operatives.
- Increase the cultivation of industrial crops, particularly in nutrient depleted lands, e.g., mining sites. There are many opportunities for hemp and other fibre crops to provide raw material to the automobile manufacturing value chain (car interiors), and well as the expertise in novel textiles.

Potential interventions

- Research and demonstration grants should target the development of high yielding varieties with tolerance in the regional climate and ecology.
- Introduce modules for agricultural biomass in regular training activities and/ or awareness campaigns for farmers, farmer cooperatives, etc.
- Create tax incentives to support industrial crops in unused and abandoned land.
- Increase public awareness.
- Provide start-up financing for farmers.

Table 9 Value chain performance for industrial crops

Issue	Impact category	Value chain performance
Climate change	GHG reduction, compared to fossil reference	Low fossil input in the chain
	GHG related to land use change	Potential (indirect) land use change; limited in case of marginal lands. If produced on medium to good quality soils there is competition with food and feed crops, leading to indirect land use change.
	Carbon stock change	Removal rates must be tailored to local ecology.
Biodiversity	Biodiversity conservation and management	No or low pesticide and nitrogen applications so (practically) no direct negative impacts on habitat quality; can provide winter shelter; birds nesting inside plants. May also destroy sensitive habitats (e.g. steppic habitats, High Nature Value farmland, biodiversity rich grasslands) when introduced.
Soil	Erosion	Risk for damaging soil structure (e.g. harvesting, root removal after 20 years),
	Soil organic carbon	Potential use of marginal lands, which can increase soil quality and soil carbon stock.
	Soil nutrient balance	
Water	Water availability and regional water stress	In arid circumstances ground water abstraction and depletion possible because of deep roots.
	Water use efficiency	
	Water quality	Some use of fertilisers / pesticides which can be leached to ground water and pollute habitats, but effect is very limited.
Air quality	Acidification (SO2-emissions)	Value chain specific measurements required.
	Particulate emissions (PM10)	Even in new stoves/boilers PM emissions are still higher than the alternative on natural gas.

Secondary residues from agri-food industries

Large number of agri-food industries in the region.

Traditional small-medium size industries can benefit from diversification of their activities to biobased products.

Suggested future actions

- To establish community installations for pilot projects to exploit agri-food side streams.
- Processing of dairy production residues: extraction of individual fractions (e.g. lactose, proteins, bioactive peptides), or through biotechnological processes, related extraction of platform chemicals (e.g. alcohols, polysaccharides, organic acids, biosurfactants, biologically active components and enzymes) or as a raw material for microbial production biomass (e.g. meat substitute)
- Specialised installation for management of side streams from meat productions, technologically advanced processing with relatively high added-value products; currently, the main challenge is more efficient and environmentally sustainable use of digestate from biogas plant.

Potential interventions

- Launch competitions for start-ups, pioneering projects, flagship initiatives to promote bioeconomic innovations in rural areas.
- Standards for agricultural biomass.
- Introduce innovation financing for food SMEs and industries.
- Regulation on agricultural raw materials for bioeconomy
- Design financing mechanisms which will support the integration of food production with bioeconomy both at field (field residues) and within agro-industries (processing residues). These mechanisms can be combined with respective regulations that foster sustainable farming and renewable energy in agro-industries.

Table 10 Value chain performance for agri-food industry residues

Issue	Impact category	Value chain performance
Climate change	GHG reduction, compared to fossil reference	Low input of fossil fuels; internal installation energy need covered with residual heat. Potential methane slip of digestate in open air lagoons.
	GHG related to ILUC	No land use change
	Carbon stock change	Removal rates must be tailored to local ecology.
Biodiversity	Biodiversity conservation and management	No link to biodiversity
Soil	Erosion	No link to land use
	Soil organic carbon	
	Soil nutrient balance	
Water	Water availability and regional water stress	No link to water use
	Water use efficiency	
	Water quality	
Air quality	Acidification (SO2-emissions)	Value chain specific measurements required.

