



# Assessing the Emergence of Bioeconomy in Transition Economies by a Future-Oriented Approach: The Case of Poland

# 9

Emmanuel Koukios, Lazaros Karaoglou,  
Danuta Ciechanska, Adam Mazurkiewicz,  
Beata Poteralska, and Anna Sacio-Szymańska

## Abstract

A seven-step approach is proposed for the assessment and management of bioeconomy-related developments affecting the pathway of transition economies and societies. The particular action steps of this approach include methodological elements from various fields, with emphasis on future-oriented methods, especially horizon scanning, identification of key drivers and barriers and scenario-building. These are combined with other relevant tools, such as mapping, techno-economic evaluation, technology assessment and strategy and policy analysis. This approach is applied in this paper to the case of Poland, a country currently in the process of preparing its bioeconomy strategy in the frame of regional and national smart specialisation efforts.

## Keywords

Bioeconomy · Biomass · Mapping · Foresight · Transition economies · Poland · Policy · Strategy

---

E. Koukios (✉) · L. Karaoglou  
National Technical University of Athens, Athens, Greece  
e-mail: [koukios@chemeng.ntua.gr](mailto:koukios@chemeng.ntua.gr)

D. Ciechanska · A. Mazurkiewicz · B. Poteralska · A. Sacio-Szymańska  
Institute for Sustainable Technologies – National Research Institute, Radom, Poland

## 9.1 Introduction and Methodology

### 9.1.1 An Emerging Socio-techno-economic Continent

According to the European Commission's definition, the use of the term "bioeconomy" includes all industrial and economic sectors that produce, manage and otherwise exploit biological resources and related services, supply or consumer industries, including a long list of activities (European Commission 2012; Koukios 2015): primary production sectors, such as agriculture, fisheries, forestry and aquaculture; the whole range of biological production- and conversion-based industries, such as agro-industries, as well as food, wood, fibre and other bioindustries; health-care and biomedical technologies, animal health applications and pharmaceuticals; biochemicals, biomaterials and "green" biochemistry; bioenergy and biofuels; waste and water management; and all kinds of biosystem design and operation tools and applications (Koukios 2014).

### 9.1.2 Expected Benefits for Transition Economies

The emergence of the whole spectrum of bioeconomic applications or some of its parts could open up a great number of strategic opportunities, especially for economies and societies that are currently in search of a new model and of the appropriate optimal change pathway leading to that. We will now summarise the main types of expected benefits (Koukios 2014, 2017).

Most of the bioeconomy sectors are of a high strategic interest, e.g. food, farming, plant and animal health and forest, thus raising the stakes for immediate action, especially at the research and policy levels. In addition, the strong momentum of bioeconomic "wave" of change could affect the modernisation efforts in almost all bioeconomy sectors, with beneficial effects on the competitiveness of the emerging economies. This trend could be enhanced by the unlocking of the huge innovation potential of bioeconomy's "Pandora's box", thus leading to synergistic and accelerated development of novel processes, products, services, tools, methods and solutions.

In the area of environmental protection, the prudent use of the reservoir of biological knowledge, especially of the dimension of environmental biotechnologies, will facilitate the trends towards "greening" of the economy and society and catalyse a symbiotic development of environment-friendly applications in all emerging bioeconomy areas. A good example of this effect is that of the substitution of fossil-based carbon fuels and chemicals by "green" bio-based ones. These effects will particularly benefit the efforts for the mitigation of the climatic change vectors and contribute to the hopeful abatement of the climate change looming tsunami.

In the field of socio-economic and other "soft" types of effects, adopting a bioeconomy perspective could facilitate matching the rapidly changing societal needs and public concerns to an also rapidly changing production base, thus leading to

increased business, employment, and local development opportunities. To take advantage of such benefits, decision- and policy-makers will have to fulfil the critical but extremely complex task of coordinating regional, national and other policies concerning all the involved bioeconomy sectors, as well as their interactions. The smooth deployment of bioeconomic applications could mobilize local and regional natural and human resources, while respecting cultures and traditions, on the way towards a more sustainable future (Bioeconomy Stakeholders Manifesto 2017; SCAR (Standing Committee for Agricultural Research) 2015).

