Leszek KWIECIŃSKI • Anna BARBARZAK

CRMS-ORIENTED POLICIES IN POLAND IN THE CONTEXT OF THE EU POLICY DEVELOPMENTS

Leszek KWIECIŃSKI (ORCID: 0000-0003-3678-6132) – University of Wrocław, Łukasiewicz Research Network
Anna BARBARZAK (ORCID: 0000-0003-2816-4755) – University of Wrocław, Ministry of Foreign Affairs

Correspondence address:
Koszarowa Street 3, 51-149 Wrocław, Poland
e-mail: Leszek.kwiecinski2@uwr.edu.pl

ABSTRACT: The aim of the article is to analyse the assumptions of the EU policy on critical raw materials (CRMs). This is a starting point for the effective design of the Polish public policy implemented in this area and the indication of the direction of its development in the short and medium term. In order to achieve the research objectives, the authors used methods appropriate to the social sciences, in particular, the institutional legal method, the comparative method and the rational choice neo-institutionalism. The sources of the analysis are documents and source materials (national and EU), baseline data, as well as participatory, sustained and covert observation resulting from the authors' professional functions and participation in industry initiatives. Furthermore, the authors collected information and data through dialogue with key stakeholders and participants of the Polish CRMs ecosystem. The development of public policy in the field of CRM is an important pillar for the implementation of the strategy for the development of an innovative economy. Poland's participation in strategic EU projects aimed at achieving technological sovereignty requires the adaptation of state policy assumptions.

KEYWORDS: critical raw materials, public policy, innovation, the European Union

Introduction

Economic development is dependent on natural resources. Uninterrupted access to the growing range of minerals is the key determinant of economic modernisation, strengthening economic innovation and achieving sustainable development goals. Security of supply of CRMs is now a prerequisite for economic modernisation, technological progress, growth and development (Patrahau, 2021; Schmid, 2021; Crochet & Zhou, 2024; Watkins et al., 2023; Baldassare & Carrara, 2025). More importantly, the ambitious goals of climate, energy and digital transformation cannot be achieved without secure access to natural resources (UNCTAD, 2024). In this context, challenges related to the CRMs--specific structure of global production and supply chains, as well as the observed growing imbalance between supply and demand, driven by the increased use of CRMs in new technologies and products, have attracted the attention of policymakers around the world (Massari & Ruberti, 2013; Girtan et al., 2021). Various events, such as the Chinese embargo on the export of Rare Earth Elements (REEs) in 2010 (Shen et al., 2020), supply chain disruptions as a result of the COVID-19 pandemic (Giese, 2022), or the recent Russian invasion of Ukraine (OECD, 2022), provide ample evidence of the need for effective public policies that could be a remedy for de-risking CRMs and reducing market interdependencies (Baldassare & Carrara, 2025). Many countries have recognised this aspect, which is reflected in the development of institutional, regulatory, financial and operational frameworks related to CRMs (IEA, 2022). Some countries (Japan, South Korea, UK, USA) have introduced CRMs-specific instruments and mechanisms, which are important from the point of view of the effective implementation of CRMs-oriented strategies.

The main aim of the research paper is to present the outcomes of the analysis of the Polish public policy response to the emerging risks related to ensuring secure access to CRMs. So far, the policies of major producers, as well as technologically and industrially advanced economies, have gained attention, which is reflected in evolving academic research. At the same time, a review of policies in the case of countries which do not fall into either of these groups remains underdeveloped and insufficient. The research, therefore, fills the existing gap in the literature and reviews the national policies of such countries based on the case study of Poland. Its aim is to identify and diagnose potential challenges and – based on this – offer relevant recommendations on the way forward. Hence, the practical value of the work is envisaged in stocktaking on what already has been achieved in the scope of the Polish public policy and recommends what needs to be further done to maximise the efficiency of actions and resources addressing contemporary challenges faced by the society, such as CRMs vulnerabilities. Furthermore, the research takes an innovative approach by identifying, based on the existing literature and extensive public discussion, 10 key areas relevant to public policy design, with a main focus on the horizontal and interdisciplinary character of CRMs problem, which generates challenges in developing result-oriented policy tools.

The review and analysis of some of the actions undertaken to date allows the conceptualisation of CRMs related public policies around ten main determinants (10 I's – Information, Institutions, Infrastructure, International Cooperation, Innovation, Industry, Investment, Integration, Interoperability, Incentives), which can be helpful to analyse and better adapt public policy processes (Schmid, 2021; Patrahau, 2020; Guenter et al., 2020; Baldassare & Carrara, 2025). In addition, the recent development of EU policy in particular the adoption of the EU Critical Raw Materials Act (EU CRMA), has acted as a catalyst for public policy processes in EU Member States (Blengini et al., 2017; Hool et al., 2023; Gonzalez & Verbeek, 2024; Council of the EU, 2024). The CRMA identifies strategic objectives and develops building blocks for EU Member States' public policies related to the security of CRMs.

The article presents, in a structured manner, a discussion about the relevance of each of the above-mentioned determinants to the CRMs related public policy. Furthermore, the authors, based on the research and their professional background, explore current development within the scope of the Polish public policy. Finally, the identification of policy gaps and inefficiencies leads to relevant policy recommendations, which may be especially helpful in the context of the ongoing discussion on the review of the Polish National Resource Policy, with an aim of its better adaptation to the contemporary challenges and needs.

DOI: 10.34659/eis.2025.92.1.1035

Research methods

The main goal of the research is to enrich the existing knowledge about the current *status quo* of CRMs related policy development at the national level, based on the case study of Poland. Furthermore, the authors analyse the determinants, principles and initial effects of the implementation of the EU Critical Raw Materials Act. The way in which this regulation has been adopted and implemented indicates that the role of states and international organisations in integration and globalisation processes is changing towards a more proactive and predictive. This implies the need to adopt new theoretical and methodological approaches and thus to move away from the state-centric methods typically used in political science, such as the systemic method or the decision-making method, to new concepts, including, above all, the new institutionalism. This also implies the need to look for new theoretical approaches to the European integration process, where functionalism, intergovernmentalism or governance do not provide sufficient explanatory power. To achieve the research objective, the hypothesis was adopted that contemporary meta-processes point to the need to find a common denominator for the growing role of international organisations and states (governments) on the one hand and for the inclusion of non-public entities in the field of effective and legitimised European politics on the other. As a result of these processes, the new intergovernmental approach could be a useful theory for analysing the implementation of CRMs.