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Table 11 Suggested policy interventions for market segments and agricultural value chains

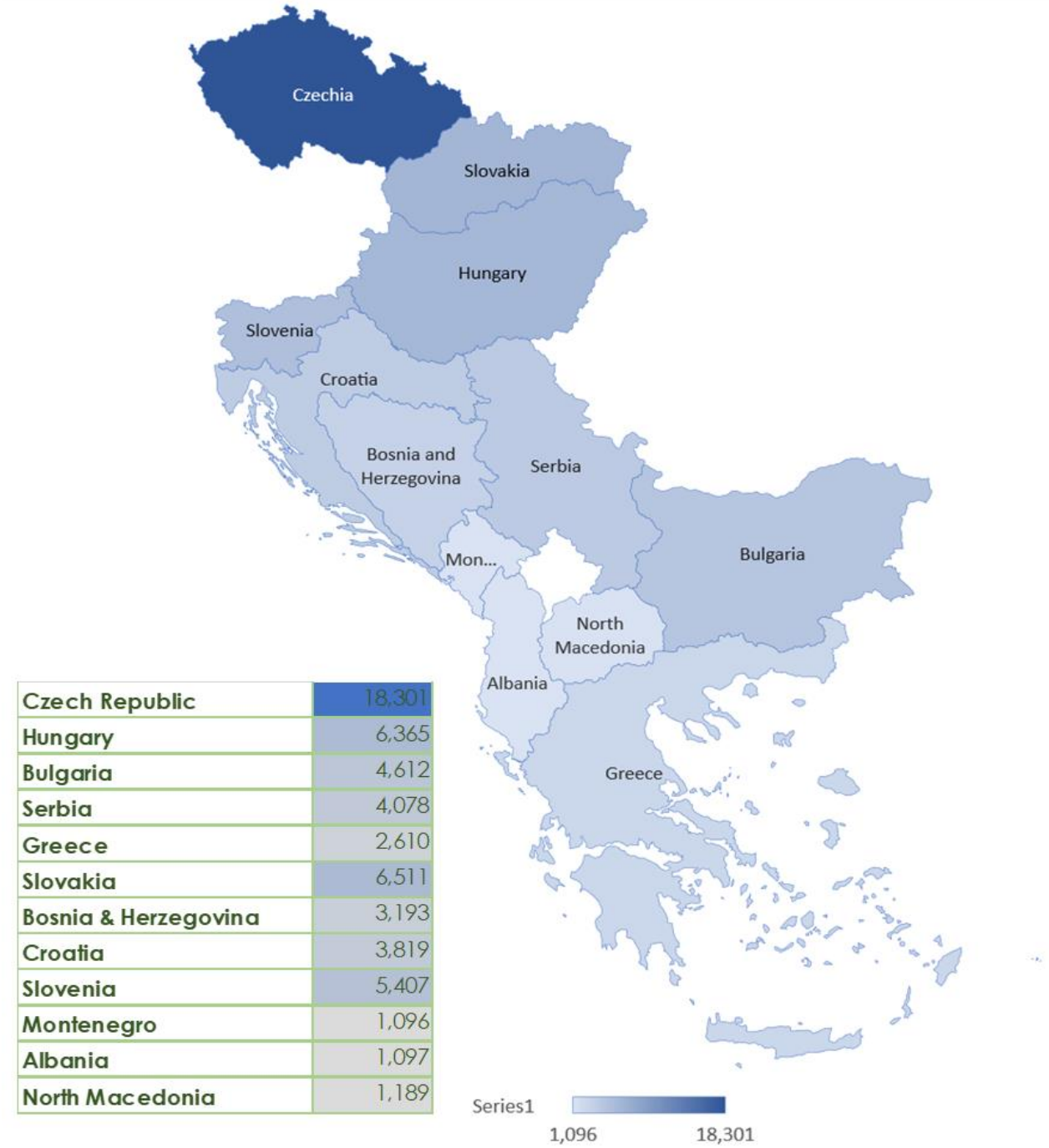
Market segment	Suggested policy interventions		Challenge the intervention will address	
	Early markets	Mature markets	Early markets	Mature markets
Plastics	Feedstock premium Capacity building	Certification/ Standardisation Premiums targeting specific indigenous feedstocks	There is no or very low market uptake for straw and agricultural residues Lack of knowledge on straw for bioenergy	Good market development for agricultural residues Competition for feedstock requires measures to mobilise other indigenous biomass streams
Construction; eco-innovation				
Car manufacturing				
Households Services- Heat				
Industry- heat& electricity	Feedstock premium Investment grant for biomass trade centers Capacity building	Feed in premiums with banding for feedstock choice Technology & innovation bonus prioritising agricultural biomass stream	Lack of infrastructure for straw storage and logistics	Competition for feedstock requires measures to mobilise other indigenous biomass streams
Utility heat& electricity				
Transport biofuels				