### 9.1.3 Methodology

A seven-step approach is proposed for the assessment and management of bioeconomy-related developments affecting the pathway of transition economies and societies, such as those of Poland, which is specifically considered in this work. The particular action steps of this approach consist of the following:

- (a) Overview of the state of the national economy and mapping of its relevant sectors
- (b) Evaluation of the bioeconomy-related sectors
- (c) Assessment of the relevant achievements and opportunities, as well as major risks and challenges
- (d) Focus on the critical factors resulting from the preceding analysis
- (e) Identification of the key factors affecting the bioeconomic developments
- (f) Construction of scenarios of these developments based on appropriate combinations of the key factors
- (g) Policy, strategy, research and innovation and other conclusions and recommendations resulting from the whole seven-step analysis and synthesis

The particular action steps of this approach include methodological elements from various fields, with emphasis on future-oriented methods, especially horizon scanning, identification of key drivers and barriers and scenario-building. These are combined with other tools, such as mapping, techno-economic evaluation, technology assessment and strategy and policy analysis (In 't Veld et al. 2007; Koukios et al. 2018; Sacio-Szymańska et al. 2015).

---

## 9.2 Results and Discussion

The six sections of this part and the Conclusions and Recommendations section following correspond to the seven steps (see the Methodology part) of the proposed approach for the assessment of the bioeconomy's emergence in a transition economy.

## 9.2.1 Mapping Bioeconomy

### 9.2.1.1 Overview

According to the latest report of the Bio-based Industries Consortium (BIC), titled “Mapping the Potential of Poland for the Bio-based Industry” (Bio-based Industries Consortium (BIC) 2019), Poland is a country with a great potential in the area of bioeconomy. In particular, Poland shows a great potential in the production of high-quality food and has large biological resources, so it could become an important point on the bioeconomic map of Europe.

The Polish bioeconomy focuses on traditional sectors: agriculture, forestry and food processing. This is an important branch of the national economy, responsible for almost 20% of employment and 10% of total production volume. Poland is seventh in Europe in terms of the value of its agricultural sector (France, Germany, Italy and Spain being at the forefront) and ranks fourth among EU countries in the production of rapeseed. Agriculture in Poland is the main source of biomass, where ~76% of biomass comes from this sector.

### 9.2.1.2 National Strategy

Poland has not published a strategy on bioeconomy until 2018. However, bioeconomic effects already play an increasingly important role in Poland and constitute an important element of the National Smart Specialization (NSS) document. In this document, agriculture and food-based, forest-based and environmental bioeconomy are defined as one of the main support areas alongside healthy society, sustainable energy industry, circular economy, water, fossil raw materials, waste and innovative technologies and industrial processes. They indicate preferences in providing support for the research, development and innovation (RDI) within the framework of the financial perspective for 2014–2020 (National Smart Specialization 2019).

Through these and other actions, bioeconomy has become one of the priority areas in Polish RDI that may contribute to the transformation of the national economy through modernisation, structural transformation, diversification of products and services and creation of innovative socio-economic solutions, also supporting the transition towards an efficient economy regarding natural and other resources.

## 9.2.2 Evaluation of Bioeconomy Sectors

### 9.2.2.1 Biomass and Bio-industry Prospects

In the report of the OECD Conference “Building a biomass innovation ecosystem in a circular bioeconomy in Poland” that took place in Krakow in 2017 (OECD 2017), several key conclusions of the discussion on biomass resources, their possibilities for utilization and recommendations for the development of the bioeconomy ecosystem in Poland were presented.

Poland is a country rich in biomass, with 18.8 Mha of agricultural land and 9.4 Mha of forest; together, they occupy about 90% of the national land area. Among EU countries, it is the third-largest producer of domestic biomass, fourth largest in

biomass consumption and seventh in organic waste generation. Four countries account for slightly over half of the agricultural biomass supply potential of the EU, of which Poland's share is 11.7%. Similarly, five countries account for over half of the EU forest biomass supply potential, of which Poland's share is 8.4%.

However, Polish bio-based industries are still at a development stage, and thus there is much for Poland to gain from further development of its bioeconomy. The number of Polish biotechnology firms has been growing in recent years although this sector is still relatively small, and the number of those companies involved in industrial processing is only a limited percentage of the total number. Future bio-economic growth for Poland requires increased and sustained spending by both the public and private sectors to stimulate biotechnology RDI and deployment.

