Memorandum ZPP: "Ukraine's Resource Policy - Strategic Resources and Rare Earth Metals"

· Without strategic resources, it will be difficult to achieve the climate goals of EU countries, as they are essential for the production of photovoltaic panels, wind turbines, and electric vehicles.

· China supplies 98% of rare earth metals.

· 21 out of the 34 critical elements (identified by the EU) are found in Ukraine, where, simultaneously, 117 out of the 120 globally used materials are being extracted.

· The World Bank predicts a 500% increase in demand for rare earth metals by 2050.

· In 2021, the EU and Ukraine entered into an alliance to enhance technological and industrial cooperation in the field of rare earth metal extraction.

· It is assumed that the rare earth resources were one of the reasons for Russia's aggression against Ukraine.

We present a memorandum summarizing the discussion during the IV roundtable of the ZPP Energy and Climate Forum, dedicated to Ukrainian energy, and conducted within the EUROPE-POLAND-UKRAINE REBUILT TOGETHER 2023 project in collaboration with the Embassy of Ukraine in Poland.

The participants of the debate were:

Anna Burkowicz - Specialist at the Department of Mineral Resource Management, Raw Materials Policy Laboratory, Polish Academy of Sciences

Roman Dryps - Chief Operating Officer, Center for Business Consulting, Polish-Ukrainian Chamber of Commerce

Roman Opimakh - President, State Geological and Subsoil Survey of Ukraine

Dr. Jarosław Szlugaj – Assistant Professor at the Department of Mineral Resource Management, Raw Materials Policy Laboratory, Polish Academy of Sciences

Seweryn Szwarocki - Director of Strategy and Sustainable Development, LW Bogdanka SA

Moderator:

Dominika Taranko - Director of the ZPP Energy and Climate Forum

Rare Earth Metal Resources in Ukraine

Roman Opimakh, President of the State Geological and Subsoil Survey of Ukraine, pointed out that Ukraine signed a memorandum of strategic partnership regarding rare earth metals with the European Union in 2021. At the same time, the EU outlined the EU Critical Raw Material Act until 2030, defining joint actions of the member states and necessary regulations that need to be implemented under EU law. Ukraine is currently a candidate for EU membership, and Ukrainians

perceive themselves as Europeans, adhering to the same principles, values, and strategic goals. Therefore, Ukraine's objectives in the field of rare earth metals align with the goals of the European Union's policy. Ukrainians intend to remain a reliable and stable trading partner in terms of extraction, processing, and supply of rare earth metals, as well as components for the battery industry, as well as the disposal of used equipment with recovery of raw materials. Consequently, a concept of establishing an entire value chain within Ukraine for supplying the EU is being developed.

Extraction and production potential of Ukraine regarding critical raw materials is among the highest in the world. Ukraine is among the top 10 global producers of titanium, kaolin, manganese, iron ore, graphite, zirconium, uranium, as well as raw materials essential for modern technologies such as beryllium, aluminum, nickel, and cobalt. Ukraine holds resources for 21 out of the 34 minerals identified by the EU as critical. Therefore, the Ukrainian government has implemented an open-door policy for foreign investments, preparing a list of 100 regions in which licensing and acquisition of exploration and production concessions will be available. Another way to enter the Ukrainian market today could be through acquiring existing concessions through agreements with local companies, thus fostering cooperation within consortia. Cooperation within greenfield and brownfield investment types is being considered. For future investment needs, 1,200 deposits of rare earth minerals have been identified, and conceptual maps have been developed. There are locations where operations can already be conducted.

Titanium - Ukraine is among the top 10 countries with documented titanium deposits worldwide and provides 7% of global production (data from 2021). Currently, titanium is extracted in Ukraine along with ilmenite, rutile, and zirconium in six deposits, yielding 900,000 tons of concentrate containing 350,000 tons of titanium annually. Currently, the largest producer and processor of titanium in Europe, JSC United Mining & Chemical Company, is being privatized.

Lithium - Currently not mined in Ukraine, but its resources constitute 1/3 of Europe's deposits. Three lithium oxide deposits have been identified for future development. One of the deposits is already under the concession of UkrLithiumMining LLC.

Other metals such as **tantalum, niobium, and beryllium** - have been identified in six deposits, with tantalum and niobium also occurring as by-products of titanium deposits. Beryllium is found in the Perzhanske deposit, where 15.3 thousand tons of beryllium oxide are located, along with tantalum, niobium, **zirconium, tin, molybdenum, lithium, and zinc**, among others. The concession for this deposit has been held by BGV Group since 2019.

Cobalt - It is found in 12 deposits containing 9 thousand tons of this element. Ukraine processes significant amounts of imported cobalt and nickel, which is handled by Pobuzhsky Ferronickel company.

Graphite - Ukraine possesses some of the world's five largest graphite deposits, amounting to 19 million tons of ore with concentrations ranging from 5% to 8%. Currently, 5 thousand tons of graphite concentrate are extracted annually from six deposits. The concession for these deposits is currently held by the Australian company Volt Resources.

Ukraine has favorable geological conditions for the occurrence of rare earth metals. As part of the mentioned strategic partnership with the EU, a Roadmap for 2023-2024 has been defined, which

incorporates environmental protection and "green mining" (low emissions in the mining industry) as priorities in the envisioned methods of resource extraction. Ukraine has also been involved in the process of creating EU regulations regarding the use of rare earth metals until 2030. In terms of cooperation, the Ukrainian Geological Survey has developed a geological map highlighting the extraction potential and has devised incentives for investors interested in the mining industry, including the extraction of rare earth metals.

