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DECARBONIZATION PROJECT MANAGEMENT: INTERNATIONAL ECONOMIC INTEGRATION, BUSINESS ANALYTICS, TECHNOLOGIES AND SUSTAINABLE DEVELOPMENT STANDARDS

МЕНЕДЖМЕНТ ПРОЕКТІВ ДЕКАРБОНІЗАЦІЇ: МІЖНАРОДНА ЕКОНОМІЧНА ІНТЕГРАЦІЯ, БІЗНЕС-АНАЛІТИКА, ТЕХНОЛОГІЇ ТА СТАНДАРТИ СТАЛОГО РОЗВИТКУ

Summary. The paper notes that a distinctive feature of the global economy is its active globalization. The dynamics of the global economy are volatile and require measures within the framework of an effective international management system. The authors propose a model of international innovative projects for economic decarbonization, identifying projects in nuclear energy, hydropower, battery storage, offshore wind farms, and hydrogen production and use in transport, as well as potential participants in such projects. The article notes that climate-neutral energy projects in Poland, involving leading Polish and international companies such as Orlen Group, Synthos, Northland Power, Vestas, GE Vernova Hitachi Nuclear Energy, Polskie Elektrownie Jądrowe, Westinghouse, Bechtel, PGE Polska Grupa Energetyczna S.A., Ørsted, and Siemens Gamesa Renewable Energy, are an effective example of successful international cooperation. The specific features of business analytics in the field of electric mobility are also discussed. It was emphasized that corporate social responsibility is a specific, organic feature of the activities of companies engaged in decarbonization. This responsibility is fully consistent with the United Nations Sustainable Development Goals.

Keywords: management, international economic integration, technology, standards, corporate social responsibility, decarbonization, business analytics, sustainable development.

Анотація. Зазначається, що специфічною рисою економіки планети є її активна глобалізація. Динаміка світового господарства відрізняється нестійкістю та потребує заходів у рамках системи ефективного міжнародного менеджменту. Для надання процесам імпульсу розвитку потрібні інноваційні, наповнені значними інвестиціями міжнародні проекти у ключових для світової цивілізації сферах економіки. Міжнародне

співробітництво на користь сталого розвитку, його особлива ефективність обумовлені вищим інноваційним, інвестиційним, управлінським, кадровим потенціалом групи країн світу, особливо країн Європи, що перевищує можливості будь-якої окремої країни. Доцільною є концентрація зусиль держав на вирішенні саме таких проблем, які вони здатні ефективно здійснити в силу економічних, інноваційних, історичних та інших причин. Міжнародне співробітництво найбільш результативне при вирішенні найважливіших проблем світової економіки. Авторами запропоновано модель міжнародних інноваційних проектів декарбонізації економіки із зазначенням проектів у сфері атомної енергетики, гідроенергетики, розробки та виробництва акумуляторних батарей, морських вітрових електростанцій, виробництва та використання водню на транспорті та перелік можливих учасників таких проектів. У статті наголошується, що ефективним прикладом успішної міжнародної співпраці є проекти кліматично нейтральної енергетики в Польщі за участю провідних польських та зарубіжних фірм, таких як Orlen Group, Synthos, Northland Power, Vestas, GE Vernova Hitachi Nuclear Energy, Polskie Elektrownie Jądrowe, Westinghouse, Bechtel, PGE Polska Grupa Energetyczna S.A., Ørsted, Siemens Gamesa Renewable Energy. Наголошено, що соціальна відповідальність бізнесу є специфічною органічною рисою діяльності компаній, що займаються декарбонізацією. Ця відповідальність повною мірою збігається з цілями сталого розвитку Організації Об'єднаних Націй. Показовим є той факт, що великі польські компанії, а саме Orlen, яка має велику історію нафтовидобутку та нафтопереробки, а також хімічна компанія Synthos, стверджуючи нову стратегію розвитку в контексті декарбонізації, показують цим також яскравий приклад соціальної відповідальності бізнесу перед суспільством у глобальному розумінні.

Ключові слова: менеджмент, міжнародна економічна інтеграція, технології, стандарти, соціальна відповідальність бізнесу, декарбонізація, бізнес-аналітика, сталий розвиток.