The same OECD Report (OECD 2017) concluded that better insights were needed on (i) the actual quantities and qualities of potential feedstock for the bio-based industry from the primary and the subsequent processing sectors; (ii) the possibilities to cope with varying and different quantities and qualities; and (iii) the readiness of actors in and across sectors to create new value chains, including primary sector actors as partners and beneficiaries.

### 9.2.2.2 The Bioeconomy Sectors

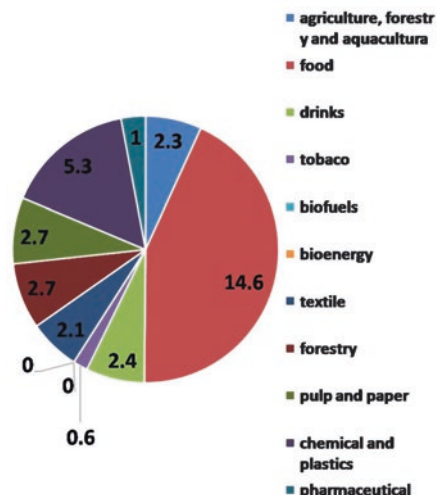
In Table 9.1, we present a rather exhaustively complete list of all the bioeconomy-related sectors in any EU economy, national and regional. This list can be used as a template for the qualitative and quantitative assessment of the national and regional bioeconomies.

In Fig. 9.1, the major fields and sectors of Polish bioeconomy are being evaluated as far as their contribution to the national economy. The already significant effects of bioeconomy, along with the key role of the food sector, and at the same time the significant presence of biomass-based activities should be noted.

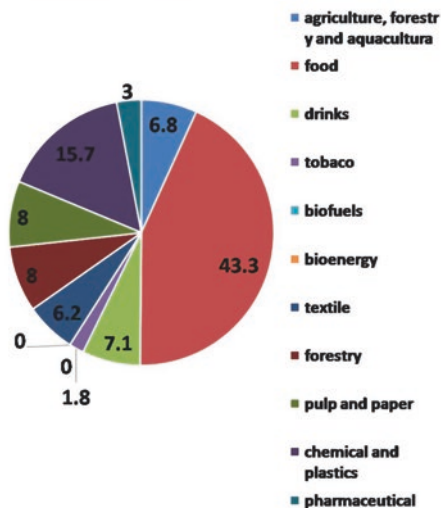
**Table 9.1** The bioeconomy-related fields and sectors of an EU economy

Economy – the big picture
Agriculture
Agro- and food industries
Forest and wood industries
Traditional/conventional bioenergy
New bioenergy – biofuels
Pharmaceuticals – cosmetics
Aquaculture – fishing
Old and new service sectors (health, environment, tourism, etc.)
New bioindustries – biorefineries
Inland waters
Education, research – strategy and policy aspects

**Bioeconomy Sectors in Poland as % of National GDP**



**Bioeconomy Sectors in Poland as % of Bioeconomy value**



**Fig. 9.1** The economic contribution of the major bioeconomic sectors of Poland. (Source: Authors’ Estimates – National Statistical Yearbook, 2017, Polish Bioeconomy Platform (Bielecki 2017))

**Fig. 9.2** Results of an assessment of the sustainably available yearly biomass potential of Poland, expressed in energy terms. (Source: Authors’ Estimates, based on source Koukios 2017)

**PL Bioresource Potential (Sustainable, 2030)**

❖ BIOMASS SOURCE	<u>Mtoe/Year</u>
- Straw & Other Agro-Residues	5.0
- Animal Manure	11.7
- Landscape Management	1.1
- Sawmill & Other Wood Residues	2.5
- Wood Used for Energy	4.6
- Co-firing with Coal for Electricity	4.9
- Transport Biofuels	0.6
- Food, Landfill, MSW, Sludges, Fats	2.3
- Paper Wastes	2.3
<b>TOTAL BIOMASS</b>	<b>35.0</b>

In Fig. 9.2, we summarise the results of the authors’ assessment of the national biomass-based energy potential. From this analysis, we can assess the very promising potential growth of the contribution of bioenergy and biofuels.