Table 12 Selected relevant policies i(finished & ongoing) in EU countries[4]

Country	Policy mechanisms (regulatory, expenditure information provision)
Austria (straw)	Support for using alternative feedstocks in biogas plants under the 2014-2020 Rural Development Programme: This measure under the 2014-2020 Rural Development Programme also aims at reducing the arable land used for biogas production by promoting alternatives to feed crops being used in agricultural biogas plants. Under the measure "Support for investments in creating and developing nonagricultural activities", investments facilitating the use of at least 50% non-feed crops, intercrops, alfalfa, grass clover, crop residues, manure etc. in existing biogas are subsidized to the extent of 35%.
	ÖPUL – Austrian Agri-environmental Programme 2007 (Österreichisches Agrar-Umweltprogramm ÖPUL): Unlike some other EU countries which apply their environmental programmes only in specific, environmentally sensitive areas, Austria chose an integral, horizontal approach for its agri-environmental program, aiming at the participation of Austrian farmers all over the country. In 2012, 526 million euros were paid to 11,200 holdings for 2.2 million hectares under the programme. Around 110,200 farms, i.e. 74.6% of all agricultural holdings, managing 89% of the utilised agricultural area, participate in ÖPUL. This high participation rate in the Agri-environmental Programme puts Austria first among the EU Member States. The areas covered by ÖPUL (not including pastures) account for approximately 2.20 million hectares. The average aid amounted to 4,800 euros per holding.
	Regulation on agricultural raw materials for biofuels and bioliquids (Verordnung über Landwirtschaftliche Ausgangsstoffe für Biokraftstoffe und flüssige Biobrennstoffe 2010 BioVO): This act regulates the proof of sustainability of agricultural sources used for the production of biofuels. It includes the basic rules for documentation, monitoring, collection and transmission of relevant data.
Germany (straw)	Germany is a large producer of agricultural commodities resulting in a significant potential of straw. But, to date there is only little use of it for energy. This is due to economic reasons, as production costs of conversion technologies for heat, power and fuel for transportation are all higher than the production costs of reference technologies [11]. The support mechanisms in force aren't sufficient to create economic viable concepts for straw as feedstock. Straw as feedstock for the production of lignocellulose ethanol biofuels can be counted towards quota obligations and benefit from an energy tax relief. Another support mechanism is the EEG. Biomass power plants that were put into operation between 2009 and 2014 can receive a bonus for the power production from straw. The utilization of straw in boilers smaller than 100kW benefit from emission thresholds that are higher than for biomass feedstock. In contrast to that the requirements for the utilization of straw in boilers larger than 100kW are very strict.

[4] S2Biom project. D8.3a National roadmaps for lignocellulosic biomass and relevant policies for a bio-based economy in 2030. http://www.s2biom.eu/en/publications-reports/s2biom.html

Forest based value chains



Czech Republic	18,301
Hungary	6,365
Bulgaria	4,612
Serbia	4,078
Greece	2,610
Slovakia	6,511
Bosnia & Herzegovina	3,193
Croatia	3,819
Slovenia	5,407
Montenegro	1,096
Albania	1,097
North Macedonia	1,189

Figure 3 Estimated forest biomass potentials (in million dry tonnes per year) in the CELEBIO countries.

Primary forest residues

eco-innovation

construction

fertilizers

bioenergy

bio-degradable packaging materials

Long tradition in forest management.

Large woody biomass potential from standing forests and landscape elements.

Unused potential available from primary residues.

Roadside cost for primary forest residues is relatively low as compared to costs from west and north European countries.

Improvement in forest management especially in south- east and parts of central Europe and efficient use of harvested biomass are expected to sustain high rates of forest biomass mobilisation.

Suggested future actions

- Establishment of regional/local biomass logistic centres.
- Promotion of efficient and effective biomass generation and bioeconomic value creation chain trough digital options in the areas of forestry.
- Wide campaign for replacement of old inefficient stoves with alternative efficient heating devices based on modern wooden biofuels and bio-heat.
- Developing suitable concepts for harvest, decentralised processing, logistics and warehousing, minimizing post-harvest losses, and ensuring biomass quality during storage and processing.
- Increased commercial use of roundwood within Slovenia, strengthening technologically more advanced alternatives to the energy use of lower quality wood assortments; optimization of logistics flows, primary processing at the local level and biorefining.