Problem statement. Modern civilization is developing in the context of progressive global economic growth, which is simultaneously accompanied by a vast array of problems. The most pressing challenges facing humanity include rapid climate change, particularly driven by economic activity; the need to secure energy, food, and clean water; and environmental protection. Climate change in 2025, as is already evident, has led to reduced yields of some vital agricultural crops, which will entail negative financial and other consequences for the entire global economy. Humanity's growing energy demand is also a common and highly complex problem requiring solutions. It can be stated with certainty that global, large-scale, and complex problems cannot be resolved by the efforts of a single country, or even several countries. Such problems can be addressed through the active efforts of the entire international community, the innovative, financial, and human potential of the world's leading countries, international cooperation, coordination, and effective international management.

Analysis of recent research and publications. Problems of global economic development, competitiveness, international management of cooperation projects in various industries, company integration, studying the negative consequences of climate change, decarbonization of the economy, and the development of innovative technologies are a topical subject of research for scientists. The issues of development of innovation management and quality of business processes in the field of green economy and entrepreneurship are explored in the work [1] of the authors Shpykulyak O., Lopatynskyi Y., Shelenko D., Kyfyak V., Shpykulyak V. in the context of European integration processes. Scientists Kovalchuk T., Zaharii V. [2] analyze innovative strategies for the international competitiveness of Ukrainian enterprises. Issues of international integration in the modern economy are the subject of research in the work of Shkurat M. [3] , while global competitiveness in the context of digitalization is considered, the author also analyzes the business strategies of international companies. In the work of Couckuyt D., Van Looy A. [4] sustainable development is examined in the context of climate-neutral business process management. Current aspects and further prospects of digital competitiveness of the most economically developed countries in the world in global development conditions are investigated in the work of authors Sholom A., Shynkarenko O. [5]. The issues of assessing energy security during the transition to a climate-neutral economy are considered in the study by Shu Zhang, Yubo Ma, Xinzhu Zheng, Qianting Zhu, Xu Tang [6]. Sohns T.M., Aysolmaz B., Figge L., Joshi A. [7] explore the issues of sustainable development and effective management in the German economy. The problems of studying the effectiveness of a set of aspects of modern international projects are numerous, interconnected, and dynamic, and therefore require further study, especially with regard to global development in the context of decarbonization and the use of innovative technologies.

Previously unsolved parts of the overall problem. The planet's global economy is developing very unevenly. A relatively small group of countries with the most developed innovative potential are at the forefront of decarbonization processes across the global economy. Through active international cooperation, these countries can influence many other, less economically developed countries and integrate them into the overall development of a climate-neutral economy. The mechanisms for such cooperation are highly complex and have not been thoroughly studied, while the process of international economic integration is rapidly evolving, and its elements are constantly changing. Therefore, it can be argued that research into the management of international

decarbonization projects, particularly in the fields of energy and transport, innovative technologies, business analytics, and corporate social responsibility within the framework of sustainable development, is of both scientific and practical interest.

The aim of the article is to study the dynamics of the global economy and construct a comprehensive model of international innovative decarbonization projects using advanced technologies.

Summary of the main research material. A characteristic feature of the modern economy is its increasingly active globalization. To give this economy a vigorous impetus for development and as a decisive response to the extremely negative consequences of climate change, innovative international projects with significant investment are needed in key economic sectors of global civilization. International cooperation for sustainable development, the positive aspects, and significant advantages of international projects are determined by the following factors.

1. The significantly higher innovative, investment, managerial, and human resource potential of a group of countries, which exceeds the capabilities of any single country.

2. The ability to concentrate the efforts of various states on solving problems that they are capable of effectively addressing due to historical, geographical, resource, and other factors.

3. Effective international management in joint projects between different countries makes it possible to avoid the irrational waste of time, financial resources, and human potential, and facilitates the exchange of experience and achieved results for shared success.

4. International cooperation is generally most effective in solving the most pressing problems of the global economy and allows for the achievement of maximum results.

Since the development of innovative technologies is of paramount importance for the sustainable development of civilization, we will consider some of what we believe to be largely key areas related to the decarbonization of the global economy in a number of areas of energy, transport, mechanical engineering, and international management in the context of international projects (Table 1), which utilize the innovative potential of the world's leading economic countries and are strengthened through active economic integration.