### 9.2.3 Assessment of the Opportunities and Challenges

According to the horizon scanning (In 't Veld et al. 2007) foresight approach adopted in the research reported here, two types of observed findings are being identified: on the one hand, achievements and opportunities, as summarised in Table 9.2, and, on the other hand, risks and challenges, as summarised in Table 9.3. These findings are based on a detailed desk research, the results of which are presented in the source documentation cited (Koukios, 2017).

### 9.2.4 Key Factors Determining Bioeconomy Dynamics (2015–2030)

Based on the information provided in Tables 9.2 and 9.3, and according to the approach for the assessment of the emerging bioeconomy as followed in this work (Koukios 2017; In 't Veld et al. 2007), we have distinguished the following as key drivers, key barriers and other key pathway-determining actions, with a time horizon of the year 2030.

**Table 9.2** Major achievements and opportunities of polish bioeconomy

Fields and sectors	Attributes
The big picture of the economy	Smooth transition – fast convergence to EU – not affected by financial crisis. GDP growth: from 1990 = 100 to 2015 = 250
Agriculture	Large sector (in GDP and employment terms) – good performance (potato, grains, meat, apples, rape)
Food industry	Competitive industries – innovation inputs high exports and direct foreign investments
Forest and wood industries	Three healthy sub-sectors (forest, wood, paper) – keeping up with technological innovation
Traditional/conventional bioenergy	Co-firing of biomass with coal for electricity, biomass-based heat and electricity generation planned
New bioenergy – biofuels	Liquid biofuel (bioethanol, biodiesel) production – biogas generation from bio/waste-sources
Pharmaceutical – cosmetics	Robust, chemistry-based pharma sector – the “success story” of national cosmetics sector
Aquaculture – fishing	Ca. 500 freshwater farms (carp, trout, stocking) – rural development impact – modernisation efforts
Old and new service sectors	Modernising national health-care system – greening options considered, e.g. for tourism
New bioindustries – biorefineries	Biotechnology in a product-oriented frame – national platform – reports RRB conf (Renewable Resources & Biorefineries), Wrocław, June 2017
Inland waters	Megaproject of inland navigation – touristic interests in water activities
Education, research – strategy and policy	Education support of some bioeconomy skills, e.g. cosmetics – 2 regions (Łódź, Lublin) with bioeconomy strategies

Source: Koukios (2017)

**Table 9.3** Major risk and challenges of polish bioeconomy

Fields and sectors	Attributes
The big picture of the economy	Need to adopt national/regional bioeconomy strategies – negative effects of ageing and demographics
Agriculture	Modernised ca. 50% of sector (small family farms) – soil and water supply (quantity/quality) problems
Food industry	Need to modernise the less competitive units of sector – branding of polish food products needed
Forest and wood industries	Accelerate sector's technological modernisation – develop integrated resource-based strategies
Traditional/conventional bioenergy	Coal replacement in electricity by renewables – air pollution control in biomass-based systems
New bioenergy – biofuels	Introduction of energy crops and 3G biofuels – innovative utilisation of lignocellulosic biomass
Pharmaceutical-cosmetics	Coordinate pharma sector with health-care trends – combine cosmetics with anti-ageing trend
Aquaculture – fishing	Modernise sector – enhance societal aspects – extend aquafarming to new outlets (micro-algae)
Old and new service sectors	Branding and strategy for tourism (agro, eco, theme) – greening targeted – esp. for clean air and water
New bioindustries – biorefineries	Biotech molecular roles in a bioeconomy – biorefineries for resource and market efficiencies
Inland waters	Environmental concerns on megaproject(s) – water quality targets – synergies with biomass
Education, research – strategy and policy	Research and innovation as key parts of polish bioeconomy – climate change factors and resilience needs

Source: Koukios (2017)

#### 9.2.4.1 Key Drivers

- (A1) Continuing Growth of GDP – Smooth Transition to a Market Economy
- (A2) Agricultural Production and Food Industry – Exports and Foreign Investments
- (A3) Momentum in Relevant Industrial Sectors – Wood, Bio, Pharma, Cosmetics