Potential interventions

- Development of Regional action plans for utilisation of forest biomass and promotion of forests with multifunctional use (combined nature protection with wood production, which has a wealth of biomass materials, products and full ecological functions available).
- Refining forest certification schemes.
- Regulation on forest raw materials for bioeconomy.

Table 13 Value chain performance for primary forest residues

Issue	Impact category	Value chain performance
Climate change	GHG reduction, compared to fossil reference	Low fossil input in the chain
	GHG related to land use change	Residues, no land use change
	Carbon stock change	Forest-specific
Biodiversity	Biodiversity conservation and management	Risk of biodiversity loss when harvesting forest residues through loss of dead wood and stumps which may be negative for forest plant species diversity and soil fauna. Increased fertilisation (N and wood ash) may have negative impacts on vegetation.
Soil	Erosion	Increased risk of soil erosion when stumps are harvested.
	Soil organic carbon	Risk to lose soil organic carbon when overharvesting forest residues
	Soil nutrient balance	Particular risk of reduced soil fertility and soil structure when harvesting stumps.
Water	Water availability and regional water stress	No link to water use
	Water use efficiency	
	Water quality	If removal leads to increased fertilisation the leaching of N to water may increase.
Air quality	Acidification (SO2-emissions)	Value chain specific measurements required.
	Particulate emissions (PM10)	PM emissions can be a serious pollution problem in older wood stoves. Even in new stoves/boilers, PM emissions are still higher than the alternative based on natural gas. There can be high savings when open fires of forest residues are avoided.

Forest residues from wood industry


biofuels


plastics


biopolymers


fibres and chemicals

The forest processing industry is large in Czech Republic, Serbia, Bulgaria, Croatia, and Hungary.

Still, the forest processing industries in all CELEBIO countries remain relatively small and use traditional exploitation pathways with low innovation.

Croatia, Slovakia, Slovenia export more than half of their roundwood and sawn wood. These countries are also important producers and exporters of wood chips and particles and overall, together with Czech Republic they are the countries that export relatively large amounts of their forest products.

Bulgaria and Hungary add more value to their forest products before exporting them such as in plywood and fiber boards; their export volumes are much smaller though.

Bosnia and Herzegovina, Serbia, and Montenegro export only forest products of low added value such as sawn wood and wood fuel directly.

Suggested future actions

- Establishment of regional/local biomass logistic centres.
- Increased commercial use of roundwood, strengthening technologically more advanced alternatives to the energy use of lower quality wood assortments; optimization of logistics flows, primary processing at the local level and biorefining.

Potential interventions

- Forest Certification.
- Regulation on forest raw materials for bioeconomy.
- Develop new or tailor existing financing towards multifunctional and sustainable forest management activities that will include use of residuals for energy and other biobased products.

Table 14 Value chain performance for forest residues from wood industry

Issue	Impact category	Value chain performance
Climate change	GHG reduction, compared to fossil reference	Low input of fossil fuels
	GHG related to land use change	Residues, no land use change
	Carbon stock change	Residues
Biodiversity	Conservation high biodiverse land	Only indirect link to land use
	Biodiversity conservation and management	
Soil	Erosion	Only indirect link to land use
	Soil organic carbon	
	Soil nutrient balance	
Water	Water availability and regional water stress	Only indirect link to water use
	Water use efficiency	
	Water quality	
Air quality	Acidification (SO2-emissions)	Value chain specific measurements required.
	Particulate emissions (PM10)	Better control options for PM emissions compared to small scale installations, but still higher PM emissions than natural gas combustion.

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Table 15 Suggested policy interventions for market segments and forest value chains

Market segment	Suggested policy interventions		challenge the intervention will address		Added value expected from their implementation	
	Early markets	Mature markets	Early markets	Mature markets	Early markets	Mature markets
Households (heat) **Services (heat & electricity in commercial sector)**	Loans Credit lines Investment grants Capacity building	Certification/ Standardisation Premiums targeting specific indigenous feedstocks	Market is not developed High shares of low & polluting stoves used	Good integration of efficient stoves Competition for feedstock requires measures to mobilise other indigenous biomass streams	Develop the market Share the costs with medium to low income population in rural areas	Mobilise indigenous resources with low competition from non-energy industries
Industry (bioplastics, biopolymers, fibres & chemicals, etc.)	Investment grants	Feed in premiums with banding for feedstock choice Technology & innovation bonus prioritising agricultural biomass stream	Market is not developed	Mobilise unused biomass streams with low competition	Develop the market	