The development of the projects discussed in Table 1 has certain specific features. At a certain stage of the process, specially created, authoritative

Table 1 – Intermediate innovative projects decarbonization economics

№	Direction	Content	Possible key participants
1	2	3	4
1	Nuclear power, large reactors	Develop a design for a large nuclear reactor that meets high safety requirements, is technologically advanced, and allows for reduced construction time for nuclear power plants	USA, France, Great Britain, Japan
2	Small modular reactors	To develop a design for a reactor with a capacity of approximately 80-120 MW (el.), which is distinguished by high safety requirements, very high technological efficiency, the possibility of serial production of modules in factory conditions and the shortest possible installation time at the station construction site	USA, France, Great Britain, Japan, Republic of Korea, Belgium
3	Hydroelectric power plants	Develop a turbine design with high technical characteristics and economic indicators	Norway, Germany, France, Switzerland, Italy.
4	Batteries for electric vehicles	To develop designs for batteries with high capacity, fast charging capability and relatively low production costs	European countries, USA, Japan, Republic of Korea
5	Offshore wind farms	Develop offshore wind farm construction projects, including the associated infrastructure. The key components of such plants should be wind turbines with a capacity of approximately 15 MW, which will be highly technological and relatively inexpensive. Large-scale construction of these installations will allow for optimal exploitation of economies of scale	Denmark, Germany, Spain, USA, Great Britain, Republic of Korea
6	Hydrogen-fueled trains	Develop designs for hydrogen-powered railway locomotives and the associated infrastructure. These locomotives must utilize hydrogen fuel produced using climate-neutral technologies	France, Germany, Switzerland, Japan, USA, Great Britain, Republic of Korea, Australia
7	Hydrogen fueled ships	Develop designs for various types of ships for transporting cargo and passengers on the World Ocean, seas, and rivers using hydrogen fuel	Japan, Germany, Italy, Netherlands, Denmark, Norway, Republic of Korea

End of Table 1

1	2	3	4
8	Commercial airliners powered by hydrogen fuel	Develop designs for various types of commercial hydrogen-powered airliners for transportation over various distances, including transcontinental flights	France, Germany, Great Britain, USA, Japan
9	Hydrogen production using climate-neutral technologies	To develop optimal technologies, equipment, and infrastructure designs for the mass production of hydrogen as an energy source for transport, industry, public utilities, and other purposes	Japan, USA, Great Britain, France, Germany, Sweden, Norway, Australia, Canada, Saudi Arabia
10	Optimal processes for managing decarbonization projects	To develop optimal technologies and management projects to address global sustainable development challenges	European countries, USA, Japan, Republic of Korea

Source: compiled by the authors

competition committees will be required to select the most promising projects from a large number. Subsequent innovation and investment efforts, maximized as much as possible, will be focused on these projects for their full implementation and widespread adoption in the global market. These objectives must be achieved in the interests of economic decarbonization and sustainable development, and their importance significantly outweighs the need to achieve commercial success. In the case of large nuclear reactors, the key goal should be a sustainable reduction in the cost and time of their construction, as this is currently a major challenge.

The development of an optimal small modular reactor should become a crucial, reliable, and flexible tool for rapidly advancing toward decarbonization. The advantage of such reactors is the ability to be mass-produced in factories and installed relatively quickly on-site, as well as the ability to increase capacity by installing additional units while an existing unit is already generating energy.

Batteries in electric vehicles are a crucial element, yet one that currently hinders their development. The challenge lies in developing optimal battery designs and production technologies that are low-cost. The use of hydrogen in various economic sectors will complement electric energy in decarbonizing the economy.

The combination of all these innovative projects, if successfully implemented, could provide a powerful boost to the global economy and accelerate its growth based on climate-neutral technologies.

Since electric mobility is a key area of economic decarbonization, activities in this field are of great interest and have potential for development worldwide. At the same time, the operating conditions for companies in different countries can vary significantly. This issue is important for effective business analytics and optimal management decision-making. An analysis of country-specific operating conditions for companies in the electric mobility sector is presented in Table 2.

