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Bioeconomy development in Europe in conditions of the globalization challenges

Scientific problem. To cope with an increasing world population, rapid depletion of resources, increasing environmental pressures and climate change, Europe needs to change its approach to production, consumption, processing, recycling and disposal of bio-resources. The Europe 2020 Strategy calls for a bioeconomy as a key element for smart and growth in Europe. Advancements in bio-economy research and innovation uptake will permit Europe to improve the management of its renewable biological resources and to open new markets in food and bio-based products. Establishing a bio-economy in Europe holds a great potential: it can create economic growth and jobs in rural and industrial areas, reduce fossil fuel dependence and improve the economic and environmental sustainability of primary production and processing industries. The bioeconomy thus contributes significantly to the objectives of the Europe 2020 flagship initiatives "Innovation Union" and "A Resource Efficient Europe".

Analysis of recent researches and publications. There are a lot of works both of the Ukrainian and foreign authors devoted to the bioeconomy formation and development. For example, Shubravskaya O. analyses the world experience of the bioeconomy development [5], Ryabchenko O. emphasizes the social element and forms the definition of the bio-social economy as a form of economic activity based on interaction of three systems – economic, ecological and social that is defined by processes of mutual exchange by renewal bio-resources with the aim of saving of ecological balance for the next generations [4]. Potapenko V. makes organizational and economic mechanisms which allow instilling the principles of "green" economy [3]. Researches of the European project «Systems Analysis Tools Framework for the EU Bio-Based Economy Strategy» (SAT-BBE) make the systematic analysis of the bioeconomy, define its role, place and impact on the other sectors, particularly economic, ecological and social impacts with developing of conceptual instruments, identify and analyze main effects of feed-back between the bio-economy and other parts of the system. So it is necessary to study and systematize the European experience what is the article is devoted.

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The objective of the article is to analyze and summarize the objectives and principles of the bio-economy in Europe.

Statement of the main results of the study.

Europe is confronted with an unprecedented and exploitation of its natural resources, significant irreversible changes to its climate and a continued loss in biodiversity that threaten the stability of the living systems on which it depends. This is exacerbated by a world population expected to increase by more than 30% in the next 40 years, from 7 billion in 2012 to more than 9 billion in 2050.

The bio-economy provides a useful basis for such an approach, as it encompasses the production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, feed, bio-based products and bioenergy. Its sectors and industries have strong innovation potential due to their use of a wide range of sciences, enabling and industrial technologies, along with local and tacit knowledge.

Global population growth by 2050 is estimated to lead to a 70% increase in food demand, which includes a projected twofold increase in world meat consumption.

The EU food manufacturing sector and households alone waste about 90 million tons of food annually or 180 kg per person, not taking into account losses in agriculture and fisheries. The Strategy will support more resource-efficient food supply chains in line with the Roadmap to a Resource Efficient Europe and the Blue Growth Initiative.

Agriculture, forestry, fisheries and aquaculture require several essential and limited resources to produce biomass. These include land, sea space, fertile soils, water and healthy ecosystems, but also resources such as minerals and energy for the production of fertilizers.

The EC formulated the following definition that was published in the 'Communication on Innovating for Sustainable Growth: A Bioeconomy for Europe' (29 February, 2012): "The bioeconomy encompasses the production of renewable biological resources and their conversion into food, feed, bio-based products and bioenergy. It includes agriculture, forestry, fisheries, food and pulp and paper production, as well as parts of chemical, biotechnological

and energy industries. Its sectors have a strong innovation potential due to their use of a wide range of sciences (life sciences, agronomy, ecology, food science and social sciences), enabling and industrial technologies (biotechnology, nanotechnology, information and communication technologies (ICT), and engineering), and local and tacit knowledge" [1]. We consider, this is relatively broad and generic definition, though it is not without some drawbacks, it does not directly indicate the concept of sustainable economy (circular economy).

