

## THEORETICAL APPROACH ON THE GREEN TECHNOLOGIES DEVELOPMENT

AGNĖ ŠNEIDERIENĖ<sup>1</sup>, HENRIKA RUGINĖ<sup>2</sup>

Klaipėda University (Lithuania)

### ABSTRACT

Technological innovations are a crucial component of a green economy transition and there is an urgent need to develop and implement the green technologies into the existing facilities, especially in the developing countries. The purpose of the article is to analyze theoretical approach on the green technologies development. In the article there are analyzed the essence of the concept of green economy and are identified key benefits of green technologies development.

KEY WORDS: *green economy, green technologies, development, economic growth.*

JEL CODES: D60, I31, O30, O52, Q20.

### Introduction

Over the last decades, there has been recognized that traditional economic models should be replaced or reformed in order to address environmental issues (such as climate change, biodiversity losses, water scarcity) and key social and economic challenges. The European Union proposed green economy concept in order to promote economic growth and incorporate in this process environmental issues. It should be noted that there is no generally accepted definition for the green economy and different terms related to green economy are used: smart economy, blue economy, sustainable economy, circular economy and so on – meanwhile, according to Pieroni et al. (2019), the boundaries of each term are not clearly explored. Gazzola et al. (2019), Popa et al. (2011), Laibach et al. (2019), Jänicke (2012), Swainson, Mahanty (2018), He et al. (2019) have developed and expanded the concept of green economy firstly proposed by Pearce et al. (1989). Borel-Saladin, Turok (2013) claim that concept of a green economy is very attractive to governments and businesses as it aims to provide a simultaneous solution to both unemployment and environmental issues with new green industries and tools for mitigating environmental damage. Meanwhile, Gibbs, O’Neill (2015), While et al. (2010), point out that the green economy has often become transformed into the narrower conceptualization of a low carbon economy – where the aim is to reduce carbon emissions as part of attempts to stabilize carbon levels in the atmosphere. Popa et al. (2011) state that the expansion of the green economy in Europe is being accelerated by concerns relating to energy generation, resource use and environment management. Wanner (2015) emphasize that in the green economy / growth discourse that there is no ‘one size- fits-all’

<sup>1</sup> Agnė Šneiderienė – doctor (social sciences), Department of Economics, Faculty of Social Sciences and Humanities, Klaipėda University  
Scientific interest: regional development, corporate social responsibility, green economy  
E-mail: agne.sneideriene@ku.lt

<sup>2</sup> Henrika Ruginė – lecturer, Department of Economics, Faculty of Social Sciences and Humanities, Klaipėda University  
Scientific interest: macroeconomics, labor economics, green economy  
E-mail: henrika.rugine@gmail.com

prescription for green growth strategies as there are different contexts of policy and institutional frameworks, economic and political circumstances, levels of development, and economic and environmental interdependencies, which also mean that “advanced, emerging, and developing countries will face different challenges and opportunities” (OECD, 2011: 10).

Technological innovations are a crucial component of a green economy transition (Droste et al., 2016), and there is an urgent need to develop and implement the green technologies into the existing facilities, especially in the developing countries (Li et al., 2015). The International Energy Agency (IEA, 2009) underlines the role of low-carbon energy technologies in ensuring green growth during the financial and economic crisis. The use of green technologies could control environmental pollutions and enhance resource recovery (Styles et al., 2009, van Loon-Stennsma et al., 2014; Li et al., 2015). So, scientific problem can be formulated – to identify what are the benefits of developing green technologies.

The object of the research: the development of green technologies.

The aim of the research: to analyze theoretical approach on the green technologies development.

The tasks of research:

1. To analyze the essence of the concept of green economy.
2. To identify the key benefits of green technologies development.

Research methods: analysis, comparison, and generalization of scientific literature.

## 1. The essence of the green economy

Green economy and development has become an important trend globally because it incorporate in economic growth such issues as global climate change, resource shortages, and environmental pollution. Gibbs and O’Neill (2017) assume that a concept of a green economy has led to a policy focus upon the potential for change to existing socio-economic development pathways. According to Lindman, Söderholm (2016), the green economy policy discourse recognizes the importance of actively promoting investments in new technologies that can open up the energy sector from the incumbent and typically less sustainable technologies based on fossil fuels and other energy resources that are non-renewable. There is no generally accepted definition for the green economy and should be emphasized that there are variety of terms related to green economy: smart economy, blue economy, sustainable economy, circular economy and so on – meanwhile, according to Pieroni et al. (2019), the boundaries of each term are not clearly explored. According to Paulauskas (2018), different economy paradigm forms different understanding of economy growth and because of misunderstanding in contacts between people and overall countries, different terms are used. Porfiriyev (2012) state that although UNEP experts offered the broadest understanding of green economy concept, but this interpretation does not differentiate it from the sustainable development concept. In this article, we analyze scientific literature which is related to green technologies and green growth.