Currently, the countries most favorable for the development of electric mobility include China and European countries, particularly Germany, the United Kingdom, France, the Netherlands, Denmark, and Norway. A significant number of countries currently do not create favorable conditions for companies

Table 2 – Specific conditions of activity for business analytics in the field of electric mobility

№	Factors to consider	Countries with favorable conditions	Countries with unfavorable conditions
1	2	3	4
1	Production volumes	Opportunity for active growth	Unsustainable growth dynamics, danger of decline
2	Sales volumes	Opportunity for active growth	Unstable dynamics
3	Logistics capabilities	Developed and growing	Underdeveloped, some elements may be missing
4	Resource prices	Relatively stable	Unstable, subject to sudden changes
5	Human resources potential	Availability of highly qualified personnel	The overall relatively low level of personnel training
6	Competitive conditions	Opportunity for competition for more progressive projects	Uncertainty and instability of conditions
7	Investment opportunities	High potential	Limited potential
8	Innovative opportunities	High, based on developed innovative potential	Extremely limited or absent

Source: compiled by the authors

in this sector, which is reflected in the dynamics of electric vehicle production and sales. At the same time, in a globalized world, operating conditions can change in various directions. This makes the work of business analysts particularly challenging and necessitates a rapid response to these changes.

International cooperation in energy decarbonization projects in Poland includes the participation of reputable foreign companies with significant innovative technological achievements alongside Polish ones. Polish companies Orlen and Synthos, in collaboration with the American company GE Vernova Hitachi Nuclear Energy [8], the developer and manufacturer of the BWRX-300 reactor, are implementing the project for Poland's first nuclear power plant with small modular reactors (electrical capacity – 300 MW(e) net to the grid) in Włocławek. It's noteworthy that Polish companies have not previously been involved in the electric power industry, and this project is an important element of their development strategy in the context of decarbonization policy. Orlen, a major Polish concern, has been extracting, refining, and selling oil and gasoline in Poland and many other European countries, as well as internationally, for many years. Synthos is a major chemical company, also well-known in Europe and beyond.

Poland's most important decision is to build the country's first large nuclear power plant with large reactors in cooperation with US companies. Polskie Elektrownie Jądrowe provides key information for specialists and the general public about the projects to build the first large nuclear reactors in Poland in the framework of international cooperation [9]: "Polskie Elektrownie Jądrowe is responsible for, among other things, preparing the investment process and acting as the investor in the project to construct nuclear power plants with a total installed capacity of approximately 6 to 9 GWe. This is based on safe, proven, large-scale Generation III (+) pressurized water reactors (PWRs), including their potential future operation. The company also supports the government administration in activities aimed at implementing the Polish Nuclear Power Programme and executing the agreement between the Government of the Republic of Poland and the Government of the USA regarding cooperation to develop a nuclear power program for civilian use and the civilian nuclear industry in the Republic of Poland. The construction of the first nuclear power plant in Poland is a key infrastructure project of strategic importance for the success of the country's energy transition. It will ensure energy independence and provide a significant developmental boost for the national economy. The first nuclear power plant in Pomerania could cover the electricity demand of over 12 million households in Poland. It is estimated that the scale of investments related to nuclear energy in Poland will translate into economic growth of nearly 1% of GDP.

The nuclear power plant will be built at the "Lubiatowo-Kopalino" site in the Choczewo municipality, in Pomerania. The project involves the construction of 3 reactors using AP1000 technology, each with a gross capacity of 1250 MWe."

On the Polish side, the state-owned company Polskie Elektrownie Jądrowe is responsible for the development and financing of the investment process. This company provides further important information about the project, emphasizing the importance of international cooperation and collaboration in such a crucial area of innovation [9]: "The investment is being carried out in cooperation with a consortium of companies – Westinghouse and Bechtel. Westinghouse Electric Company is the supplier of the AP1000 technology and specializes in the manufacturing, servicing, and maintenance of nuclear equipment. Westinghouse technologies are used in nearly half of the operating nuclear power plants worldwide. Bechtel is an American engineering company specializing in project management and construction. Cooperation with the consortium will ensure the comprehensive implementation of the project – from engineering and procurement to the construction and commissioning of the power plant."

The development of nuclear energy must be accompanied by the training of qualified specialists in this field. International cooperation plays a key role here as well. Bechtel points out [10] that the company "signed agreements with Gdansk University of Technology and Warsaw University of Technology to launch new Nuclear Energy Career Development Programs to help prepare the workforce for Poland's emerging nuclear power industry."