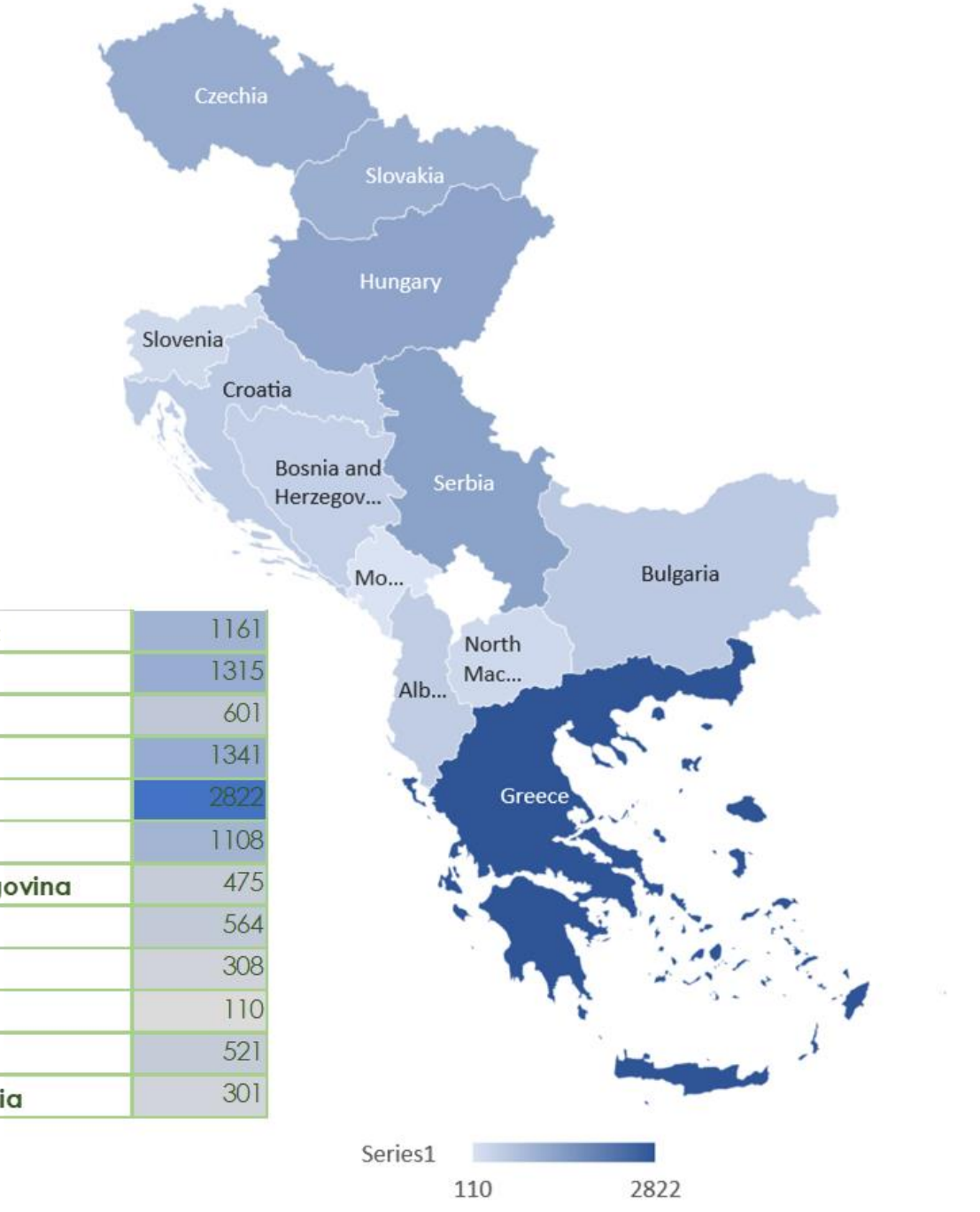
Table 16 Selected relevant policies (finished & ongoing) in EU countries[4]