The new intergovernmentalism does not treat intergovernmentalism as a synonym for stagnation or regression in integration. The challenge for this approach is to understand and anticipate sources of instability and uncertainty and to increase the scope of integration, the search for consensual political solutions and, consequently, an alternative to the concept of differentiated integration or political segmentation, which can become a path to evolutionary disintegration processes within the EU (Ziółkowska, 2016; Junge, 2007).

Special role of the member states in the entirety of the integration process should be emphasised here. The new intergovernmental approach is dominated by what is known as member statehood, i.e., a form of statehood in which the power and influence of the state and its non-state actors depend on the nature and extent of their participation in transnational networks. This approach to the European integration processes, which gives great leverage to member states while at the same time involving key non-state actors in solving complex societal needs such as climate, energy and quality of life, results in a win-win situation (Bickerton et al., 2014). The concept of member states can be traced back to elements of the policy network model, as states have to rely on the resources of 'their' national stakeholders, i.e., companies, scientific institutions, industry organisations, etc., in order to achieve their goals in the integration process. These actors, supported by the member states at the supranational level, have both an interest in the choice of a particular policy and its mechanisms, and the ability to influence its implementation. The situation of member statehood assumes that it is the member states (governments) that set the agenda of activities through formal (treaty) and informal (non-treaty) powers, which then allows for the involvement of non-state entities (so-called constructed spill-over). The primary role is therefore envisaged in the activity and initiative of states, which, however, need diversified resources for their efforts.

In addition, in the new intergovernmental approach, European institutions, including above all the European Commission, play the role of playmaker, balancing the interests of states, interest groups and, finally, the European institutions themselves. This phenomenon is described in the literature as a special bargaining situation (Burns, 2004).

It can, therefore, be assumed that the concept of a new intergovernmentalism should represent a kind of lowest common denominator, allowing for the creation of diversified networks and instruments in which member states retain their leading role, EU institutions act as coordinators and facilitators of this cooperation, and non-public entities (companies, research and development entities) are involved in the implementation of supranational projects. The 10 I's concept is the operationalisation of the New Institutionalism theory, which, according to the authors, allows for a transparent description of public policy issues related to critical raw materials, taking into account the three dimensions of this policy: top-down (supranational), bottom-up (national) and add extra (global, outside the European integration process) (Geyer, 2015).

The analysis carried out, along with the relevant literature review, was additionally supported by qualitative research based on In-Depth Interviews, with the engagement of key participants of the

DOI: 10.34659/eis.2025.92.1.1035

Polish CRMs ecosystem – public administration, academic and research institutions, CRMs dependent industry, extractive sector investors, experts and opinion makers, specialised legal offices and representatives of relevant international organisations dealing with CRMs (Minski, 2017). Given the nature of the problem, methods appropriate to social sciences have been evaluated as the most relevant ones. The analysis of documents and materials shaping the legal situation (EU and national dimensions) is based on the institutional-legal method (see Annex 1 for the list of documents reviewed). The comparative method enabled the identification of opportunities for Poland to pursue its raw materials policy objectives both in relation to other EU Member States (macro dimension) and in relation to the availability of raw materials and their use in the creation of technologies and products (meso dimension). The concept of rational choice neo-institutionalism has been used to identify tools and methods for optimising raw materials policy, together with an assessment of their effects, benefits and costs (Lowndes, 2006). The main sources of the analysis are documents and primary materials (national and EU), baseline data, as well as participatory, sustained and covert observation resulting from the authors' functions and participation in industry initiatives (UNCTAD, OECD, NCBR, Łukasiewicz Research Network) (Babbie, 2007).

Complex policy problems can no longer be broken down into independent policy subsets without running the risk of producing an approximately correct solution to the wrong problem (Dunn et al., 2016). A smart or 'out of the box' policy approach to CRMs requires an assessment of different components of public policy that can form a holistic machine and reinforce each other through better integration and interoperability. Concerted efforts in different policy areas can help to achieve spillover results, making policy not part of the sum of its parts but a synergetic project with concrete benefits. The breakdown of the 10 factors identified as most important from a CRMs perspective can help to define obstacles and potential opportunities at national level that can turn this policy problem into an opportunity.

An overview of the literature – CRMs as a public policy

Identifying the problem to be addressed is the first step in conceptualising and designing public policy to address it. It is therefore important to conceptualise CRMs in terms of public policy by understanding them as a public policy challenge that governments 'choose to do or not to do' (Dye, 1987). Classified as an unmet need, value, or potential opportunity to achieve specific goals or improve existing activities (Dunn et al., 2016), CRMs gradually drive the development of public policy by introducing and implementing new policy solutions that would allow responding to specific needs (Peters et al., 2018).

CRMs offer an interesting approach to the issue of problem definition in the context of public policy. Critical materials are not a homogeneous group and cannot be treated as a coherent concept within an established epistemological definition (Mancini et al., 2015; Glöser et al., 2015; Blengini et al., 2017; Hofman et al., 2018). They are usually defined along two vectors: vulnerability and supply risk (European Commission, 2010, 2014, 2017, 2023a; Fortier et al., 2018; Ferro & Bonollo, 2019; Miyamoto et al., 2020). With differentiated classification methodologies developed by different countries over the last decades, the process of defining the level of criticality is fully within the limits of national strategies related to socioeconomic development and national security (Hackenhaar et al., 2022; Schrijvers et al., 2020). As the specifics of industrial and economic development, including domestic resource production potential and innovation strategies, combined with the assessment of supply risks, are the fundamental factors in the established classification methods, the definition of criticality at the level of national policy-making is the starting point for the delineation of public policy frameworks (Buijs & Sievers, 2011; Gunn, 2014; Hayes & McCullough, 2018; Patrahau, 2020).

Based on this approach, the classification of raw materials as "critical" should not be understood in terms of their scarcity, but includes the notion of their economic importance for the national economy, the identification of supply risks due to very high import dependency and monopolised production structure, the lack of alternatives as well as limited potential for secondary use (Ferro & Bonollo, 2019). As the classification methods try to answer the question "critical for whom?" CRMs are deeply rooted in the policy and management dimension. A number of countries (Australia, Brazil, Colombia, DRC, Finland, France, Germany, India, Indonesia, Japan, Korea, Malaysia, Nigeria, Norway, Peru, South

DOI: 10.34659/eis.2025.92.1.1035

Africa, Ukraine, US, UK) have developed their individual lists of minerals (Sala et al., 2013; Radwanek-Bąk et al., 2018; Patrahau, 2020; IEA, 2023).