Efforts to cooperate in the field of nuclear energy are broader in nature and affect the interstate level: "As part of these efforts to expand nuclear knowledge within Poland, the U.S. Department of Energy inaugurated a regional training center for clean energy technologies in Warsaw" [10]. Such cooperation will have a positive impact on the implementation of nuclear energy development projects in Poland and can also serve as a shining example of effective international management for other countries.

The Baltic Power offshore wind farm is a significant joint international project for ORLEN Group (Poland) and Northland Power (Canada). Baltic Power provides key information about the project [11]: "The Baltic Power offshore wind farm is a key project for the ORLEN Group and Northland Power, supporting transition towards a clean, low-carbon economy. Located 23 km to the north of the Polish coastline, on the level of Choczewo and Łeba, Baltic Power is one of the most advanced projects planned in the Polish Exclusive Economic Zone in the Baltic Sea".

The Baltic Power project will use turbines from Vestas (Denmark), one of the most reputable companies in this field worldwide. Each turbine (V236) has a

capacity of 15 MW. Baltic Power is scheduled to be commissioned in 2026, with a total capacity of approximately 1.2 GW. The plant's technical and economic indicators are shown in Fig. 1.

Project participants emphasize its importance and point to greater prospects for the development of offshore wind energy [11]: "The Polish State National Energy Policy (PEP2040) outlines the potential of and assumes the development of offshore wind energy in the area of the Polish Exclusive Economic Zone of the Baltic Sea, with the capacity of aprox. 5.9 GW in 2030 and up to 11 GW in 2040. Offshore wind farms in the Baltic may play a key role in Poland's energy transition, contribute to the strengthening of the country's energy security, and help tackle air pollution".

In addition to the Baltic Power project, an even larger international project, Baltica 2, is being implemented in the Baltic Sea [12]: "The Baltica 2 offshore wind farm is the biggest offshore wind energy 1st phase project by capacity in the Polish part of the Baltic Sea under development by PGE Group and Ørsted. Its 1498 MW of capacity will allow for producing green energy from wind for about 2.4 million recipients, including households, schools, hospitals, institutions and companies. Together with the Baltica 3 stage it will create the Baltica Offshore Wind Farm complex which will contribute significantly to Poland's green energy transition. The offshore part of the Baltica 2 project will be operating in the Polish part of the Baltic Sea north of the coastline between Choczewo and Ustka. It will consist of 107 turbine