Concept of green economy was introduced by Pearce et al. (1989) in response to the undervaluation of environmental and social costs in the current price system. Since then, the concept has been expanded. Green economy is a resource-saving and environment-friendly economy (He et al., 2019), a way for solving environmental problems that shows confidence in human ingenuity and technological advancements (Gazzola et al., 2019), an economic development based on the sustainable development model and knowledge of ecological economics (Popa et al., 2011), a socially inclusive and economically beneficial yet environmentally sustainable alternative (Laibach et al., 2019), a way to substitute renewable energy and low-carbon technologies for fossil fuels, and to improve resource and energy efficiency (UNEP 2011), a term for the growth of the entire economy (Jänicke, 2012), integrated, economy-wide framework contrasts with many previous sustainable development initiatives that have been more sector or site focused (Swainson, Mahanty, 2018), an “umbrella” concept that encompasses different implications with regard to growth and well-being, or efficiency and risk reduction in the use of natural resources (Loiseau et al., 2016). These potentially contradictory implications require clarification regarding the capability of a green economy implementation to support a transition towards sustainability. Borel-Saladin, Turok (2013) claim that concept of a green economy is very

attractive to governments and businesses as it aims to provide a simultaneous solution to both unemployment and environmental issues with new green industries and tools for mitigating environmental damage. Gibbs, O'Neill (2015), While et al. (2010), point out that the green economy has often become transformed into the narrower conceptualization of a low carbon economy – where the aim is to reduce carbon emissions as part of attempts to stabilize carbon levels in the atmosphere.

In scientific literature (Bina, 2013; Ferguson, 2015; Gibbs, O'Neill, 2017) are identified a range of discursive approaches to the green economy. Bina (2013) green economy divide into three categories: “business as usual”, “greening” and “all change”; Ferguson (2015) separate “conventional pro-growth”, “selective growth” and “limits to growth”. Gibbs, O'Neill (2017) indicate that there is a spectrum of interpretations of the green economy, from market-led, business-as-usual to proposals for more radical changes such as a steady-state economy and de-growth. Loiseau et al. (2016) identify practical solutions for a green economy which can be implemented in practice. They encompass a broad range of approaches: reuse, repair, recover or recycling, applying of eco-design rules or even developing industrial symbiosis. In order to measure the effects of these solutions on green economy goals, different assessment tools can be used: life cycle analysis, life cycle costing, social life cycle assessment, material flow analysis, environmentally extended input-output model and cost-benefit analysis or energy input-output analysis (Bagheri et al. 2018).

According to Droste et al. (2016) economy strategies require investments, but for the normative ones (associated with green economy) private and public investments are necessary in order to implement strategies which would be greener and fairer. According to UNEP (2011: 16) such investments must be supported “by targeted public expenditure, policy reforms, and regulation changes”. This requirement stresses the role and the need of government intervention. Yang et al. (2019) underline, that many countries have highlighted green development as an important measure for the promotion of regional sustainable development. For example, the United States has proposed plans to support the green economy – “Reinvigorate Manufacturing”; the European Union has adopted technological and market-driven approaches to achieve green industries and low-carbon development, meanwhile, Japan in order to promote green technological developments has implemented an “Environmental and Energy Innovation Technology Development Program”. But it should be emphasized that in the European Union there is no singular green economy strategy. According to Pitkänen et al. (2016) some aspects of green economy are integrated in other strategies such as sustainable development, energy, low-emission and resource efficiency ones. In order to stimulate issues related to environmental protection, efficiency of resource utilization and promote urban green development, China also proposed initiatives of green development (Xiao et al., 2014). According to World Bank (2012) green policies can promote green growth through four effects: an input effect (through increase of production factors), an efficiency effect (when production is closer to the frontier of production), a stimulus effect (this effect is related with stimulation of economies during economic crisis), and an innovation effect (through acceleration, development and adoption of technologies). Mundaca et al. (2016) point out that green growth policies was focused only on a short-term and the main aim of these policies were to accelerate economic growth by creating jobs and increasing demand for various goods and services.

Popa et al. (2011) main reasons of expansion of the green economy in Europe relates with a concern related to energy generation, resource efficiency and environment management issues. According to these authors, in energy policies are addressed the need to contribute to climate change and reduce greenhouse gas emissions and achieve greater energy security through diversification of different kind of generation. These two issues should be dealt with simultaneously in order to develop renewable energy technologies. The urge to create a European green economy arrived from the prevailing agreement of the scientific community on issues related to dangers of greenhouse gases and the depletion of fossil fuels. EU Member States have agreed to impose targets on carbon emissions and adopt other international agreements, especially the Kyoto accord.

Wanner (2015) emphasize that there is green growth strategies differ among countries. These differences are related with different policy context, different institutional frameworks, levels of countries development, and interdependencies of economic and environmental surroundings. It should be noted that economic and political circumstances also differ. According to Wanner (2015) in this discourse there is no prescription

related with green growth that could fit to all countries. OECD (2011: 10) also emphasize that countries that are advanced, emerging or developing faces different challenges and opportunities, so it is one of the reasons of different strategies of green growth.

Porfiryev (2018) emphasize that the noted trend can be clearly tracked analyzing the economic policy of the European leaders in green economic growth (that is, the United Kingdom and Germany), the most promising lines for national exports include the production of environmentally safe and low-carbon products, environmental protection equipment, technologies for mitigating climate risks, as well as adapting to the impacts of climate change. So far, according to Biber-Freudenberger et al. (2018), different European countries adopt various strategies, for example Denmark's strategy broadly advocates for a green economy (or a sustainable economy), and Portugal focuses on the blue economy (concentrating on fisheries and other marine and coastal economic sectors). In Lithuania's strategy "Lithuania 2030" have been separated three main priorities: smart society, smart economy and smart governance. It should be noted that there is emphasized that attention will be paid to create an economy that is flexible and able to compete globally, generating high added value and based on knowledge, innovations entrepreneurship and social responsibility as well as green growth.