In the case of the EU Member States, the definition of critical minerals as a public policy issue is mainly driven by the classification methodology developed and applied in the framework of the EU policy to enhance the security of raw material supply, launched in 2008 (European Commission, 2008). The systematic revision of the list of minerals defined as critical (2011, 2014, 2017, 2020, 2023) is based on developments in the EU Member States and thus reflects the notion of mineral criticality also established at national level. As the EU classification evolves, the differentiation between critical and strategic minerals shall be the most indicative for determining the level of supply risk as well as designing relevant policies and dedicated instruments to address challenges related to criticality of minerals (Hool et al., 2023; Council of the EU, 2024). At the same time, the EU list of CRMs has become a basis for the assessment and evaluation of the national classification of resources. The case of Poland provides good evidence of this trend.

Authors note that relevant literature review specific to various aspects of the research and discussion is presented in a separate section of the article.

ANALYSIS: Understanding the need for CRMs related public policies – 10 I's concept. Poland's experience

Information

Facilitating access to quality information and information governance through public policy and funding is a particularly important determinant of successful policy implementation in the context of emerging, complex and interdisciplinary policy problems (Reynolds et al., 2020). Information policy should also be seen as an important facilitator in bridging the communication gaps between different stakeholders in the field of CRMs. Public policy involvement is necessary in efforts to integrate national CRMs ecosystems. Access to information is key for understanding all aspects of CRMs. Effective information policies, focused on the dissemination of information to different stakeholders important for policy implementation and communication strategies on the challenges and opportunities of CRMs should be at the forefront of policymaking (Howlett & Saguin, 2018). This is particularly important for CRMs related policies, such as the circular economy concept, which are highly dependent on changing business models, industry standards and consumer behaviour. The expected development of non-regulatory instruments in policies aimed at reducing the intensity of CRMs in products should be seen as an important factor for improving information policies. Finally, making public support an ally rather than an obstacle in the implementation of CRMs related strategies requires the development of tailored information-oriented policy instruments.

In the case of Poland, The National Resource Policy 2050 (NRP2050) emphasises the need for improved access to information as well as information-based education (Ministerstwo Klimatu i Środowiska, 2022). The Polish Geological Institute (PGI) plays an important role in the implementation of the information policy by managing scientific, geoscientific and geological databases. As a result of the digitalisation of information systems, the availability of data has increased and improved in recent decades, especially in the context of geological data related to CRMs. The distribution of information to different groups of participants in the CRMs ecosystem remains a challenge within the Polish system (Peryt, 2018). No structured information management process has been put in place to bridge the communication gaps between the geological, industry, innovation research and policy sides. There is no single institution or dashboard (website) that presents policies, programmes, projects and instruments that can be used for CRMs-related activities. This aspect is particularly important in the process of policy adoption and adaptation to stakeholders' needs and expectations. Access to data on Polish investment in CRMs projects is a challenge – no single source has been identified to map and monitor the development of CRMs projects.

DOI: 10.34659/eis.2025.92.1.1035

Institutions

Institutions play a crucial role not only in setting the 'rules of the game', but also in identifying policy priorities, their implementation and coordination (Pontarollo, 2019). Today, the role of an effective institutional architecture in the launch and implementation of public policies is indisputable. While today's challenges, such as climate change, international security or sustainable development, depend heavily on national public policy capacities, the role of institutions in these efforts is stronger than ever. Over the past decades, ensuring an integrated policy approach through institutional governance has been advocated to address the need for better coherence of policies across sectors, improved consistency of policy instruments and enhanced cooperation between all actors involved in the process of both policy formulation and implementation (Domorenok et al., 2021).

The emerging problem of CRMs in the context of national public policies has triggered an institutional evolution, in particular with the aim of improving integration, coherence and an inclusive approach, which is reflected in the construction of public institutions dealing with this problem that "bring together multiple actors" (Howlett & Saguin, 2018). In recent years, an evolution of new CRMs--specific public organisations has been observed within the framework of public administration (such as the French Observatory of Mineral Resources for Industrial Sectors (OFREMI), the UK Critical Minerals Intelligence Centre (CMIC), the German Mineral resources Agency (DERA). Financial institutions can help define and implement plans to support critical minerals companies in their existing portfolios to increase their profitability, upscale their products and ensure widespread adoption by industry incumbents (Van Hoey & Sandstrom, 2024).

The institutional network of institutions important for the implementation of CRMs policy in Poland is sophisticated but also complex. Although no specialised body has been established within the Polish public administration, the creation in 2016 of the Interministerial Committee for Raw Minerals Policy, preceded by the Government Plenipotentiary for Raw Minerals Policy (exercised by the Chief National Geologist), has contributed to the institutionalisation of raw minerals, including CRMs (Rozporządzenie, 2016). Poland also has a strong institutional capacity in the mining sector as a result of the operation of coal mines (e.g. the Main Mining Institute (Główny Instytut Górnictwa – GIG) and the Higher Mining Institute (Wyższy Urząd Górniczy – WUG). Achieving the goals set by the NRP2050 will also require the involvement of various public institutions responsible for innovation and research (National Centre for Research and Development – NCBR), investment support (Agency for Trade and Investment – PAIH, Agency for Industrial Development – ARP, Agency for Entrepreneurship Development – PARP) or facilitating access to finance (National Development Bank – BGK, Polish Development Fund – PFR, Export Credit Insurance Corporation – KUKE).

There are a number of research and innovation institutions carrying out projects related to CRMs. The network of industry and sectoral associations remains a missing link in the institutional architecture for CRMs.

Prospective establishment of dedicated to CRMs institution may not be a source of efficiency gains in policy implementation. Instead, the focus should be on improved communication, coordination and interaction between different institutions, especially with a view to capacity building and a more tailored approach to tackling new policy problems.

Infrastructure (regulatory and legal)

An effective political system depends on robust political capacity (Washington, 2022). Infrastructure therefore, plays a central role in policy implementation and expected outcomes. Legal and regulatory frameworks, human capacity or policy quality systems are the basic assets that public policy can provide in the policy-making process.

A dynamic growth of legal, regulatory and financial frameworks oriented at CRMs has been witnessed around the world. In 2022, the IEA launched the International Energy Agency (IEA) CRMs Policy Tracker 2022. The results confirm that legal and regulatory infrastructure aimed at defining CRMs policies is one of the most popular approaches taken globally by both producers and consumers. More than 450 policies in 35 countries were identified, including policy strategies, economic and trade policies, classification of CRMs, stockpiling policies or public investment programmes (IEA, 2023). Many of these policies focus on securing access to CRMs as the upstream side of green industrial policies (Crochet & Zhou, 2024).