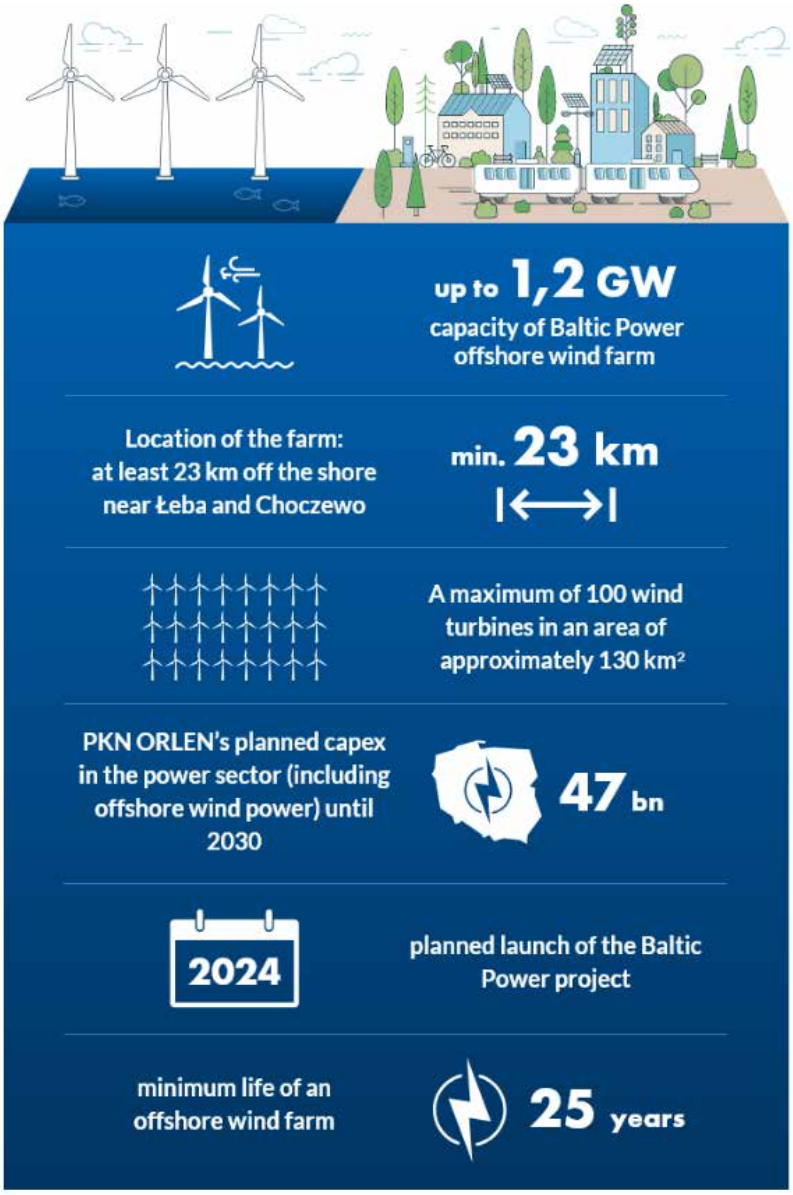

Figure 1 – Technical and economical showcases of the Baltic Power project

Source: [11]

wind generators of 14 MW capacity each laid out on the sea surface of about 190 sq. km. The distance to the closest turbine from the shore will be about 40 km. The turbines will be mounted on monopile foundations. Four offshore substations will be built for the farm to allow the electricity to be exported onshore via subsea cable lines. The onshore part of the Baltica 2 project, the connection infrastructure necessary for Baltica 2 will be developed in the village of Osieki Lęborskie, Choczewo municipality, poviat of Wejherowo. It will consist of the onshore transformer substation and underground cable lines which will allow for delivering electricity produced by the offshore wind farm to the onshore substation. From here on the electricity will be distributed to the Polish Power System. Commissioning of Baltica 2 is planned for 2027".

The project utilizes turbines from Siemens Gamesa Renewable Energy [13], one of the world's leading turbine manufacturers. The technical and economic indicators of the Baltica 2 project are presented in Fig. 2.

Cooperation projects between Poland and its foreign partners in the field of decarbonization are illustrated in Fig. 3.

An analysis of Poland's transition to climate-neutral electricity generation revealed the following.

1. Poland has carefully and carefully selected the most promising climate-neutral electricity generation options, including offshore wind farms located in the Baltic Sea, at significant distances from the country's coast, traditional large nuclear reactors, and small modular reactors for nuclear power plants.

2. The above-mentioned climate-neutral energy options and the management decisions surrounding their selection are particularly important for Poland due to the fact that the country has never had a single nuclear power plant in its history. Also noteworthy is the country's commitment to the long-term mass construction of small modular reactors, which are currently not widely used globally, even among many countries that have long operated traditional large nuclear reactors. Poland has also chosen what we believe to be the most important and promising form of energy—namely, offshore wind energy – on a very large scale for Europe and even the world. This energy efficiency is higher than onshore wind energy and offers a number of other advantages. This management decision was made in a context where the country did not previously have such large wind farms.

3. Poland is abandoning its traditionally important coal mining and its use in energy and other sectors of the economy. Although these industries have existed in the country for a long time and boasted significant production potential, they did not meet modern global ideas of decarbonization and sustainable development.

4. By adopting a management decision to large-scale develop key forms of climate-neutral energy, Poland has demonstrated to the world its stable and consistent position in upholding high principles and standards of decarbonization in the global economy and striving to preserve the planet's climate for the benefit of present and future generations.