Yang et al. (2019) underline the main purpose of the green development is to improve the growth of the existing economic mode. Wang et al. (2018) mention the necessity to provide additional resources for future generations, a better ecological environment, and safeguard existing developments. Lin, Benjamin (2017), Wang et al. (2018), Yang et al. (2019) point out that green development is an innovative economic development model in which are encompassed the constraints of treatment and utilization of pollutant, improvement of ecological efficiency, optimization of economic growth, enhancement of living environment, development of innovative potential, and striving to achieve sustainable development. Luukkanen et al. (2019) assume that green growth or green economic development is focused on greening these areas: consumption, production, business, and markets. Yi (2014) emphasize the need of ensuring that renewable and sustainable technologies would bring stable economic growth.

A major component of green economy, according to Gibbs and O'Neill (2017), is to involve low carbon initiatives (they can reduce emissions of greenhouse gas, and reduce climate change) and the development of a low-carbon economy. It should be emphasized that despite the fact that green economy encourages capital accumulation and creation of jobs. It is also seen as a path to solve environmental issues. Gibbs, O'Neill (2017) emphasize that there are criticized policy measures because of the fail solving environmental crisis and omitting social justice and equity issues. These authors suggest offer ideas of de growth and post growth in order to promote economic development. In these approaches there are emphasized seek to promote lower consumption and downscale production and, the same time, increasing human welfare, enhancement of ecological conditions and ensuring equity on the planet. Bonsinnetto, Falco (2013) see the opportunities for regions and cities to overcome global economic crisis and transform economies. Communities could be transformed in more sustainable, less resource intensive, inclusive manner. Porfiryev (2012) distinguish drivers of the increased green growth: an aim to guarantee energy security as a strategic priority for fossil-fuel importing countries; powerful multiplicative effect that allowed the government to expand employment and mitigate unemployment, stimulate activities in other economic spheres; society demand for environmental cleanness and environmental security and reduction of the climate change risks; high R&D intensiveness and high technological level of the green industries providing for accelerated transition to a new (sixth) technological wave, which will determine the profile of the global economy and the competitiveness of national economies. Schanasa et al. (2019) separate that growth and innovation in Europe are stimulated by these key factors: high level of technological advancement in the field of energy efficiency, more resource-efficient consumption and production patterns, innovation and large scale market mechanisms, technology transfer, the growth of global product agreements also supports the move towards resource efficiency.

To summarize essence of green economy is quite hard because there is no one description of it. But it can be described as resource-saving and environment-friendly economy, actively promoting investments in

new energy saving technologies, low-carbon initiatives, environmental protection equipment, technologies for mitigating climate risks and etc.

## 2. The benefits of green technologies development

Technological innovations are a crucial component of a green economy transition (Droste et al., 2016), and there is an urgent need of developing and implementing such kind of technologies in the existing facilities, especially, according to Li et al. (2015), in the developing countries because they face the lack of green technologies implementation. Yang et al. (2016), Chen et al. (2006) define green technologies as hardware or software innovation and relates them to green products or processes. These innovations also encompass innovations in energy saving, pollution prevention, waste recycling, green product designs, or corporate environmental management processes. The role of low carbon energy technologies for achieving green growth is underlined by the International Energy Agency (IEA, 2009). Huang, Li (2017) relate green innovation and evolution of sustainable manufacturing initiatives. According to them, green innovation has essential role on moving industries toward sustainable production. At the same time, there is seen that the evolution of sustainable manufacturing initiatives has huge impact on facilitating green innovation process. It should be noted, that in order to implement green innovations, companies firstly should focus on technological advances. These advances are closely connected with the products or processes appointed for green innovation. As Zhu, Sarkis (2004), Chen (2008) have mentioned, the main purpose of green innovation is to create such processes and products that could have minimum effect on whole environment. In these processes are included many activities, from design toward practices of lifecycle assessment. Dean, McMullen (2007), Demirel et al. (2019) emphasized the role of investments into environmentally sustainable technologies. According to them, these investments are crucial in order to address environmental issues and facilitate the shift toward low carbon economy. Constantini, Mazzanti (2012), Ghisetti, Quatraro (2013) highlight the role of investments in green technologies in restoring the competitiveness of economies, creating competitive advantages and providing new jobs, especially in advanced economies. Leoncini et al. (2019) investigate the relationships between green / non-green technologies and firm growth with particular focus on the corporate life cycle and find out that environmental technologies exert superior effects on the rate of growth compared to non-green technologies. Demirel et al. (2019) stress the importance of regional cluster for the rapid adoption of green innovations that improve environmental conditions and sustainability of existing products or processes. Besides, clusters tend to be seen as supporting innovative production and R&D activities, promoting economic spillovers and stimulating sustainable energy (Marra et al., 2017).