#### 9.2.4.2 Key Barriers

- (B1) Ageing of Population – Unfavourable Demographic Trends at All Levels
- (B2) Coal-based Electricity – High Energy Consumption – Climate Change Effects
- (B3) Environmental Pollution – Air, Water, Soil, Solid Wastes – Low Greening Pressure

#### 9.2.4.3 Key Path-Determining Actions Towards 2030

- (C1) Modernisation – Re-organisation – Management and Leadership Options
- (C2) Innovation Eco-system – Research and Development – Education and Training
- (C3) Policy Frame – Smart Regional Specialisation – Strategies and Plans



## 9.2.5 Critical Factors for the Emergence of Bioeconomy in Poland

### 9.2.5.1 Strategic Consultation Workshop

The key factors identified in the previous step of the whole process were evaluated at this step with the help of a *Consultation and Discussion Workshop*, which took place at the Institute for Sustainable Technologies – National Research Institute (ITeE-NRI) in Radom, Poland, on June 26, 2017. The aim of the Workshop was to assess the research findings on the emergence of bioeconomy in Poland by a multi-disciplinary audience of ca. 20 stakeholders from a large spectrum of relevant fields, including research, innovation, agriculture, industry, technology, economics, humanistic studies, materials, bioengineering, environmental studies, foresight and policy-making. For more details on the Workshop proceedings, see ref. Koukios (2017).

The landscape of the dynamics of change according to this assessment is a *multi-parameter* one, as shaped by three high and very high strength factors, specifically:

- (C2) *Innovation Eco-system – Research and Development – Education and Training*; being the only very high overall strength factor, and the strongest action factor;
- (A3) *Momentum in Relevant Industrial Sectors – Wood, Bio, Pharma, Cosmetics*; and
- (B2) *Coal-based Electricity – High Energy Consumption – Climate Change Effects*; being the strongest driver and barrier factors, respectively, and the high strength ones overall.

The rest of the bioeconomy emergence dynamics consists of

- three moderate strength factors (A2, B3, C3), one driver, one barrier, one action; whereas
- the remaining three factors (A1, B1, C1) are expected to have rather weak but still not negligible effects, which will possibly affect the fine tuning of the major developments.

A small number of participants proposed additional key factors, which were found to have either weaker or complementary effects compared to those of the already identified factors, thus indirectly validating/confirming the “saturation” of the workshop issue by the nine tabled factors.

### 9.2.5.2 The Factors of High Importance

(C2) *Innovation Eco-system – Research and Development – Education and Training* is the single key factor with the highest comparative strength of effects, being one of the three action types considered. The great majority of participants indicated the particular importance of this factor for the emergence and development of

bioeconomy in Poland. Its strategic actions are found to have triggering effects on the whole dynamics of change, including amplification effects on the key drivers, disrupting effects on the key barriers and shaping effects on the other key actions. The participants were specifically asked for their opinion on the presentation of R&D in (C2) together with education and training, in an innovation ecosystem format, which was welcomed by all of them, while stressing the key role of education.

(A3) *Momentum in Relevant Industrial Sectors – Wood, Bio, Pharma, Cosmetics* is the key driver of the highest comparative strength, which was also mentioned by the majority of participants as the most important driver. The importance of the particular driver results, among other reasons, from the fact that all the sectors covered by this driver are important for the Polish economy and that they complement each other. According to many participants, relevant industrial sectors are not only the few mentioned by this driver, but any sectors in which bioresources and bioprocesses are used, i.e. all bio-based industries.

(B2) *Coal-based Electricity – High Energy Consumption – Climate Change Effects* was mentioned by the majority of participants as the strongest barrier to the emergency of bioeconomy in Poland in the period until 2030. As coal is a fossil energy source, the shift towards renewable resources is inevitable, through a systemic approach at the national level. At the same time, an inter-sectoral approach is needed for the Polish economy to overcome the additional serious barriers of a fragmented industry. Another obstacle for such a major re-orientation of the Polish economy regarding energy sources is the number of jobs linked with the coal industry and other vested interests in the energy sector.