On this occasion the research project team The EU FP 7 SAT-BBE project: Systems Analysis Tools Framework for the EU Bio-Based Economy Strategy stresses although not explicitly mentioned, it takes into account the important process of moving from a linear towards a circular economy by using agricultural waste streams at farm (e.g. manure), post-harvest (e.g. straw, plant residuals) and retail levels (e.g. food waste). Instead of looking at waste as a cost factor linked to currently existing bans on dumping waste, organic or biodegradable waste could be treated as a by-product or return factor of agro-food and fishery. Moreover, the definition allows for an ecosystem-driven green economic and industrial vision on the bioeconomy, i.e. in which fossil fuels are replaced by biobased substitutes, not only for energy, but also for material, clothing, plastic, and chemical applications and non-market services [11]. The transition towards a bioeconomy thus implicitly embeds a transition towards a circular economy, ensuring the sustainable use of agricultural waste and by-products, contributing to new competitive opportunities of the concerned sectors, reducing the potential harm to the environment and taking into account the value of non-market services [10].

Global challenges demand global solutions. The Bio-economy Strategy will support a global approach to more sustainable resource use. This will include developing an internationally shared understanding of biomass sustainability and best practices to open new markets, diversify production and address long term food security issues [1].

Investments in research and innovation under this societal challenge will support Europe in contributing to food security, climate protection and sustainability. It will also enable Eu-

rope to take leadership in the concerned markets and will play a role in supporting the goals of the Common Agricultural Policy, the European Bio-economy Strategy, and more broadly of the Europe 2020 strategy and its flagship initiatives 'Innovation Union' and 'Resource-efficient Europe' [2].

The bio-economy encompasses a range of established policy areas at global, EU, national and regional level which share and adhere to its objectives, yet result in a complex and sometimes fragmented policy environment. The Bio-

economy Strategy calls for a more informed dialogue, in particular on the role of scientific advancement, and better interaction between existing bio-economy-supporting policies at EU and Member States level. This will provide stakeholders with a more coherent policy framework and encourage private investment. Furthermore, information systems will need to be created, building on existing but often unconnected databases, to monitor the progress of the bio-economy (Figure 1).