DOI: 10.34659/eis.2025.92.1.1035

Various strategic and regulatory documents relevant to CRMs have been adopted in Poland over the last two decades (Ministerstwo Klimatu i Środowiska, 2022; Obwieszczenie, 2021; Uchwała, 2019; Strategia, 2020). To date, no specific legislation on CRMs has been implemented. CRMs continue to be part of a broader strategic discussion on national security and economic development. The National Security Strategy (Stategia, 2020) as well as the Strategy for Responsible Development (SRD) until 2020, including the perspective up to 2030, defined important parameters that determine the perception of CRMs. The review of the existing legal and regulatory architecture allows for the positioning of CRMs as an integral part of the raw minerals policy, with important implications for the National Environmental Policy 2030, the Polish Energy Policy 2040 and the Polish Industrial Policy (Figure 1).

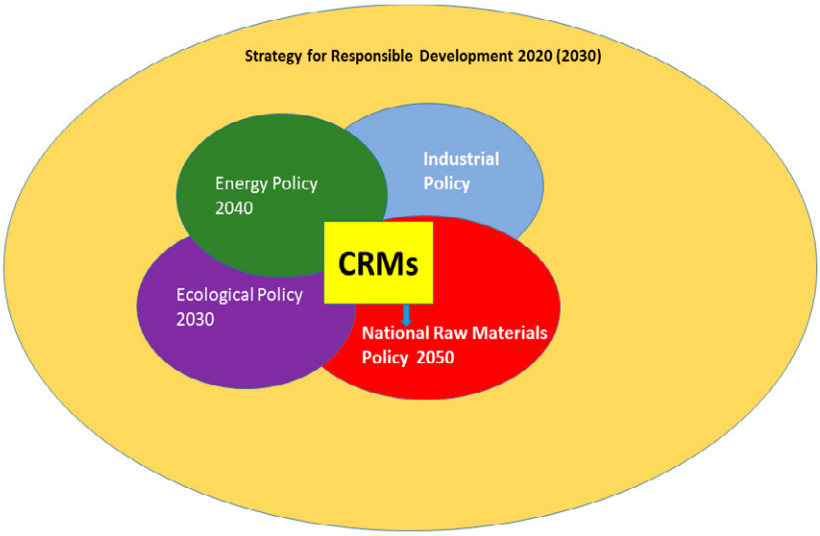

Figure 1. CRMs as a subset of selected policies in the Polish public policy system

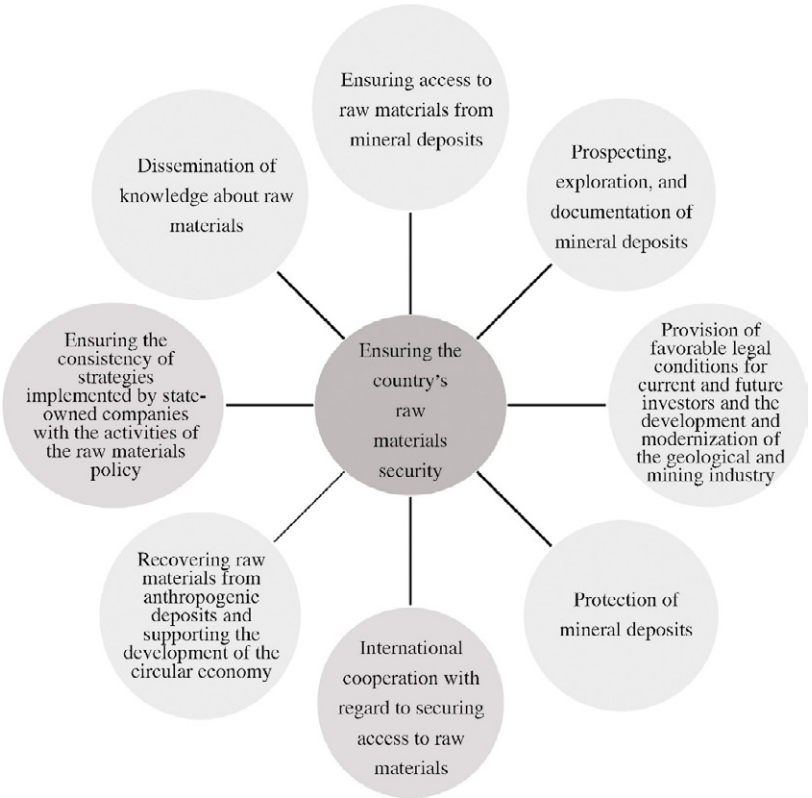

Figure 2. The main goal of the Polish State's Raw Materials Policy and specific objectives

Source: Kulczycka et al. (2023).

DOI: 10.34659/eis.2025.92.1.1035

The National Resource Policy 2050 (NRP2050) is the first document of a strategic nature. Based on the revised resource classification methodology, the document classifies raw minerals as strategic and critical. The group of minerals defined as critical includes 17 different resources, 12 of which are also classified as critical by the EU. All the objectives set out in the NRP2050 are relevant to CRMs considerations (Figure 2), making them horizontal issues across the raw materials strategy, feeding into aspects such as access to better quality information, investment, industrial development, innovation, integration or policy integration and interoperability (Ministerstwo Klimatu i Środowiska, 2022).

There are also a number of regulatory documents that define the process of extraction and management of raw materials (European Commission, 2024).

Further changes in the Polish legal and regulatory framework related to CRMs are expected, mainly due to the fact that both resource security and national economic policy are susceptible to political processes and cycles. The development of new regulations will also be determined by the need to implement certain provisions related to the implementation of the EU CRMA.

International Cooperation

The emerging profile of CRMs, with clear demarcation lines between their producers and consumers, is an important factor in foreign policy and may in the future lead to a revision of the current landscape of international relations (Vivoda et al., 2024). The 'weaponization' or 'instrumentalization' of CRMs with an aim to achieve various political interests is a challenging risk arising from the growing interdependencies between producers and consumers of critical minerals (Bartekova & Kemp, 2016; Kalantzakos, 2020). In addition, the increasing role of CRMs in achieving strategic objectives that are likely to determine the competitive power of the world's largest economies has foreign policy implications (Hammond & Brady, 2022; Vivoda et al., 2024). While there are challenges in identifying and mapping them, there is no doubt that they could have a significant impact on the development of global markets. This aspect is particularly important for medium-size economies, as strengthening ties between the demand side and resource-rich countries could potentially limit opportunities for new actors to engage in these complex international resource networks at a later stage (Bleischwitz & Perincek, 2017).