The use of green technologies could help to control environmental pollutions and enhance resource recovery; lead to better environment management system and achieving green economy (Styles et al., 2009; Van Loon-Stenmsma et al., 2014; Li et al., 2015). It should be noted that many local industries and enterprises lack access to green technology. This lack is explained by the fact that institutional, regulatory, and financial barriers have influence in creating or even extending technological barriers and disturbing the process of new technology creation. According to Li et al. (2015), if countries do not deal with these barriers, green technologies won't be created; so in the future, it would be even more difficult to undertake different environmental issues, such as climate change, loss of biodiversity, and others. According to Lindman, Söderholm (2016), introduction of new green technologies following R&D efforts will affect future innovations through different learning processes, for example, learning by doing, learning by using and vice versa. This process will lead to the re-development of a technology. It should be emphasized, that an important reason for the existence of such feedback effects is that experiences of the production and use of a technology often lead to the encountering of new problems and the discovery of new opportunities. Grant, Yeo (2018) state, that technological investments have positive influence on business performance. Technological investments are further motivated to improve performance, reduce transactional costs, inventory and cycle times, product quality, increasing flexibility, efficiency, productivity, and economic growth (OECD, 2008; Grant, Yeo, 2018). Meanwhile, Kleis et al. (2012) determine that a 10 per cent increase in technological investments is associ-

ated with an increase of 1.7 per cent in innovation output. Chen et al. (2018) found that in order to achieve green development it requires some circumstances: the support of a reasonable industrial structure, advanced technology, government policies and so on. It should be noted that there is a link between economic development, industrial structure, and environmental regulation. These three factors have positive influence on efficiency of green development. According to Yang et al. (2019), remarkable positive effects on the efficiency of industrial green development also have such factors: technological progress, industrial scale, R&D input intensity, and industrial output per unit energy consumption. These authors also emphasize the role of economic development level on developing green economy. Studies of Miao et al. (2017), Zuo et al. (2017), Feng et al. (2018) show that technology innovations have impact on green development by reducing the environmental pollution and increasing the efficiency of natural resources.

According to Walker, Preuss (2008), green technological innovation can be divided in four categories: innovations of green product; innovation in cleaner process, end-technology innovation and others. Marra et al. (2017) assume that green technologies innovations have to improve environmental performance. They distinguish such types of technologies: renewable energy (is divided also in other parts according to the adopted technologies, for example, wind-power, solar-power, biomass, hydro- power, biofuels), recycling, green transportation, green buildings, electric motors, green chemistry, lighting, grey water, information technology, and many other energy efficient appliances. Li (2019), green technology classifies in to four categories: cleaner production technology, waste recycling technology, pollution treatment and prevention technology. This classification depends on design stage. In the upstream design stage, innovation can strengthen the utilization of clean energy sources instead of high-carbon energy sources, and enhance the application of environmentally friendly and renewable materials. Meanwhile, in the midstream production stage, energy consumption, and waste gas emissions can be reduced by adopting advanced technologies in clean coal utilization system along with combined heat and power system. Finally, in the downstream disposal stage, innovation contributes to the recycling of wastes, remanufacturing of waste products, and reuse of waste heat (Li et al., 2019). It should be noted that technological innovation can give not only positive, but also negative effects on green growth. Fisher-Vanden, Wing (2008) has noted that technological innovation can even result in the overdraft consumption of energy and carbon emissions. This is named as Jevons paradox. Li (2019) relates this paradox to the fact that innovative technologies can significantly increase production capacity. Increase in capacity could result in an increase of energy consumption and even increase in pollution. It should be noted that some new products are oriented not reduce its impact on environmental issues, but are oriented pure process of profit maximization. According to Li (2019), high energy consumption and pollution could be also caused by used materials in the production of new products. Hall et al. (2019) emphasize that green technology demonstrating technological feasibility is necessary but not sufficient. According to them, green technology ventures should engage in institutional work in order to articulate the benefits of technologies to regulators, establish legitimacy, and avoid misuse of them.

Cuerva et al. (2014) has related development of technologies and eco-innovations. They state out that R&D investments have positive technological spillovers and emphasize that eco-innovations can create positive externalities that can result in reducing external environmental costs. Cuerva et al. (2014) emphasize that essential drivers of eco-innovations are technology push factors. It should be emphasized that innovation propensity depends on: the availability (or lack) of resources, and capacity of a business to innovate. In this regard, human skills, knowledge resources, access to finance markets are essential drivers of green innovation. According to Popp et al. (2007), public policy can have impact on the adoption of environmental innovations and technologies. In order to promote implementation of environmentally friendly or green technologies, subsidies for R&D should be proposed. De Marchi (2012), Belin et al. (2011) conducted analysis confirmed that there is a dependency of green innovation and public subsidies. Other drivers that have impact on development of technologies and eco-innovations are organizational capabilities and customer demand for environmentally friendly products. Chiarveso et al. (2015) have emphasized the fact that environmental innovation differ from other types of innovation. According to van Kleef, Roome (2007), company's networking process is crucial in order to collect the key knowledge and apply this knowledge for greening purposes.

Rennings (2000) emphasize that eco-innovation can also be driven by institutional pressure through various processes of certifications. As main drivers of eco-innovation market pressure and technological improvements can be mentioned.

To sum up, technology innovation is the most critical driving factor of green development through enhancing the efficiency of natural resources or reducing the environmental pollution. But, many local industries and enterprises lack access to green technology. Institutional, regulatory, and financial barriers further exacerbate technological barriers by preventing the creation of new technology. If these barriers are not dealt with and green technology is not created, it will be even more difficult in the future to address different issues (climate change, loss of biodiversity, and other environmental problems) enhancing economic growth.

## Conclusions

The green economy has no generally accepted definition. It should be emphasized that there are variety of terms related to green economy. In general, green economy is a resource-saving and environment-friendly economy seeking for technological advancements that saves energy and are solving environmental problems, also its an economic development based on the sustainable development model and knowledge of ecological economics.

Main challenges on green technologies development are through enhancing the efficiency of natural resources or reducing the environmental pollution. Local industries and enterprises lack access to green technology that are so much needed for the safe economic growth in the future.