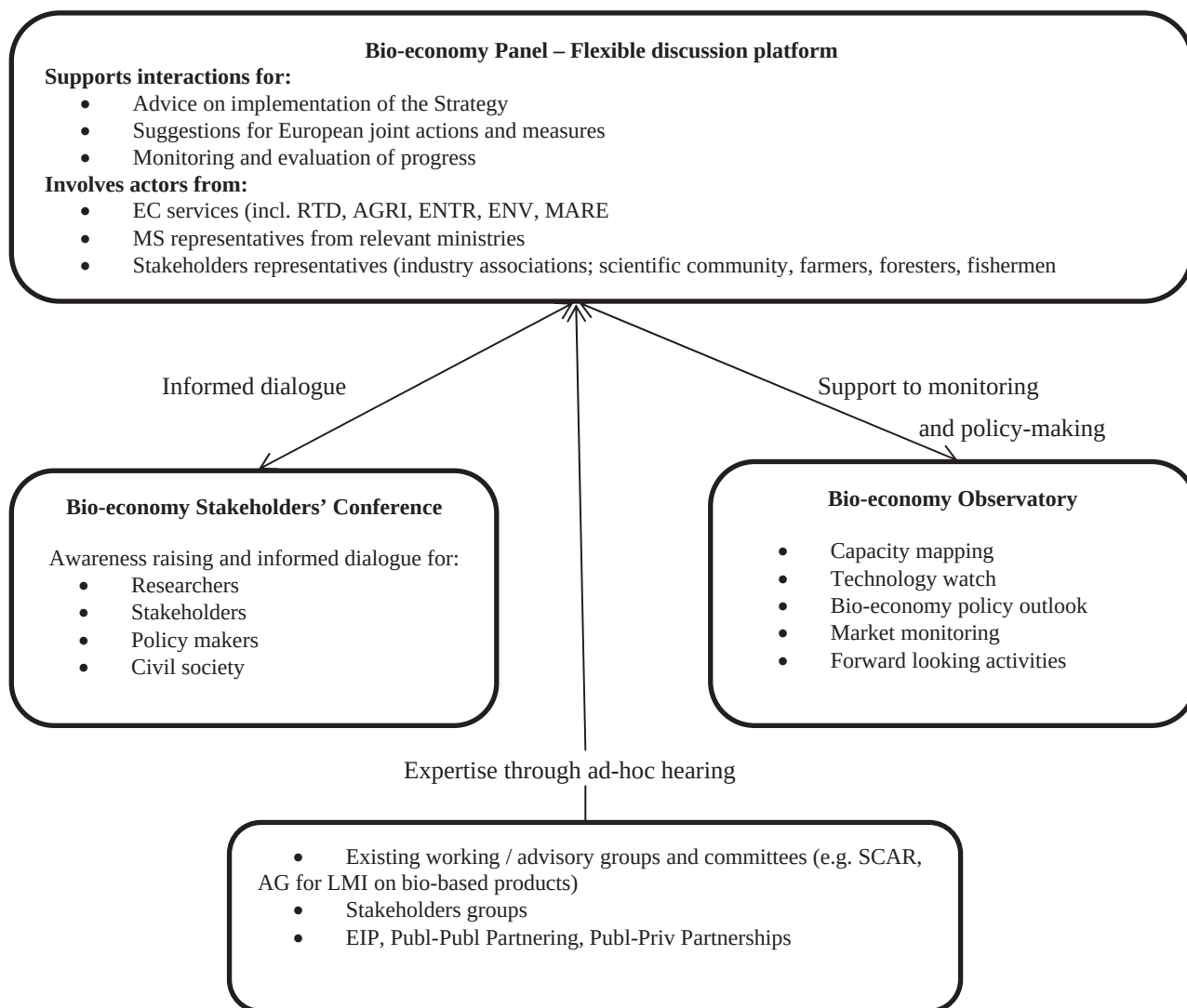


Figure. A policy interaction model for the bio-economy [3].

The Bio-economy Strategy will support better alignment of EU research and innovation funding with established priorities of bio-economy-related policies. In the same way, it will ensure that innovation is taken into account at the onset of policy development. The upcoming European Innovation Partnerships (EIPs)

will have a key role in this respect, as will Joint Programming Initiatives (JPIs). A bio-economy dialogue that improves the knowledge base and fosters informed interaction between policy measures at EU, Member State and regional level will also provide further stimulus for growth and incentives for investments.

Table 1. The concept of the European bio-economy

Challenge	The EU needs a holistic strategy which weaves the bio-economy into the fabric of policy making across many sectors throughout its Member States. To be successful, it is essential that we address the regulatory fragmentation that exists across the range of policy areas that can enhance the bio-economy. This is a problem which is especially keenly felt in Europe and which is much less present for the EU's global competitors.
Opportunity	On 13 February 2012 the European Commission adopted its strategy on the bio-economy. This represents a milestone in the recognition of the potential and value of the bio-economy and its actors across Europe. Leading the world in transitioning to an economic model which uses more renewable resources is an ambitious goal. EuropaBio believes that the bio-economy strategy, as proposed by the European Commission, is an important first step toward the development of a strong and sustainable European bio-economy
Action	To harness the potential of the bio-economy we call upon EU and national decision makers to: integrate the bio-economy strategy into agricultural, environmental, energy, regional, climate and industrial policies; implement the Priority Recommendations from the Lead Market Initiative (LMI) for Bio-based products to help bridge the gap from research to EU commercialization of sustainable bio-based products. The LMI for Bio-based products Priority Recommendations address a range of measures including access to feedstock, research and development, access to markets, public procurement and communications aspects; communicate the benefits of the bio-economy with farmers, consumers, investors, industry, and policy makers via dedicated communication programs.

Source: [4].

An important issue now is the development of tools for assessment of bioeconomy impact. There are impacts in three areas of sustainable development, i.e. environmental, economic and social impacts below in Tables 2-4

The impacts can be positive and negative, and they occur at different stages throughout

the cycle of resources: manufacturing, mining, transportation, processing, consumption, reuse, recycling and disposal. Moreover, the impacts may be different, depending on the level or their assessment (where is the limit of system).