## 9.2.6 Synthesis of Change Dynamics: From Clusters to Scenarios

### 9.2.6.1 Identification of Clusters of Factors

The results of the assessment presented above make possible the final step of the process of mapping the landscape of dynamics affecting the emergence of the bioeconomy in Poland by the year 2030. According to the so far results of mapping, there appear to be in operation two major clusters of forces shaping this landscape, i.e.:

**CLUSTER I:** The development of the appropriate National Innovation Ecosystem, including interdisciplinary research, technology, education and training – as described in action (C2) *Innovation Eco-system – Research and Development – Education and Training*. This is directly linked with the strategic target of upgrading the position of the country on the EU innovation score board but should also cover obtaining excellence on specific bioeconomic lines. Developing appropriate policies and strategies – see action (C3) – is an essential part of this cluster, which guarantees the feasibility of the emerging bioeconomy developments.

CLUSTER II: The establishment of an integrated and coordinated strategy for a national *Sustainable Bioeconomy*, as part of the Responsible Development Plan. This should include primarily bio-based industries (see driver (A3)) and clean energy (see barrier (B2)) but also agriculture and food (see driver (A2)) as well as bio-greening solutions for clean environment (see barrier (B3)). A main role of this cluster will be to guarantee the socio-economic desirability of the emerging bioeconomy developments.

### 9.2.6.2 Emergence Scenarios

The following scenarios result from the above assessment of the bioeconomy dynamics:

The key dialogue of the clusters of forces that generate the five scenarios shown in Fig. 9.3 is found to be the one of *Socioeconomic Acceptance/Partnership* vs. *Scientific/Technological (S/T) Excellence*, leading to the following types of emergence outcomes:

- PROUD EAGLE: High S/T excellence and high socio-economic support, leading to great innovation-based success stories and highly competitive, modernised applications and multi-sector, “Made in Poland” branding
- GALLOPING HORSE: High S/T excellence but low socio-economic support, leading to limited technology-based success stories and selective cases of branding based on sector-specific competitiveness and modernisation

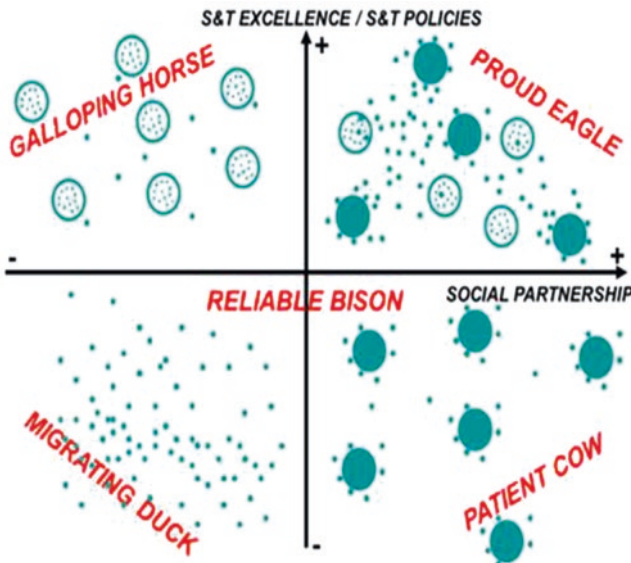


Fig. 9.3 Scenarios for the bioeconomy in Poland by 2030. (Source Koukios 2017)

- PATIENT COW: Low S/T excellence but high socio-economic support, leading to few success stories and traditional/low-to-medium tech cases of branding, spread across several low modernisation sectors
- MIGRATING DUCK: Low S/T excellence and low socio-economic support, leading to very few innovation-based success stories and even less cases of branding “islands”, catalysing brain-drain and other types of losses of capital and resources
- RELIABLE BISON: Moderate S/T excellence and moderate socio-economic support, leading to the continuation of the present dynamics of “business as usual” and accompanied by a mixture of limited elements from the other scenarios

### 9.3 Conclusions and Recommendations

Of the highest priority for the future of Polish bioeconomy will be a dual-target scheme, consisting of the development of the appropriate Innovation Ecosystem, especially focusing on the bio-industrial sectors, along with sustainability friendly policies, especially focusing on the energy, food and resources sectors (Polish Government 2017).

While assessing action types, a number of additional policy and/or innovation priorities were identified, in an effort to complement and elaborate the ones already considered: networking and international cooperation; human resources, especially in education; logistics; modelling bioeconomy systems; opinion leadership; legal framework of policies; and updating the smart regional specialisation option by formulating regional platforms.