## References

- Bagheri, M., Guevara, Z., Alikarami, M., Kennedy, C. A., Doluweera, G. (2018). Green growth planning: a multi-factor energy input-output analysis of the Canadian economy. *Energy Economics*, Vol. 74, p. 708–720.
- Belin, J., Horbach, J., Oltra, V. (2011). Determinants and specificities of eco-innovations: an econometric analysis for the French and German industry based on the community innovation survey. <https://www.researchgate.net/publication/228933923> [Accessed March 15, 2019].
- Biber-Freudenberger, L., Basukala, A. K., Bruckner, M., Börner, J. (2018). Sustainability performance of national bio-economics. *Sustainability*, Vol. 10, No. 8, p. 2–20.
- Bina, O. (2013). The green economy and sustainable development: an uneasy balance? *Environment and Planning C: Government and Policy*, Vol. 31, No. 6, p. 1023–1047.
- Bonsinetti, F., Falco, E. (2013). Analysing Italian regional patterns in green economy and climate change. Can Italy leverage on Europe 2020 strategy to face sustainable growth challenges? *Journal of Urban and Regional Analysis*, Vol. 2, p. 123–142.
- Borel-Saladin, J. M., Turok, I. N. (2013) the green economy: incremental change or transformation? *Environmental Policy and Governance*, Vol. 23, No. 4, p. 209–220.
- Chen, Y. S. (2008). The driver of green innovation and green image – green core competence. *Journal of Business Ethics*, Vol. 81, No. 3, p. 531–543.
- Chen, Y., Lai, S., Wen, C. (2006). The influence of green innovation performance on corporate advantage in Taiwan. *Journal of Business Ethics*, Vol. 67, No. 4, p. 331–339.
- Chen, W., Shen, Y., Wang, Y. (2018). Evaluation of economic transformation and upgrading of resource-based cities in Shaanxi province based on an improved TOPSIS method. *Sustainable Cities and Society*, Vol. 37, p. 232–240.
- Chiarvaso, M., De Marchi, V., Di Maria, E. (2015). Environmental innovations and internationalization: theory and practices. *Business Strategy and the Environment*, Vol. 24, No. 8, p. 790–801.
- Constantini, V., Mazzanti, M. (2012). On the green and innovative side of trade competitiveness? The impact of environmental policies and innovation on EU exports. *Research Policy*, Vol. 41, No. 1, p. 132–153.
- Cuerva, M. C., Triguero-Cano, A., Corcoles, D. (2014). Drivers of green and non-green innovation: empirical evidence in Low-Tech SMEs. *Journal of Cleaner Production*, Vol. 68, p. 104–113.
- Dean, T. J., McMullen, J. S. (2007). Towards theory of sustainable entrepreneurship: reducing environmental degradation through entrepreneurial action. *Journal of Business Venturing*, Vol. 22, No. 1, p. 50–76.
- De Marchi, V. (2012). Environmental innovation and R&D cooperation: empirical evidence from Spanish manufacturing firms. *Research Policy*, Vol. 41, No. 3, p. 614–623.