Table 2. Environmental impact indicators of the bioeconomy*

Resource	Impact	Indicators		
		Local	EU-wide	Global
Land	Land use change	- Change in cropland area - Change in grassland area - Change in non-arable land use (e.g. "marginal" land use) - Change in forest area - Change in short rotation plantations	- Change in cropland area - Change in grassland area - Change in non-arable land use (e.g. "marginal" land use) - Change in forest area - Change in short rotation plantations	- Change in cropland area - Change in grassland area - Change in non-arable land use (e.g. "marginal land use") - Change in forest area - Change in short rotation plantations
	Land use intensity	- Change in land use intensity (inputs / outputs / system based; e.g. felling ratio, crop yields and animal stocking density) - Change in forest carbon content	- Change in land use intensity (inputs / outputs / system based; e.g. felling ratio, crop yields and animal stocking density) - Change in forest carbon content	- Change in land use intensity (inputs / outputs / system based; e.g. felling ratio, crop yields and animal stocking density) - Change in forest carbon content
	Soil quality depletion	- Acidification - Salinization - Soil carbon content - Soil loss (erosion) - Bulk density	Level of soil degradation	Level of soil degradation
	Biodiversity loss	-Rate of biodiversity loss - Rate of habitat loss (forest and agriculture) - Rate of forest fragmentation	-Rate of biodiversity loss - Rate of habitat loss (forest and agriculture) - Rate of forest fragmentation	-Rate of biodiversity loss - Rate of habitat loss (forest and agriculture) - Rate of forest fragmentation
	Decline in ecosystem service provision	Change in ecosystem service provisioning	Change in ecosystem service provisioning	Change in ecosystem service provisioning

Water	Water depletion	- Water scarcity - Consumptive water use	- Water Exploitation index - Water use for agriculture and forestry - Water use for manufacturing and recycling	Water Exploitation Index
	Water pollution	- Eutrophication (N, P concentration) - Toxicity (herbicide concentration)	Level of water pollution	Water pollution
Materials	Reduced consumption of fossil resources	-	Change in consumption level of fossil resources	-
	Increased consumption of biomass	-	- Change in consumption level of biomass - Change in wood resource balance	-
	Increased re-use of biomass	-	Organic waste diverted from landfills	
	Increased consumption of fish	-	Change in fish stocks	Change in fish stocks
Air and carbon	GHG emissions	Change in GHG emissions	- Change in GHG emissions - Change in LULUCF carbon baseline	- Change in GHG emissions - Change in LULUCF carbon baseline
	Atmospheric pollution	- Level of emission of air pollutants - Level of concentration of air pollutants	Level of emission of air pollutants	Tropospheric ozone
	Material carbon pools	Change in carbon stocks	Change in carbon stocks	Change in carbon stocks

*Source: [10].

The Roadmap states that what is needed is "...a 'dashboard' of indicators on water, land, materials and carbon and indicators that measure environmental impacts and our natural capi-

tal or ecosystems as well as seeking to take into account the global aspects of EU consumption". Work on these indicators as well as targets is on-going at the European Commission [2].

Table 3. Economic impact indicators of the bioeconomy *

Impact	Indicator		
	Local	EU-wide	Global
Change in GDP/CNI	Change in GDP/CNI	Change in GDP/CNI	-
Development of a new market for innovative bio-based products	Change in turnover of bio-based sectors	Change in turnover of bio-based sectors	
Change in trade balance (imports/exports)	-	- Change in cropland-based biomass net trade - Change in cropland-based biomass product net trade - Change in animal-based product net trade - Change in fish and fish product net trade - Change in wood net trade - Change in forest products net trade	
Change in commodity prices		- Change in food prices - Change in real wood prices - Change in forest products prices	- Change in food prices - Change in real wood prices - Change in forest products prices
Change in demand for biomass products (sectoral shift)		- Change in cropland-based biomass demand for products - Change in cropland-based biomass demand for energy - Change in wood/wood fibre demand for forest products - Change in wood biomass demand for energy use	

*Source: [10].

Indeed, turnover could be used to measure the size of the bioeconomy, but change in turnover could also be an impact of the bioeconomy. The same goes for the development of new markets, which are a result of the bioeconomy, but also monitored for the evolution of the bioeconomy. Change in food prices is dealt

within the social indicators. Change in employment could be classified as an economic impact, but it is assessed with the social indicators below. These examples show how interrelated the issues are, making it difficult to clearly distinguish some issues as social, environmental or economic impacts.