Regarding strategic priorities, it is recommended that bioeconomy-oriented policies should develop symbiotic relationships with the Polish Government Strategy for Responsible Development (Polish Government 2017), where many of the above-discussed issues are tackled, and many strategic actions are proposed, which should integrate selected bioeconomic elements and help re-orient the Polish economy towards more competitive, more innovative and more sustainable, socially and environmentally, targets.

**Acknowledgements** This paper was based on the original research prepared in the frame of the project titled “The New Tsunami of Socio-Technical Change: Foresight Agro/Bio/Chemo/Eco/Cogno ... Convergence (BIO-TSUNAMI)”, supported by the POLONEZ 1 Programme of the National Science Centre (NCN) with contract no. UMO-2015/19/P/HS4/04103. This project has received funding from the European Union’s Horizon 2020 Research and Innovation Programme under the Marie Skłodowska-Curie grant agreement No. 665778.



The authors are particularly grateful to the Institute for Sustainable Technologies – NRI, Radom, Poland, for their permission of the use of material included in the ITeE monograph: Koukios E., Mazurkiewicz A., Sacio-Szymańska A., Poteralska B. (eds.), *The Emergence of Bio-Economy, Opportunities and Risks – A Forward-Looking Study*, ISBN 978-83-7789-484-2. ITeE-PIB, Radom, 2017, which was based on the above-mentioned project, and of which monograph the four co-editors are co-authors of the present work.

---

## References

- Bielecki S (2017) Bioeconomy in Poland – the road to the future. IFIB, Rome
- Bio-based Industries Consortium (BIC) (2019) Report. Mapping the potential of Poland for the bio-based industry. <https://biconsortium.eu/news/bioeconomy-potential-portugal-romania-and-poland-profiled-new-bic-country-reports>, Accessed 1 Mar 2019
- Bioeconomy Stakeholders Manifesto (2017). [https://ec.europa.eu/research/bioeconomy/pdf/european\\_bioeconomy\\_stakeholders\\_manifesto.pdf](https://ec.europa.eu/research/bioeconomy/pdf/european_bioeconomy_stakeholders_manifesto.pdf), Accessed 1 Mar 2019
- European Commission (2012) Innovating for sustainable growth: a bioeconomy for Europe, 60 final. COM, Brussels. 13.2.2012
- Koukios E (2014) Technology management for the bio-based economy: mapping, dynamics and policies – the case of Greece. In: Trzmielak DM, Gibson DV (eds) International cases on innovation, knowledge and technology transfer. Centre of Technology Transfer, University of Łódź, Łódź
- Koukios E (2015) From biotechnologies to bioeconomy and biosociety. In: Agraftotis D (ed) Technology foresight. Ellinika Grammata, Athens. (in Greek)
- Koukios E (2017) The bio-tsunami project. In: Koukios E et al (eds) The emergence of bioeconomy – opportunities and risks – a forward-looking study. ITeE, Radom
- Koukios E et al (2018) Targeting sustainable bioeconomy. J Clean Prod 172:3931–3941
- In 't Veld R et al (eds) (2007) Horizon Scan Report: Towards a future oriented policy and knowledge agenda. Horizon Scan Publication, The Hague
- National Smart Specialization (2019). <https://www.smart.gov.pl/en/>. Accessed 4 Mar 2019
- OECD (2017) Conference report. Building a biomass innovation ecosystem in a circular bioeconomy in Poland. Krakow
- Polish Government (2017) National responsible development plan
- Sacio-Szymańska A, Mazurkiewicz A, Poteralska B (2015) Corporate foresight at the strategic research institutes. Bus: theory Pract/Verslas: Teorija Prakt 16(3):316–325
- SCAR (Standing Committee for Agricultural Research) (2015) Sustainable agriculture, forestry and fisheries in the bioeconomy – a challenge for Europe. Report, 4th Foresight Exercise, 2015, [http://ec.europa.eu/research/scar/pdf/feg4-draft-15\\_mawy\\_2015.pdf](http://ec.europa.eu/research/scar/pdf/feg4-draft-15_mawy_2015.pdf). Accessed 1 Mar 2019