- Demirel, P., Li, C. Q., Rentocchini, F., Tamvada, J. P. (2019). Born to be green: new insights into the economics and management of green entrepreneurship. *Small Business Economics*, Vol. 52, No. 4, p. 759–771.
- Droste, N., Hansjürgens, B., Kuikman, P., Otter, N., Antikainen, R., Leskinen, P., Pitkänen, K., Saikku, L., Loiseau, E., Thomsen, M. (2016). Steering innovations towards a green economy: understanding government intervention. *Journal of Cleaner Production*, Vol. 135, p. 426–434.
- Feng, C., Huang, J. B., Wang, M. (2018). Analysis of green total-factor productivity in China’s regional metal industry: a meta-frontier approach. *Resource Policy*, Vol. 58, p. 219–229.
- Ferguson, P. (2015). The green economy agenda: business as usual or transformational discourse? *Environmental Politics*, Vol. 24, No. 1, p. 17–37.
- Fisher-Vanden, K., Wing, I. S. (2008). Accounting for quality: issues with modeling the impact of R&D on economic growth and carbon emissions in developing economies. *Energy Economics*, Vol. 30, No. 6, p. 2771–2784.
- Gazzola, P., Del Campo, A. G., Onyango, V. (2019). Going green vs going smart for sustainable development: Quo vadis? *Journal of Cleaner Production*, Vol. 214, p. 881–892.
- Gibbs, D., O’Neill, K. (2015). Building a green economy? Sustainability transitions in the UK building sector. *Geoforum*, Vol. 59, p. 133–141.
- Gibbs, D., O’Neill, K. (2017). Future green economies and regional development: a research agenda. *Regional Studies*, Vol. 51, No. 1, p. 161–173.
- Ghisetti, C., Quatraro, F. (2013). Beyond inducement in climate change: does environmental performance spur environmental technologies? A regional analysis of cross-sectoral differences. *Ecological Economics*, Vol. 96, p. 99–113.
- Grant, D., Yeo, B. (2018). A global perspective on tech investment, financing, and ICT on manufacturing and service industry. *International Journal of Information Management*, Vol. 43, p. 130–145.
- Hall, J., Matos, S., Bachor, V. (2019). From green technology development to green innovation: inducing regulatory adoption of pathogen detection technology for sustainable forestry. *Small Business Economy*, Vol. 52, No. 4, p. 877–889.
- He, L., Zhang, L., Zhong, Z., Wang, D., Wang, F. (2019). Green credit, renewable energy investment and green economy development: empirical analysis based on 150 listed companies of China. *Journal of Cleaner Production*, Vol. 208, p. 363–372.
- Huang, J. W., Li, Y. H. (2017). Green Innovation and Performance: the view of organizational capability and social reciprocity. *Journal of Business Ethics*, Vol. 145, No. 2, p. 309–324.
- IEA. (2009). *Ensuring green growth in a time of economic crisis: the role of energy technology*. [https://www.iea.org/publications/freepublications/publication/ensuring\\_green\\_growth.pdf](https://www.iea.org/publications/freepublications/publication/ensuring_green_growth.pdf) [Accessed March 15, 2019].
- Yang, L. R., Chen, J. H., Li, H. H. (2016). Validating a model for assessing the association among green innovation, project success and firm benefit. *Quality & Quantity: International Journal of Methodology*, Vol. 50, No. 2, p. 885–899.
- Yang, Y., Guo, H., Chen, L., Liu, X., Gu, M., Ke, X. (2019). Regional analysis of the green development level differences in Chinese mineral resource-based cities. *Resource Policy*, Vol. 61, p. 261–272.
- Yi, H. (2014). Green businesses in a clean energy economy: analyzing drivers of green business growth in U. S. states. *Energy*, Vol. 68, p. 922–929.
- Jänicke, M. (2012). “Green growth”: from a growing eco-industry to economic sustainability. *Energy Policy*, Vol. 48, p. 13–21.
- Marra, A., Antonelli, P., Pozzi, C. (2017). Emerging green-tech specialization and clusters – a network analysis on technological innovation at the metropolitan level. *Renewable and Sustainable Energy Review*, Vol. 67, p. 1037–1046.
- Mundaca, L., Neij, L., Markandya, A., Hennicke, P., Yan, J. (2016). Towards a green energy economy? Assessing policy choices, strategies and transitional pathways. *Applied Energy*, Vol. 179, p. 1283–1292.
- Kleis, L., Chwelos, P., Ramirez, R. V., Cockburn, I. (2012). Information technology and intangible output: the impact of IT investment on innovation productivity. *Information Systems Research*, Vol. 23, No. 1, p. 42–59.
- Laibach, N., Börnera, J., Bröring, S. (2019). Exploring the future of the bioeconomy: an expert-based scoping study examining key enabling technology fields with potential to foster the transition toward a bio-based economy. *Technology in Society*. <https://doi.org/10.1016/j.techsoc.2019.03.001> [Accessed March 15, 2019].
- Leoncini, R., Marzucchi, A., Montresor, S., Rentocchini, F., Rizzo, U. (2019). ‘Better late than never’: the interplay between green technology and age for firm growth. *Small Business Economics*, Vol. 52, No. 4, p. 891–904.
- Li, J., Pan, S. Y., Kim, H., Linn, J. H., Chiang, P. C. (2015). Building green supply chains in eco-industrial parks towards a green economy: barriers and strategies. *Journal of Environmental Management*, Vol. 162, p. 158–170.
- Li, W., Wang, J., Chen, R., Xi, Y., Liu, S. Q., Wu, F., Masoud, M., Wu, X. (2019). Innovation-driven industrial green development: the moderating role of regional factors. *Journal of Cleaner Production*, Vol. 222, p. 344–354.
- Lindman, A., Söderholm, P. (2016). Wind energy and green economy in Europe: measuring policy-induced innovation using patent data. *Applied Energy*, Vol. 179, p. 1351–1359.