Table 4. Social impact indicators of the bioeconomy *

Impact	Indicator		
	Local	EU-wide	Global
Food security		- % change in food price volatility - Change in food prices - Changes in macro-nutrient intake/availability - Change in malnutrition or risk of hunger	- Change in food prices - Changes in macro-nutrient intake/availability - Change in malnutrition or risk of hunger - % change in food price volatility
Land access and tenure	- Land prices - Land tenure and property rights - Access to land		- Land prices - Land tenure and property rights
Employment	- Change in employment rate - Full Time Equivalent jobsa - Job creation in skilled / unskilled labour	- Change in employment rate - Full Time Equivalent jobsa - Job creation in skilled / unskilled labour	
Household income	Average income of employees in the bioeconomy sectors	Average income of employees in the bioeconomy sectors	
Workdays lost due to injury	Average number of work days lost per worker per year	Average number of work days lost per worker per year	
Quality of life	Change in quality of life	Change in quality of life	Change in quality of life

*Source: [7].

The global dimension of the societal challenges that the bio-economy is addressing requires reinforced cooperation at international level. The Bio-economy Strategy will assist Europe in taking a leading role in promoting the transition towards a global bio-economy. The existing international cooperation on bio-economy matters will need to be driven by research and innovation and facilitate exchange of scientific knowledge and sharing of best practices on global issues and policy areas, in particular regarding food security, climate change, environment and resources, capacity building and trade.

The bio-economy needs continued and increasing support from public funding and private investment and must contribute to better coherence between national, European and global research and innovation efforts. Research and the application of its results are often disconnect because of an information and knowledge gap and institutional and conceptual barrier between researchers, innovators, producers, end-users, policy-makers and the civil society. Knowledge transfer networks, knowl-

edge and technology brokers, as well as social enterprises, embedded in broader citizens and stakeholder initiatives, can bridge these gaps.

Many promising research results also remain unexploited due to pending legislative issues and patenting. Furthermore, more investment is needed for demonstration and scale-up activities and the development of entrepreneurship and advisory services for the whole supply chain.

The need to increase public funding for bio-economy research and innovation has been recognized under Horizon 2020: Almost € 4.7 billion has been proposed for the Challenge "Food security, sustainable agriculture, marine and maritime research, and the bio-economy".

There will be further support under elements of the Challenges "Climate action, resource efficiency and raw materials", "Secure, clean and efficient energy" and "Health, demographic changes and wellbeing". The European Institute of Innovation and Technology (EIT) with its Knowledge and Innovation Communities (KICs) in different areas will address questions related to the bio-economy, in particular under

the proposed KIC "Food4future". This will be complemented by research and innovation in enabling and industrial technologies (e.g. biotechnology, nanotechnology and ICT) and the promotion of emerging technologies.

Providing stakeholders along the entire bio-economy value chain with the knowledge base and a toolbox that includes a range of key enabling technologies will also be critical to the implementation of a wide range of bio-economy-related policies.

Conclusions. The analysis of the principles and objectives of the bio-economy in Europe permits to make such conclusions. The Europe 2020 Strategy calls for a bio-economy as a key element for smart and stable growth in Europe. Advancements in bio-economy research and innovation uptake will permit Europe to improve the management of its renewable biological resources and to open new markets in food and bio-based products.

The bio-economy provides a basis for such an approach, as it encompasses the production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, bio-based products and bioenergy. Its sectors and industries have strong innovation potential due to their use of a wide range of sciences, ena-

bling and industrial technologies, along with local and tacit knowledge.

It is defined that the Bio-economy Strategy aims to improve the knowledge base and foster innovation to achieve productivity increases while ensuring sustainable resource use and alleviating stress on the environment. Declining biodiversity can significantly degrade the quality of resources while constraining the yields of primary production, particularly in forestry and fisheries. The Strategy will thus support the implementation of an ecosystem-based management.

To harness the potential of the bio-economy we call upon EU and national decision makers to: integrate the bio-economy strategy into agricultural, environmental, energy, regional, climate and industrial policies; implement the Priority Recommendations from the Lead Market Initiative (LMI) for Bio-based products to help bridge the gap from research to EU commercialization of sustainable bio-based products. The LMI for Bio-based products Priority Recommendations address a range of measures including access to feedstock, research and development, access to markets, public procurement and communications aspects; communicate the benefits of the bio-economy with farmers, consumers, investors, industry, and policy makers via dedicated communication programs.

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