Country	Policy mechanisms (regulatory, expenditure information provision)
Austria Waste wood	Regulation on recycling of waste wood (RecyclingholzV): The objective of this ordinance is an efficient recycling of waste wood by the wood industry. This has to be made without any impacts on humans and the environment. The directive should avoid any accumulation of hazardous substances and supports the sorting of waste wood for reuse and recycling in accordance with the Waste Management Act AWG. A basic requirement is that the application of wood should have the same environmental risks as the usage of primary wood materials.
Belgium Industrial wood residues	Decree of 27/06/2003 for establishing the criteria for sustainable forest management for forests situated in the Flemish Region: The management of public forests and forests situated in the VEN (Flemish Ecological Network) should be done according to the criteria for sustainable forest management. Subsidies for afforestation and forest management *Subsidies for the purchase of land for afforestation:* Subsidies are provided to cities, municipalities and provinces to buy land for afforestation. The subsidy amounts to 80% of the buying price, with a maximum of €2.5/m². Priority is provided to the realisation of urban fringe woodlands, play areas and the strengthening of local forest expansion initiatives. Also, priority is given to projects situated in special protection areas which contribute to the realization of the specific conservation objectives of this special protection area. *Subsidies for the afforestation of agricultural land:* Subsidies are provided for the afforestation of agricultural land if three conditions are met: (1) a minimal surface within the Flemish region has to be afforested, (2) the land has been used for agriculture at least one year within the last five years and (3) the land will have to be afforested for at least 25 years. The subsidy consists of a plantation subsidy, maintenance subsidy and income compensation. *Subsidy for the ecological function of forests:* The Flemish government provides subsidies to stimulate the ecological function of forests. Subsidies are provided to those forest managers that have an approved management plan in accordance with the criteria for sustainable forest management. *Subsidies for reforestation or afforestation:* Subsidies for the reforestation or afforestation with native tree species. The goal of the subsidies is to stimulate the usage of tree species that are most suited from an ecological point of view. *Subsidies for the opening of private forests:* The demand for green space and play areas in Flanders is large, therefore, the Flemish government provides subsidies to private forest owners to open up their forest. *Subsidies for the preparation of a forest management plan:* Forest owners that prepare a comprehensive forest management plan, in which criteria for sustainable forest management are taken into account, can apply for a subsidy. The reason is that costs for a comprehensive forest management plan can be high due to the strict requirements (e.g. forestry and vegetation measurements).

Table 17 Selected relevant policies (finished & ongoing) in EU countries[4]

Country	Policy mechanisms (regulatory, expenditure information provision)
Finland Forest Strategy	Government report of Forestry 2050. the most important measures included are: Create the conditions for renewal of enterprises in the field through business policy and legislation. Create the conditions for business-like and active forestry, for example, by developing taxation and improving the structure of holdings and forest ownership. Secure the supply of raw materials and improve the functioning of the markets. Target R&D activities by means of public funding to support the renewal of forest-based business and activities and transition to bioeconomy. Secure the biodiversity of forest nature, ecosystem services and ecological and social sustainability of forests
Finland Afforestation Private forest owners	Act on the Financing of Sustainable Forestry (1094/1996, 1311/1996, 544/2007, 100/2011, 34/2015, 594/2015) and degree (from the annual appropriations included in the State budget in the form of aid and loan shall be allocated for measures which promote the sustainable management and use of forests in accordance with the Forest Act (1093/1996) as provided in this Act. The measures referred to in subsection 1 above are: 1) ensuring the sustainability of timber production; 2) maintaining the biological diversity of forests; 3) forest ecosystem management projects; and 4) other measures in support of the activities referred to in subsections 1-3. Financing may be granted to private landowners upon application. Nonindustrial, private forest owners are entitled to seek governmental grants for the afforestation of understocked areas, prescribed burning, the tending of young stands, the harvesting of energy wood, forest recovery, fertilisation, etc. The Ministry of Agriculture and Forestry pays support for the harvesting, forestry transport and chipping of wood sold for fuel as part of the management of young stands.
Finland Forest certification	Finnish PEFC certification requirements have been documented in 29 criteria that define forest certification requirements for ecologically, socially, culturally and economically sustainable forest management and forest use. Like with other types of certification, legal compliance is the basic requirement also in forest certification.

Biowaste value chains



Czech Republic	1161
Hungary	1315
Bulgaria	601
Serbia	1341
Greece	2822
Slovakia	1108
Bosnia & Herzegovina	475
Croatia	564
Slovenia	308
Montenegro	110
Albania	521
North Macedonia	301

Figure 4 Estimated potentials for biowastes and post-consumer wood (in million dry tonnes per year) in the CELEBIO countries.