- Lin, B., Benjamin, N. I. (2017). Green development determinants in China: a non-radial quantile outlook. *Journal of Cleaner Production*, Vol. 162, p. 764–775.
- Lithuania's progress strategy "Lithuania 2030". <https://www.docdroid.net/ERhjMs3/en-lietuva2030.pdf#page=8> [Accessed March 15, 2019].
- Loiseau, E., Saikku, L., Antikainen, R., Droste, N., Hansjürgens, B., Pitkänen, K., Leskinen, P., Kuikman, P., Thomsen, M. (2016). Green economy and related concepts: an overview. *Journal of Cleaner Production*, Vol. 139, p. 361–371.
- Luukkanen, J., Kaino-oja, J., Vähäkari, N., O'Mahony, T., Korkeakoski, M., Panula-Ontto, J., Phonhalath, K., Nanthavong, K., Reincke, K., Vehmas, J. Hogarth, N. (2019). Green economic development in Lao PDR: a sustainability window analysis of green growth productivity and the efficiency gap. *Journal of Cleaner Production*, Vol. 211, p. 818–829.
- Miao, C., Fang, D., Sun, L., Luo, Q. (2017). Natural resources utilization efficiency under the influence of green technological innovation. *Resources, Conservation and Recycling*, Vol. 126, p. 153–161.
- OECD. (2008). Measuring the impacts of ICT using official statistics. *OECD Digital Economy Papers*, No. 136. <http://dx.doi.org/10.1787/230662252525> [Accessed March 15, 2019].
- OECD. (2011). *Towards green growth: monitoring progress OECD indicator*. <https://www.oecd.org/green-growth/48224574.pdf> [Accessed March 15, 2019].
- Paulauskas, S. (2018). Circular economy 3.00: tourism service case. *Journal of Management*, Vol. 32, No. 1, p. 91–97.
- Pieroni, M. P. P., McAlloone, T. C., Pigosso, D. C. A. (2019). Business model innovation for circular economy and sustainability: a review of approaches. *Journal of Cleaner Production*, Vol. 215, p. 198–216.
- Pitkänen, K., Antikainen, R., Droste, N., Loiseau, E., Saikku, L., Aissani, L., Hansjürgens, B., Kuikman, P. J., Leskinen, P., Thomsen, M. (2016). What can be learned from practical cases of green economy? – studies from five European countries. *Journal of Cleaner Production*, Vol. 139, p. 666–676.
- Pearce, D., Markandya, A., Barbier, E. (1989). *Blueprint for a green economy*. Earthscan: London, Great Britain.
- Popa, O., Dina, G. C., Martinc, C. (2011). Promoting the corporate social responsibility for a green economy and innovative jobs. *Procedia Social and Behavioral Sciences*, Vol. 15, p. 1020–1023.
- Popp, D., Hafner, T., Johnstone, N. (2007). Policy vs. consumer pressure: innovation and diffusion of alternative bleaching technologies in the pulp industry. *NBER Working Paper*, No. 13439. <https://www.nber.org/papers/w13439.pdf> [Accessed March 15, 2019]
- Porfiryev, B. N. (2012). Green economy: worldwide development trends and prospects. *Herald of the Russian Academy of Sciences*, Vol. 82, No. 2, p. 120–128.
- Porfiryev, B. N. (2018). The green factor of economic growth in Russia and the World. *Studies on Russian Economic Development*, Vol. 29, No. 5, p. 455–461.
- Rennings, K. (2000). Redefining innovation: eco-innovation research and the contribution from ecological economics. *Ecological Economics*, Vol. 32, No. 2, p. 319–332.
- Schanesa, L., Jagerb, J., Drummond, P. (2019). Three scenario narratives for a resource-efficient and low-carbon Europe in 2050. *Ecological Economics*, Vol. 155, p. 70–79.
- Styles, D., O'Brien, P., O'Boyle, S., Cunningham, P., Donlon, B., Jones, M. B. (2009). Measuring the environmental performance of IPPC industry: I. devising a quantitative science-based policy-weighted environmental emissions index. *Environmental Science Policy*, Vol. 12, No. 3, p. 226–242.
- Swainson, L., Mahanty, S. (2018). Green economy meets political economy: lessons from the "Aceh Green" initiative, Indonesia. *Global Environmental Change*, Vol. 53, p. 286–295.
- UNEP. (2011). *Towards a green economy: pathways to sustainable development and poverty eradication*. [https://sustainabledevelopment.un.org/content/documents/126GER\\_synthesis\\_en.pdf](https://sustainabledevelopment.un.org/content/documents/126GER_synthesis_en.pdf) [Accessed March 15, 2019].
- Van Kleef, J. A. G., Roome, N. J. (2007). Developing capabilities and competence for sustainable business management as innovation: a research agenda. *Journal of Cleaner Production*, Vol. 15, No. 1, p. 38–51.
- Van Loon-Steensma, J. M., Schelfhout, H. A., Vellinga, P. (2014). Green adaptation by innovative dike concepts along the Dutch Wadden Sea coast. *Environmental Science and Policy*, Vol. 44, p. 108–125.
- Zhu, Q., Sarkis, J. (2004). Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises. *Journal of Operations Management*, Vol. 22, No. 3, p. 265–289.
- Zuo, Y. Shi, Y. I., Zhang, Y. Z. (2017). Research on the sustainable development of an economic-energy-environment (3E) system based on system dynamics (SD): a case study of the Beijing-Tianjin-Hebei Region In China. *Sustainability*, Vol. 9, No. 10, p. 1727–1750.
- Walker, H., Preuss, L. (2008). Fostering sustainability through sourcing from small businesses: public sector perspectives. *Journal of Cleaner Production*, Vol. 16, No. 15, p. 1600–1609.
- Wanner, T. (2015). The new "Passive Revolution" of the green economy and growth discourse: maintaining the "Sustainable Development" of Neoliberal capitalism. *New Political Economy*, Vol. 20, No. 1, p. 21–41.

- Xiao, M., Lin, Y., Han, J., Zhang, G. (2014). A review of green roof research and development in China. *Renewable and Sustainable Energy Review*, Vol. 40, p. 633–648.
- Wang, M. X., Zhao, H. H., Cui, J. X., Fan D., Ly, B., Wang, G., Li, Z. H., Zhou, G. J. (2018). Evaluating green development level of nine cities within the Pearl River Delta, China. *Journal of Cleaner Production*, Vol. 174, p. 315–323.
- While, A., Jonas, A. E. G., Gibbs, D. C. (2010). From sustainable development to carbon control: eco state restricting and the politics of urban and regional development. *Transactions of the Institute of British Geographers*, Vol. 35, No. 1, p. 76–93.
- World Bank. (2012). *Inclusive green growth: the pathway to sustainable development*. [http://siteresources.worldbank.org/EXTSDNET/Resources/Inclusive\\_Green\\_Growth\\_May\\_2012.pdf](http://siteresources.worldbank.org/EXTSDNET/Resources/Inclusive_Green_Growth_May_2012.pdf) [Accessed March 15, 2019].

## ŽALIŲJŲ TECHNOLOGIJŲ PLĖTROS TEORINIAI ASPEKTAI

AGNĖ ŠNEIDERIENĖ, HENRIKA RUGINĖ  
Klaipėdos universitetas (Lietuva)

### Santrauka

Straipsnyje analizuojama žaliosios ekonomikos koncepcijos esmė, nustatomi pagrindiniai žaliųjų technologijų plėtros pranašumai.