In the case of Poland, the NRP2050 pays special attention to international cooperation as one of the most desired dimensions that can ensure diversification of supply and participation in projects of strategic importance for the transformation of the CRMs landscape. In recent years, the Polish Geological Institute (PGI) has intensified its efforts in international cooperation and has concluded a number of bilateral agreements related to CRMs, i.a. with Mongolia, DRC, Uzbekistan, Ukraine, Kazakhstan, Dominican Republic, Indonesia, Argentina, Vietnam (Dziadzio, 2023). Although Poland participates in CRMs related discussions within the intergovernmental organisations, no national profile has yet been developed in these processes, which limits their impact. Poland does not participate in the US Mineral Security Partnership, which is the flagship international forum addressing specific CRMs through the development of various international projects. While the EU strategic partnerships developed in recent years offer opportunities for increased international cooperation for EU member states, this formula needs further clarification and operationalisation, at least from the perspective of concrete stakeholders.

Investment

Investment is a powerful public policy tool. Public investment stimulates economic activity and increases the productivity of existing private capital (physical and human). Public financing also stimulates new private investment, creating the conditions for economic growth (Miyamato et al., 2020).

Investment in the development of critical minerals saw a sharp increase of 30 per cent in 2022, following 20 per cent growth in 2021 (IEA, 2023). China, for example, continued its surge to strengthen its position in overseas mining with a record investment of USD 10 billion in the first six months of 2023 (IEA, 2024).

Investment strategies introduced by a number of countries (Australia, Canada, Japan, US, Republic of South Korea, Germany, France) should help reduce market tensions that are a source of supply

DOI: 10.34659/eis.2025.92.1.1035

risk. Recently, Germany and France announced the creation of special investment funds to promote diversification, domestic production and commercialisation of new technological solutions to reduce material intensity (Kowalcze & Nienaber, 2023; Messad, 2023).

At this stage, with the high imbalance between public and private investment, there is a high risk that CRMs will become a highly nationalised policy issue, which may not necessarily be a relief for de-risking efforts.

Polish companies are increasingly investing abroad in activities related to the extraction and production of CRMs. So far, the largest Polish foreign investment in CRMs is a copper mine in Sierra Gorda in Chile, owned by KGHM Polska Miedź SA together with the Japanese Sumitomo Group (from February 2022, the Australian mining group South32), with the highest EBITDA in 2021 of PLN 10.3 billion (approx. EUR 2.3 billion) (Kulczycka et al., 2023). KGHM is also developing investments in copper and silver production projects in Botswana and Canada. In recent years, the Azoty Group invested USD 30 million and acquired 55 per cent of the Senegal phosphate mine. Over the years, the Polish company Kulczyk Investments has invested in many exploration and mining projects in Africa (Tanzania, Tunisia, Equatorial Guinea, Namibia, Nigeria) as well as in other parts of the world (Ukraine, Romania). The Polish mining company Bogdanka has also announced its interest in investing in CRMs mining activities abroad (Paćkowski, 2023). To date, no CRMs-specific instruments have been established to support high-risk foreign investments by Polish companies abroad.

Poland is a country with limited investments in industries important for the circular economy (Esipnoza et al., 2024). One of the objectives of the EU CRMA is to overcome the investment gap dilemma by establishing funding mechanisms aimed at accelerating R&D and business model change towards circular economy, which could make circular economy an important part of CRMs de-risking. It is therefore important that Poland prepares for these measures, including by creating various incentives for companies interested in developing recycling and waste management facilities, which will be the focus of the EU.

Innovation

Innovation has been the main driver of the use of natural resources. While recognising the fundamental role of science in solving most of today's cross-cutting challenges, such as environmental and climate issues, the dilemma of resource security and sustainable use cannot be solved without new scientific discoveries and inventions (Meng et al., 2025).

Table 1. Key dimensions of CRMs related innovation policies

Area	Goals and results
Exploration	new policies and instruments are needed to ensure the improvement of data and earth exploration technologies, as well as to increase the effectiveness of exploration by offering new technologies and governance solutions
Mining	new innovative solutions in mining are a unique opportunity for sustainable development of new sources of CRMs
Processing and application	optimising resource use and reducing the cost of materials development can be achieved mainly through the application of innovative technologies
CRMs use in end products	the use of CRMs has gained special consideration in efforts to reduce dependency
Product use	innovation in product management processes and standards, including by extending product life cycles or optimising use, can help reduce CRMs consumption, especially at the stage of limited opportunities for their recycling and reuse
Recycling and reuse	the introduction of new programmes related to the circular economy opens a new space of opportunities for increased R&D activities targeting the need for new technologies and solutions to increase the level of recycling of CRMs

Source: authors' work based on Espinoza et al. (2024).

The promotion of research and innovation (R&I) plays a central role in public policies related to CRMs (European Commission, 2023e; Espinoza et al., 2024). In the case of the majority of countries, including the EU Member States, investing in the substitution of CRMs as well as in the reduction of

DOI: 10.34659/eis.2025.92.1.1035

the material intensity of CRMs-based industries offers prospects for reversing negative trends of increasing dependence on natural resources. Research and innovation policies should help to address almost all stages of the CRMs supply chain (Table 1).

With an extensive network of research and innovation institutions, the majority of which are publicly funded, Poland has significant potential to address the challenges of CRMs by providing new scientific and technological solutions. As geology, geoscience, mining technologies and materials engineering remain a strong specialisation of various institutions, innovation should be a strong pillar of CRMs policy in Poland. The screening of research projects, both basic and applied, carried out under the umbrella of the National Centre for Research and Development (NCBR) has revealed a limited number of studies on CRMs being carried out by Polish R&D institutions (Narodowe Centrum Badań i Rozwoju, 2024). This may change as innovation and research should receive additional funding from various sources. For example, the inclusion of CRMs in Cluster 4 of Horizon Europe should encourage such projects among national entities. In addition, the EU's R&I Framework Programme (part of Horizon Europe) has invested €470 million in developing innovative solutions to reduce our dependence on CRMs (European Commission, 2023a). Polish innovation and research institutions are increasingly active in international projects such as the EIT Raw Materials initiative, which is a platform for dialogue and cooperation for over 300 partners from industry, academia, research and investment from EU countries, including Poland (EIT Raw Materials, 2024).