5. The decision to develop nuclear energy in Poland is a concerted effort that serves the interests

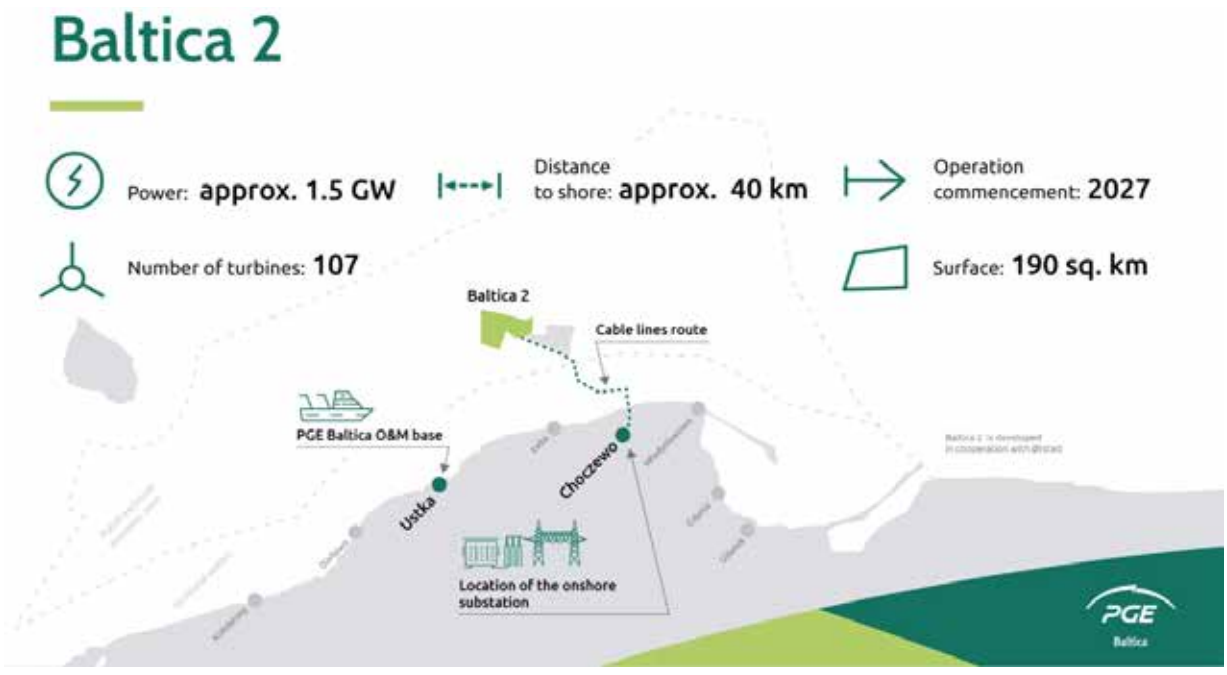

Figure 2 – Technical and economical showcases of the Baltica 2 project

Source: [12]