Biowastes

There is a significant potential of biowastes that can be exploited following the waste hierarchy.

New insights based on life cycle thinking to use biowastes for digestion before an existing composting facility, can unlock the already separately collected biowaste as feedstock for biobased applications.

By coupling digestion to an existing composting facility, the recycling of the material to compost remains in place.

Suggested future actions

- Acceleration the introduction of end of waste legislation to facilitate utilisation of biowastes.
- Awareness raising about waste sorting and collection.
- Development of biogas plants that would utilize untapped waste streams.
- Communication with all relevant stakeholders on improving the legislative framework.

Potential interventions

- National wide recycling and waste separation campaigns and education programmes in schools.
- Incentives for the use of waste for biogas production (subsidies) and the development of clean and renewable energy production. This could include penalties and rewards for energy production, depending on their environmental impact.

Table 18 Suggested policy interventions for market segments and biowaste value chains

Market segment	Suggested policy interventions		Barrier/ gap/ specific challenge the intervention will address		Added value expected from their implementation	
	Early markets	Mature markets	Early markets	Mature markets	Early markets	Mature markets
Industry/ Utility **Transport**	Investment grants Capacity building	Premiums targeting specific indigenous feedstocks Technology & innovation bonus	Market is not developed High shares of low & polluting stoves used	Competition for feedstock requires measures to mobilise other indigenous biomass streams	Develop the market	Mobilise indigenous resources with low competition from non energy industries

40

Table 19 Selected relevant policies (finished & ongoing) in EU countries[4]

Country	Policy mechanisms (regulatory, expenditure information provision)
Austria	Waste management: The legal framework for waste treatment in Austrian is the Waste Management Act 2002. The waste treatment hierarchy defined in this legislation is intended to promote (1) waste prevention, (2) reuse and recycling and, as an ultimate option instead of disposal on landfills, (3) energetic utilization. For biowaste and packaging paper waste, there is an obligation for separate collection. An effective wastepaper collection system is in place, providing separate bins for almost every household. Originators of biogenic waste are obliged to deliver the waste either to home or community composting facilities, make it available for separate collection or bring it to an appropriate collection point.
	EU Landfill Directive: EU legislation aimed at diverting biodegradable municipal waste from landfills has been adopted in Austria before respective regulations under the EU Landfill Directive came into force. A reduction of biogenic MSW landfilling to almost zero was achieved through a landfill ban for untreated waste with total organic carbon content over 5%. This ban already came into effect in 2004 (with exemptions until 2008). Furthermore, a special tax for landfilling waste is in place.
Germany	EEG: Renewable Energy Sources Act: The EEG in Germany supports the anaerobic digestion from organic wastes by means of higher feed in tariffs. To be eligible for the bonus, the biogas has to be produced by a minimum of 90% biodegradable waste within the period of one year.
	Waste disposal: The Legislation on the advancement of the recycling economy and securing environmentally friendly waste disposal (Kreislaufwirtschaftsgesetz-KrWG) transforms the guidelines of the Directive 2008/98/EC into national law. The Legislation aligns the term of waste with the European term and expands it. It describes the waste hierarchy and the separate collection of waste.

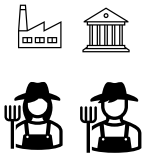
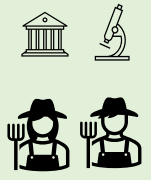
Table 20 Selected relevant policies i(finished & ongoing) in EU countries[4]

Country	Policy mechanisms (regulatory, expenditure information provision)
Belgium	Material Decree and Vlarema: The use of organic waste is bound to the regional translation of the EU Waste Frame Directive. In Flanders the use/treatment of waste is regulated by the Material Decree and Vlarema. In practise this means that organic waste can be collected separately and can be used for combustion, digestion or composting. Historically composting was one step higher on the priority ranking than digesting and combustion. New insights based on life cycle thinking have opened possibilities (evaluated case by case) for digestion of organic waste combined with composting of organic waste.
	VLAREM II and VLAREM II The collecting and treatment of organic waste is regulated by environmental policy measures, covering the environmental permits of the installations. In Flanders this is specified in VLAREM I and VLAREM II. An installation using organic waste as feedstock for bioenergy has to fulfil stricter regulations (e.g. flue gas emissions) than a bioenergy installation only using fresh biomass.
Netherlands	The Netherlands has implemented a strategic initiative in order to promote anaerobic digestion of MSW-derived organics. The country has a very well developed infrastructure for natural gas, the government intends to produce a large amount of biomethane which can be distributed across the country. The Netherlands has the ambition to replace 15 to 20%of the natural gas by green gas by 2030.