Industry

The fundamental role of industry is more alive today than ever before. As the European Commission puts it, industry is "a key driver of productivity and innovation" and "a cornerstone of economic prosperity in Europe" (EESC, 2018). For this reason, industrial development and economic specialisation through industrial development have long been the focus of policy attention.

Industrial development, which drives demand for natural resources, has inevitably brought the issue of CRMs into the industrial equation. On the one hand, industrial innovation, revitalisation and modernisation are the bane of CRMs, as all strategic projects, such as climate neutrality and digitalisation, are the main drivers of CRMs demand. On the other hand, industrial development may be the only hope for addressing the imbalance between supply and demand for CRMs.

Poland belongs to the group of EU countries with a high (28.1 per cent in 2022) industrial share in GDP and export-led growth (Statista, 2024). Therefore, Poland has a strong potential to influence the implementation of the EU industrial strategy. Poland's industrial policy, which is part of the Strategy for Responsible Development 2020 (including the perspective until 2030), defines innovation, energy and digitalisation as the main drivers of economic development. Energy transition and digitalisation are the leading pillars of the Polish Resilience and Recovery Plan (Rozporządzenie, 2016). Out of €60 billion of financial resources in various forms (loans, grants, subsidies), almost 50 per cent is to be allocated to the green transition and more than 20 per cent to the digital transition, which can have a direct impact on Poland's engagement in CRMs related projects (Ministerstwo Aktywów Państwowych, 2022).

Downstream and upstream activities should be the focus of Poland's industrial policy in the context of CRMs. The Polish mining sector has a well-developed mining infrastructure and *know-how.* Some companies have already been active in the extraction of CRMs. While KGHM is co-owner of one of the largest copper mines in Chile, the JSW group is the largest producer of high-quality coking coal in the EU and one of the leading producers of coke for steel smelting. Poland's domestic reserves have been identified as prospective for exploration under EU strategic projects, which should catalyse the reactivation of the Polish mining industry. Polish companies are also active in the processing of CRMs (copper, sulphur, zinc and lead concentrates, cadmium, selenium, feldspar, rhenium) (European Commission, 2022).

Integration

Policy integration has been widely discussed in the past as a factor for increasing the effectiveness of public policy institutions and resources. It is mainly perceived as a process that motivates actors and agencies across different policy subsystems to coordinate their actions and develop coherent combinations of instruments from different policy sectors, as well as arrangements for their con-

DOI: 10.34659/eis.2025.92.1.1035

sistent implementation and evaluation, to address different dimensions of a complex problem (Cejudo & Trein, 2023).

CRMs are increasingly becoming a sub-policy within various sectoral policies, such as economic and trade, resources, environment, R&D and defence (Figure 3). In addition, strong external vulnerabilities that public policy is expected to address automatically make foreign policy an important component of CRMs policy.

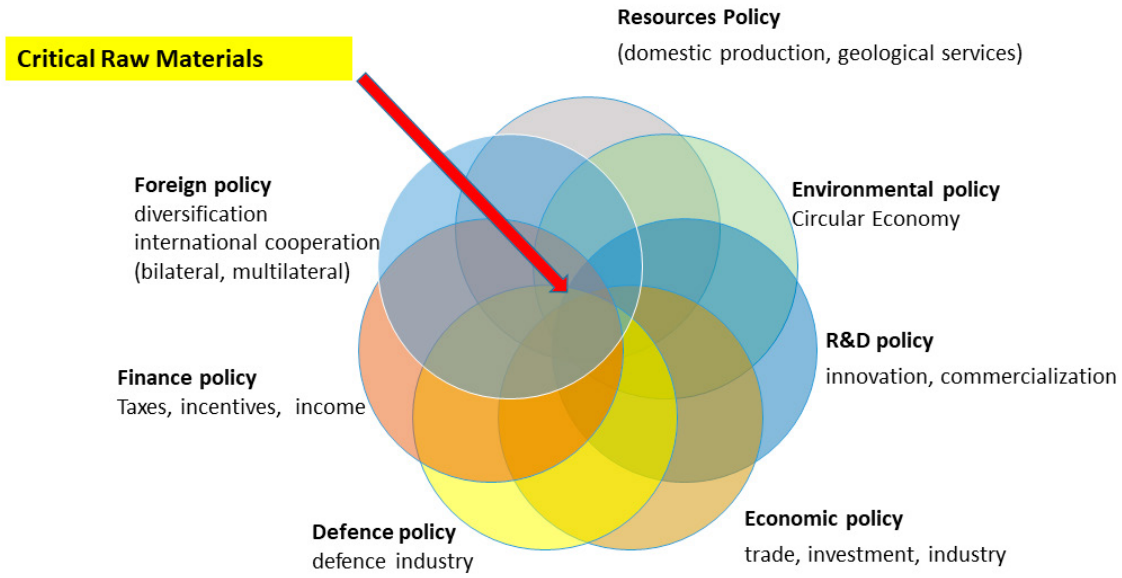

Figure 3. Integrating CRMs into various policy fields

The integration of CRMs into existing policy fields and systems the assessment of the usefulness of existing policy resources and instruments to achieve the defined objectives is an essential part of the policy formulation process, especially in the context of avoiding policy accumulation, which can lead to proliferation of policy instruments and projects, reduce policy transparency, lead to a dispersion of resources and – as a consequence – make it more difficult for non-state actors to participate in policy implementation (Candel & Biesbroek, 2016). The creation of new coordinating institutions to ensure intra-governmental dialogue is a direct response to the management of policy integration. Policy integration should be seen as a process that helps to deconflict different aspects of CRMs-related policies through early identification and effective mitigation of potential tensions between different stakeholders involved in policy formulation and implementation (Candel & Biesbroek, 2016). As institutional complexity has been recognised as a potential obstacle to achieving gains from integrity, the elaboration of a workable intra-governmental process will be key to achieving the expected outcomes of a CRMs related approach (Bolognesi et al., 2021).

Policy integration has not been a transparent process in the case of Poland. While a number of institutions have effectively managed this process, also by increasing their expertise and human capital potential, the commitment of other institutions needs to be further developed. The implementation of CRMs-specific instruments as well as the expansion of activities in new areas (such as circular economy) will catalyse efforts to ensure transparency in the division of competencies between different policy actors and their new role with regard to the introduction of new regulations and laws, and to improve cooperation with non-state actors, including through policy design and management.