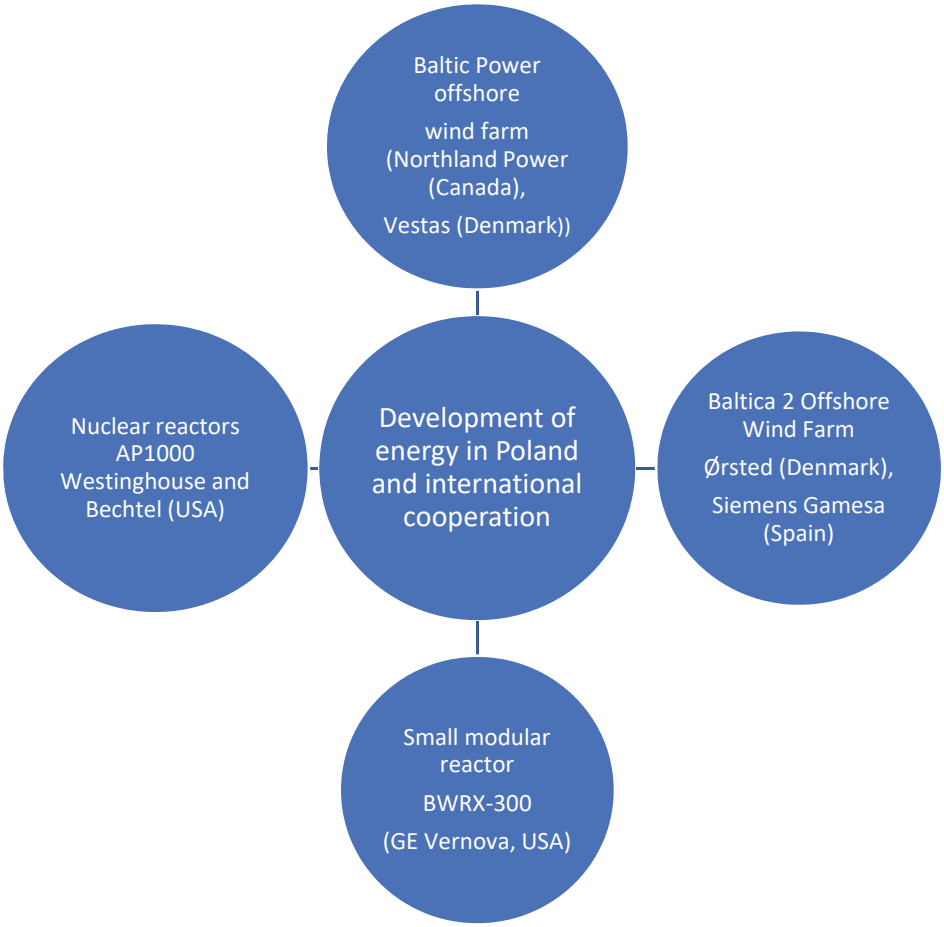

Figure 3 – Poland's cooperation in decarbonization projects

Source: created by the authors, based on [8–13]

of Poland's development and economy. It is made by the country's politicians and supported by the majority of experts in the field and the general public. This decision stands in stark contrast to the German government's decision several years ago to completely shut down nuclear power plants in that country, even though they had long been an important component of the country's energy system. We believe Poland's position is more appropriate in this case – nuclear energy can be a significant tool in the global transition to a climate-neutral economy.

6. The powerful potential of climate-neutral energy sources, once developed in Poland, will provide a significant boost to the country's entire economy and will facilitate the active expansion of electric mobility, electric rail transport, public utilities, and logistics. Significant amounts of energy can be used to produce hydrogen through electrolysis. This hydrogen will have very wide applications.

7. Poland's climate-neutral energy projects are a very convincing example of international economic integration and international cooperation in the most important area of innovation.

Corporate social responsibility is a specific, organic feature of the activities of companies engaged in decarbonization. This responsibility fully aligns with the United Nations Sustainable Development Goals to preserve the planet's climate, the natural environment, human civilization itself, and the ability of people to live and develop in harmony with nature and social harmony. It is indicative that major Polish companies, notably Orlen, which has a long history of oil production and refining, and the chemical company Synthos, by effectively establishing a new development strategy in the context of decarbonization, are also shining examples of corporate social responsibility to society, and in a global sense.

Conclusions. Thus, an analysis of modern economic development in the context of states' pursuit of sustainable development and decarbonization has revealed the following. A distinctive feature of the global economy is its active globalization. The dynamics of the global economy are volatile and require measures within the framework of an effective international management system. To give the global economy a boost, innovative international projects, supported by significant investment, are needed in key economic sectors. International cooperation for sustainable development and its particular effectiveness are determined by the greater innovative,

investment, managerial, and human resource potential of several countries combined, particularly European countries, which exceeds the capabilities of any single country. It is advisable for states to focus their efforts on addressing precisely those issues that they are capable of effectively addressing due to economic, innovative, historical, and other factors. International cooperation is most effective in addressing the most pressing issues facing the global economy and enables the achievement of maximum results. A model of international innovative projects for decarbonizing the economy is proposed, identifying projects in the fields of nuclear energy, hydropower, battery storage, offshore wind farms, and hydrogen production and use in transport, as well as potential participants in such projects. A powerful example of successful international cooperation is the climate-neutral energy projects currently underway in Poland, involving leading Polish and international companies such as Orlen, Synthos, GE Vernova Hitachi Nuclear Energy, Polskie Elektrownie Jądrowe, Westinghouse, Bechtel, ORLEN Group, Northland Power, Vestas, PGE Polska Grupa Energetyczna S.A., Ørsted, and Siemens Gamesa Renewable Energy. Corporate social responsibility is a specific, organic feature of the activities of companies engaged in decarbonization. This responsibility fully aligns with the United Nations Sustainable Development Goals to preserve the planet's climate, the natural environment, and human civilization itself.

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