4. Actions

This section capitalises on the evidence and suggestions provided in this report, aggregates the actions and interventions, and outlines key actors that should be involved.

Table 21 Recommended actions for the development of bioeconomy to 2030

Suggested Actions	Potential interventions	Key actors
Promote the efficient, sustainable use of available natural resources within safe planetary boundaries.	Awareness campaigns, educational programmes, training activities in biomass producers/ suppliers and industry.	
Optimise the efficient uses of straw & agricultural biomass	Pilot, demonstration, and flagship actions. Assist farmer cooperatives to apply for grants. Improved machinery.	
Stimulate the usage of agricultural residues and carefully consider local practices to ensure appropriate soil organic carbon organic levels.	Design financing mechanisms which will support the integration of food production with bioeconomy both at field (field residues) and within agro-industries (processing residues). These can be combined with regulations that foster sustainable farming and renewable energy in agro-industries. Financing should favour the development and/ or upgrade of biomass logistics/ trade centers, etc. to strengthen the local capacities with high quality standards which will further trade unmobilised indigenous biomass sources. Assist farmer cooperatives to apply for grants.	
Establishment of smaller biogas installations on larger agricultural holdings, or in cooperation with other users (e.g local communities) in collective investments.	Future policy for biogas should reward anaerobic digestion installations not only as a renewable energy installation but also as a solution for environmental issues (avoid methane emissions) and as a producer of valuable products like soil fertilizer, meaning that an anaerobic digestion installation becomes a decentralised biobased refinery.	
Increase the cultivation of industrial crops, particularly in nutrient depleted lands, e.g. mining sites. These offer many opportunities for raw material to the automobile manufacturing (car interiors), novel textiles, advanced biofuels, etc.	Research and demonstration grants should target the development of high yielding varieties with tolerance in the regional climate and ecology. Create tax incentives to support industrial crops in unused and abandoned land. Provide start-up financing for farmers.	

Suggested Actions	Potential interventions	Key actors
Establishment of regional/local biomass logistic centres	Develop new or tailor existing financing towards multifunctional and sustainable forest management activities that will include use of residuals for bioeconomy.	
Increased commercial use of roundwood, strengthening technologically more advanced alternatives to the energy use of lower quality wood assortments; optimization of logistics flows, primary processing at the local level and biorefining.	Forest Certification. Regulation on forest raw materials for bioeconomy.	 
Acceleration the introduction of end of waste legislation to facilitate utilisation of biowastes.	Incentives for the use of waste for biogas production and fostering the development of clean and renewable energy production. This could include penalties and rewards for energy production, depending on their environmental impact.	
Awareness raising about waste sorting and collection.	National wide recycling and waste separation campaigns and education programmes in schools.	

5. Recommendations for future steps

This report was based on a participatory approach and the project team together with selected experts and local stakeholders co-designed a set of actions that are tailored to domestic raw materials and regional challenges. As such they can be considered in the future for the development of a Regional Bioeconomy Action plan for the twelve countries that are included in the CELEBIO project.

The project team acknowledges that Action Plan development requires numerous meetings and interactions at cross Ministerial level as well as involvement of academia, industry and citizens from the respective region and countries. This was not fully possible in the short duration of the CELEBIO project which also coincided with the recent pandemic and restrictions in networking and physical interactions. The work, however, establishes a consistent, informed basis and provides focus for future activities in the bioeconomy sector by 2030.

Future steps can build on the evidence provided in CELEBIO, validate it further through extensive consultations across countries, market sectors and respective stakeholders and:

- Support countries to establish inter-ministerial working groups on bioeconomy.
- In cooperation with national contact points for bioeconomy, develop awareness campaigns, targeting regional and national stakeholders, to explain and promote the European Bioeconomy Strategy.
- Perform impact assessment of the future actions.
- Prioritise interventions.
- Steer funding towards prioritised value chains, and
- Improve knowledge among citizens about the merits of a sustainable bioeconomy in the light of the European Green Deal and the Sustainable development Goals.