Technologinės naujovės yra esminė žaliosios ekonomikos pereinamojo laikotarpio sudedamoji dalis, todėl svarbu plėtoti ir įgyvendinti žaliašias technologijas, ypač besivystančiose šalyse. Tarptautinė energetikos agentūra (TEA 2009) pabrėžia mažą anglies dioksido kiekį išskiriančių energetikos technologijų vaidmenį, siekiant užtikrinti ekologiškai tvarų augimą šalyse finansų ir ekonomikos krizės laikotarpiu. Mokslininkai (Styles et al. 2009; Van Loon-Stennsma et al. 2014; Li et al. 2015) teigia, kad žaliųjų technologijų taikymas padėtų kontroliuoti aplinkos užterštumą ir pagerintų gamtos išteklių atkūrimą. Straipsnyje analizuojama mokslinė problema galima įvardyti kaip siekiamybę nustatyti žaliųjų technologijų taikymo naudą.

Mokslinio tyrimo objektas – žaliųjų technologijų vystymas.

Mokslinio tyrimo tikslas: išanalizuoti teorinį požiūrį į žaliųjų technologijų plėtrą.

Mokslinio tyrimo uždaviniai:

1. Išanalizuoti žaliosios ekonomikos koncepcijos esmę.
2. Nustatyti pagrindinius žaliųjų technologijų plėtros privalumus.

Visuotinai priimto žaliosios ekonomikos apibrėžimo nėra. Be to, reikėtų pabrėžti, kad su žaliaja ekonomika susijusios įvairios kitos sąvokos: *išmanioji ekonomika*, *mėlynoji ekonomika*, *tvari ekonomika*, *žiedinė ekonomika* ir pan. M. Pieroni'io ir bendraautorių (2019) teigimu, šių sąvokų ribos aiškiai neapibrėžtos.

Žaliosios ekonomikos sąvoka pristatyta D. Pearce'o ir bendraautorių (1989), reaguojant į nepakankamą aplinkos taršos ir socialinių sąnaudų vertinimą dabartinėje kainų sistemoje. Žalioji ekonomika – tai išteklius taupanti ir aplinką tausojanti ekonomika, būdas spręsti aplinkosaugos problemas, pasitelkus žmogaus išradimus ir technologinę pažangą (Gazzola et al. 2019). Tai ekonominė plėtra, grindžiama tvaraus vystymosi modeliu ir ekologinės ekonomikos žiniomis (Popa et al. 2011), užtikrinanti socialinį išitraukimą bei ekonominę naudą. Būtina paminėti, kad žalioji ekonomika yra būdas tradicinių išteklių naudojimą pakeisti atsinaujinančia energija ir mažą kiekį anglies dioksido išskiriančiomis technologijomis, siekiant pagerinti išteklių ir energijos vartojimo efektyvumą (UNEP 2011).

Išgryninti žaliosios ekonomikos apibrėžimą gana sudėtinga, nes bendro sąvokos aprašymo nėra. Tačiau šią žaliają ekonomiką galima apibūdinti kaip išteklius taupančią ir aplinką tausojančią ekonomiką, aktyviai skatinančią investuoti į naujas energijos taupymo technologijas, mažo anglies dioksido kiekio iniciatyvas, aplinkos apsaugos įrangą, klimato riziką mažinančias technologijas ir kt.

Anot Y. Yang'o ir bendraautorių (2016), W. Chen'o ir bendraautorių (2006), ekologiškos technologijos apibrėžiamos kaip technikos ar programinės įrangos inovacijos, susijusios su ekologiškais produktais ar

procesais, įskaitant technologijas, susijusias su energijos taupymu, taršos prevencija, atliekų perdirbimu, „žaliųjų“ produktų dizainu ar įmonės aplinkosaugos vadyba.

J. W. Huang'o, Y. H. Li (2017) teigimu, žaliosios inovacijos vaidina pagrindinį vaidmenį perkeliant pramonę į tvarią gamybą bei palengvina tvarių gamybos iniciatyvų raidą. Dabartinė technologinė pažanga daugiausia dėmesio skiria ekologiškoms naujovėms, jų diegimui, tai siejama su produktais ar procesais, kurie nukreipti į ekologines inovacijas. Žaliosios inovacijos siekia sukurti procesus ir produktus, kurie minimaliai veiktų aplinką (Zhu, Sarkis 2004; Chen 2008).

Apibendrinant galima teigti, kad technologinės naujovės yra pagrindinis žaliosios plėtros veiksnys didinant gamtos išteklių efektyvumą bei mažinant aplinkos taršą. Tačiau daugelio vietos pramonės šakų ir įmonių galimybės taikyti žaliausias technologijas menkos. Finansinės kliūtys lemia technologines kliūtis, nes trukdo kurti bei diegti naujas technologijas. Jei nebus surasta sprendimų, kaip šiuos trukdžius pašalinti, ir nebus kuriamos bei diegiamos ekologiškos technologijos, ateityje spręsti įvairias problemas, kurios susijusios su ekonomikos augimo skatinimu (klimato kaitos, biologinės įvairovės nykimo, kt.), bus dar sunkiau.

PAGRINDINIAI ŽODŽIAI: *žalioji ekonomika, žaliosios technologijos, plėtra, ekonomikos augimas.*

JEL KODAI: D60, I31, O30, O52, Q20.

*Received: 2019-*

*Revised: 2019-*

*Accepted: 2019-*