Interoperability

The complex and interdisciplinary nature of the problem of CRMs highlights the issue of public policy development as a nexus of activities that can generate synergies and correct each other. Most importantly, the development of public policies must be based on reliable data and input from a wide range of stakeholders. The World Intellectual Property Organization (WIPO) 2024 report "Making Innovation Policy for Development" presents a new paradigm, the "Scrabble Metaphor", in which the acquisition of all necessary and appropriate capacities and assets will not produce the desired results

DOI: 10.34659/eis.2025.92.1.1035

without their relevant sequencing and interrelationship (WIPO, 2024). This concept can be applied to the policies discussed in this paper, which focus on mitigating the vulnerabilities and risks of CRMs. An adequate response to CRMs through different policy instruments will require the establishment of communication and cooperation between different stakeholders in the emerging ecosystems.

According to the World Bank, interoperability in the public sector is about enabling connections between ministries, departments, agencies, sectors, levels of government and countries through data, information systems, legal agreements, organisational processes, as well as shared values and practices. It identifies interoperability as a prerequisite for responsive and efficient delivery of public services (The World Bank, 2022). Interoperability is a source of efficiency gains, greater transparency, accountability and integrity in public policies.

Interoperability remains one of the main challenges in the Polish policy formulation in relation to CRMs. The lack of a single centre to manage the process makes it chaotic, uneven and lacks the participation of key stakeholders from industry, science and innovation, environmental communities and local governments. Poland has never paid sufficient attention to the development of a comprehensive but realistic vision for raw minerals policy. The interdisciplinary nature of CRMs has not yet been adequately reflected in Polish policy management. As a result, the policy lacks priorities that could be operationalised at the stakeholder level. The overly ambitious goals for the development of the Polish economy have not yet been translated into concrete and measurable actions. Efforts to improve interoperability should, therefore, focus on investment gaps, mobilising business and science, and providing incentives through funding and stable policy planning and implementation. Building interoperability into the public policy system will require an enhanced dialogue with all stakeholders, including experts and policy makers dealing with the issue in relevant ministries and engaged public institutions.

Incentives

Public support is the most effective public policy instrument. Today, public support is mainly aimed at overcoming market failures or vulnerabilities, stimulating the economy, promoting international competitiveness and supporting strategic sectors (Rosario & Varum, 2024). Government intervention through public investment, subsidies, tax incentives and financial support is a driving force for the successful mobilisation of private investment (Aghion et al., 2009).

Incentive-based policy instruments have been widely used to implement CRMs-related strategies in recent decades. Many of them, introduced by producer countries, have led to the formulation of market conditionalities. which have triggered public policy responses on the part of countries representing the demand side (Shen et al., 2020).

Development of incentive-based interventions has been observed in recent decades, such as joint ventures involving public capital, subsidies, financing of research and innovation and geoscientific projects, financing of pre-investment feasibility studies or seabed exploration activities, loans and preferential credits, credit guarantees or investments in the development of CRMs-related infrastructure (storage depots, transport corridors, etc.). Mapping and evaluating these instruments could provide answers to questions about the viability, profitability or even sustainability of CRMs.

The current policy framework for CRMs is not based on specific incentives. At this stage, a more regulatory approach has been taken in the design of policies for raw minerals. The NRP2050 describes areas such as promoting exploration and mining, facilitating the development of relevant infrastructure, supporting investment or financing innovation projects, improving expertise and *know-how* in the field of geology and mining, international cooperation or establishing dialogue with local communities (Ministerstwo Klimatu i Środowiska, 2022). The regulatory environment for CRMs in Poland, related to the inclusion of CRMs in the framework of environmental law incentives, is at a very early stage of adaptation to possible changes resulting from EU CRMA. Improving the circularity of the economy should broaden the range of policy instruments with concrete benefits. Further research is needed, in particular through empirical studies, to optimise the development of tailored incentives that could be attractive from an end-user perspective. Over-regulation and the accumulation of such instruments may reduce their usefulness.

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Discussion and concluding remarks

Decades long efforts to mitigate the risks associated with the security of the supply of critical minerals have not yet yielded the expected results. At the same time, the growing thirst for new resources, both in diversity and volume, has exacerbated some of the worrying trends related to critical minerals. A clear correlation between CRMs, climate and digital transformation is a reality today (UNCTAD, 2024). In the medium and long term, we can expect continuity in policy development along three main axes: ensuring availability, managing affordability and addressing sustainability (Figure 4.) (Van Hoey & Sandstrom, 2024). These parameters best describe the current CRMs landscape and should, therefore be seen as the main determinants for setting public policy trajectories for the coming years. Given the expected imbalances and gaps (supply/demand, investment, production capacity, industrial uptake), public policies on CRMs are no longer an option but a necessity (IEA, 2023). This implies the need for a systematic and more in-depth analysis of CRMs related policies (IEA, 2023).

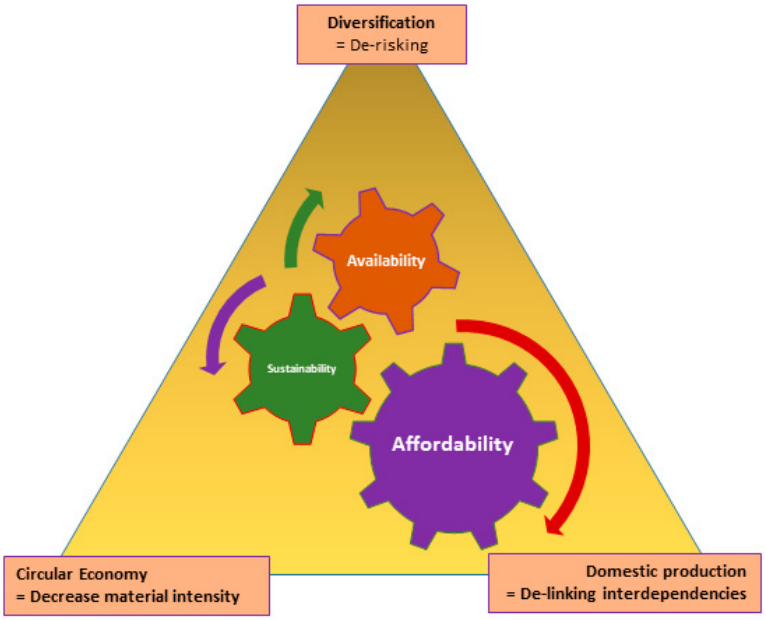

Figure 4. CRMs policy determinants and trajectories

Public policies towards CRMs by countries representing both major consumers and major producers have so far dictated policy paradigms in the global context (Shen et al., 2020; Kalantzakos, 2020; Terazawa, 2023; Zhou, 2024). However, the sustainable supply of CRMs is increasingly becoming a problem for policymakers in capitals that have embraced innovation and industrial development as drivers of economic growth without breaking down these ambitious plans into achievable building blocks (Galos et al., 2021). Raw material security is inevitably one of them. Since non-major producers and non-major consumers cannot be expected to redefine the major policy paradigms of CRMs, the implementation of public policies that can help maximise the benefits of the current global policy formula, such as investment, innovation or demand-driven industrial development, is essential for the successful implementation of economic strategies (IEA, 2024). CRMs, as a horizontal, interdisciplinary and complex policy problem, require equally sophisticated policies.

Poland's experience in CRMs policy development can provide valuable input for understanding obstacles and identifying opportunities to achieve efficiency gains through stronger policy integration. Although the legal and institutional policy framework continues to develop and CRMs are increasingly reflected in strategic and programming documents, Polish CRMs policy lacks a helmsman who could accelerate policy consolidation and coordination efforts (Dziadzio, 2023). The establishment of a policy management centre, with a clear division of responsibilities, should be seen as a starting point for the development of CRMs relevant policy algorithms and systems, allowing for

DOI: 10.34659/eis.2025.92.1.1035

greater participation of different stakeholders and interest groups. This is particularly important to maximise the benefits from the expansion of the EU's incentive-based instruments and to achieve synergies through a more interoperable policy system, moving from individual actions to a more project-oriented approach.

The architecture of the CRMs institutional nexus in Poland lacks transparency and clarity (Galos et al., 2021). This, together with the lack of specialised instruments tailored to CRMs, can be a challenge and demotivating factor for key stakeholders to engage in the overall CRMs efforts. A more incentive-based approach could help enhance the capacity of various stakeholders that are important from a CRM perspective. The role of sectoral associations or interest groups, and policy networks could also be enhanced through better policy coordination mechanisms. Efforts aimed at strengthening the competencies and role of industrial, research and innovation networks are also needed. The identification of tailor-made policy instruments specific to CRMs are essential to motivate further engagement on the part of Polish stakeholders.

The high level of regulatory and institutional volatility observed in Poland hampers policy efforts. Systematic amendments to the Geological and Mining Law or plans to revise the National Resource Policy 2050, should not necessarily be seen as an inviting signal to investors and R&D institutions to engage in the high-risk, capital-intensive and management-challenging projects related to CRMs (Galos et al., 2021).

A shift from an individual and fragmented policy approach to a project-oriented mechanism is needed today more than before. Although CRMs have been thoroughly assessed from the perspective of defining their markets, risks and correlation with industry development, further research is needed to develop parameters measuring national policy potential, which is important to gain efficiency through greater transparency, synergy, coherence and coordination (OECD, 2023b). Policy formulation, based on objective data (for example, concerning policy capacity and infrastructure) as well as transparent and inclusive dialogue with stakeholders, important for CRMs actions, needs further consideration and analysis. This work is needed especially for middle-size economies that – without developing a timely pragmatic and result-oriented approach – will most probably incur the consequences of the established policy paradigms.

Access to information is an essential part of CRMs management. The creation of a single institution for CRMs policy management could result in developing databases containing information such as strategic projects, Poland's investments in CRMs abroad, available programmes, projects and initiatives, public policy instruments or stakeholder groups. Consolidation and coordination of information is essential to close communication gaps and build interoperability in the CRMs ecosystem.

The authors of the research indicate existing challenges in access to quality information as well as the limited willingness of various stakeholders (especially state-owned companies) to engage in discussion on policy development. This identified limitation can potentially lead to establishing policy design processes, which may lack important reflection of the situation on the ground and deliver artificial or even inefficient solutions.

DOI: 10.34659/eis.2025.92.1.1035

Annex 1. Primary legislative sources for review (regulations, reports, analyses)

Name of document
EU documents
Regulation (EU) 2024/1252 of the European Parliament and of the Council of 11 April 2024 establishing a framework for ensuring a secure and sustainable supply of critical raw materials and amending Regulations (EU) No 168/2013, (EU) 2018/858, (EU) 2018/1724 and (EU) 2019/1020, Pub. L. No. 32024R1252. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32024R1252
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The contribution of the authors

Conceptualisation, L.K. and A.B.; literature review, L.K. and A.B.; methodology, L.K. and A.B.; formal analysis, L.K. and A.B.; writing, L.K. and A.B.; conclusions, L.K. and A.B.

The authors have read and approved the published version of the manuscript.

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Leszek KWIECIŃSKI • Anna BARBARZAK

SUROWCE KRYTYCZNE (SK) JAKO ZAGADNIENIA DLA KSZTAŁTOWANIA POLITYKI PUBLICZNEJ. PERSPEKTYWA POLITYKI SUROWCÓW KRYTYCZNYCH W POLSCE KONTEKŚCIE UWARUNKOWAŃ EUROPEJSKICH

STRESZCZENIE: Celem artykułu jest analiza założeń polityki UE w odniesieniu do surowców krytycznych. Stanowi to punkt wyjścia dla efektywnego projektowania polskiej polityki publicznej realizowanej w tym obszarze oraz wskazania kierunków jej rozwoju w krótkim i średnim okresie. Do realizacji celów badawczych autorzy wykorzystali metody właściwe dla nauk społecznych, takie jak: metoda instytucjonalno-prawna, metoda porównawcza oraz neoinstytucjonalizm racjonalnego wyboru. Źródłem analizy są dokumenty i materiały źródłowe (krajowe i unijne), dane wyjściowe, a także obserwacja uczestnicząca, trwała i niejawna, wynikająca z pełnionych przez autorów funkcji i udziału w inicjatywach branżowych. Rozwój polityki publicznej w obszarze SK jest ważnym filarem realizacji strategii rozwoju innowacyjnej gospodarki. Udział Polski w realizacji strategicznych projektów unijnych zmierzających do osiągnięcia suwerenności technologicznej wymaga, jednakże dostosowania założeń polityki państwa.

SŁOWA KLUCZOWE: surowce krytyczne, polityka publiczna, innowacyjność, Unia Europejska

DOI: 10.34659/eis.2025.92.1.1035