Abundance of Rare Earth Metals in Poland

Dr. Eng. Jarosław Szlugaj, Assistant Professor at the Department of Mineral Resource Management in the Laboratory of Raw Materials Policy at the Polish Academy of Sciences, emphasized that his unit has been monitoring the management process of mineral resources for almost 30 years. They oversee all mineral resources located in Poland that are subject to trade and are simultaneously produced or consumed. A thematic publication titled "Balance of Poland's Mineral Resource Management," which covers over 100 types of resources, is being issued on the topic. The list of critical resources for the European Union continues to expand. Over the past 10 to 20 years, their utilization has become widespread, and today we are facing a new situation in which Poland, the European Union, and the world consume vast amounts of resources, many times greater than in past decades and centuries.

Poland consumes significant amounts of rare earth metals imported from abroad. Unfortunately, it does not have its own sources or deposits of rare earth metals, so reliance must be placed solely on imports. However, there is resource potential, especially in terms of resource recovery. With the dismantling of the Wizów Chemical Plants (where phosphoric acid was produced from apatite from the Kola Peninsula, enriched with rare earth elements), there is a repository of post-production waste from which rare earth metals can still be extracted. Currently, no recovery is being carried out because none of the tested technologies allow for it on an industrial scale.

As a result, Poland imports increasing amounts of rare earth metals (mostly in the form of oxides, not necessarily in separated form). They are mainly used as glass colorants, polishing agents, but also in batteries, electric motors, or permanent magnets. Poland only imports finished products, especially when it comes to permanent magnets.

The situation is similar with lithium. Thanks to foreign investments, Poland has become a significant producer of lithium-ion batteries, primarily used in the automotive industry. The entire process involves importing raw materials, processed in the source country of imported product. Semi-finished products reach Poland, where they are assembled to create finished batteries. Currently, Poland does not have domestic facilities utilizing these advanced technological processes and production methods. Everything relies on enterprises owned by foreign investors.

Strategic resources (according to the list of 34 identified by the EU) possessed by Poland.

Poland essentially possesses only two strategic resources that it independently processes on a larger scale. The first is coking coal, which is used to produce coke, a crucial component in steel production processes. The second is copper, recently added to the list.

On March 16, 2023, the European Commission published the announced draft regulation on critical

and strategic raw materials for the European Union's economy. The document also includes a new, updated list of critical raw materials (CRM). The CRM Act aims to stimulate the production of strategic resources by intensifying new activities related to extraction and recycling within the European Union. Furthermore, it seeks to increase awareness of potential threats related to raw material supplies, supply chains, and related opportunities among EU countries, enterprises, and investors.

The published new list of critical raw materials (CRM) in the document COM(2023) 160 final titled "Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL establishing a framework for ensuring a secure and sustainable supply of critical raw materials and amending Regulations" expands the list of critical raw materials for the EU (available in Annex II, Section 1).

Antimony	Fluorite	Helium	*Nickel*	Strontium
Arsenic	Phosphorites	Cobalt	Niobium	Tantalum
Bauxite / Aluminum	Phosphorus	*Silicon metal*	*PGM - platinoids*	*Titanium*
Barite	*Gallium*	*Lithium*	*Heavy REE*	*Vanadium*
Beryllium	*Germanium*	*Magnesium*	*Light REE*	Coke coal
Bismuth	*Graphite*	*Manganese*	Spodumene	*Tungsten*
Boron / Borates	Hafnium	*Copper*	Scandium	

Table description: Critical raw materials for the European Union according to the European Commission (2023). New CRMs compared to the 2020 list are marked in red. Strategic raw materials for the European Union *are indicated in italics.*

Source of compilation: PIG-BIP.

In the process of preparing the document, 70 different substances were analyzed, assessing their economic importance and estimating supply risks. Ultimately, the number of identified elements was increased from 30 to 34. Although the document refers to "34 critical raw materials," there are actually more, as rare earth metals are presented as two resources: HREE (heavy rare earth elements) and LREE (light rare earth elements), aside from which, PGM (platinum group metals) account for an additional 5 noble metals. The highest level of supply risk applies to heavy rare earth metals.

It is also worth comparing the proposed European list (2023) with the American list, which includes 50 items (2022 - https://www.usgs.gov/news/national-news-release/us-geological-survey-releases-2022-list-critical-minerals).

In 2023, **helium** reappeared in the European register after being absent for the past three years, and the newly designated critical raw materials are **copper, nickel, spodumene and arsenic**. An interesting case is copper and nickel, which, although they do not meet the CRM thresholds, are included in the list according to the Critical Raw Materials Act. Conversely, indium and natural rubber have been removed from this year's compilation. A novelty is the identification of several strategic

raw materials within the critical raw materials (16 out of 34). The list is updated every 3 years. The strategic importance is determined based on the material's significance for green transformation, digital technologies, defense applications and space exploration.

Among the newly added CRMs, Poland has mineral deposits and prospects for further documentation for the following resources:

- Raw spodumene materials (mostly in Lower Silesia, but also in Lesser Poland)
- Helium (Wielkopolska) - recovery from natural gas
- Polymetallic deposits, primarily copper (Lower Silesia and Lubusz Land)
- Arsenic (Lower Silesia and as a co-occurring element in other deposits in Upper Silesia)
- Nickel (Lower Silesia)

The CRM Act document should help develop activities in the field of scientific research and innovation, negotiate trade agreements, and implement new projects related to the exploration and exploitation of critical raw materials.

Unfortunately, Poland does not possess resources for most strategic raw materials necessary for the production of devices related to "new energy," such as wind turbines or photovoltaics. In the past, crystalline silicon, which is the basis for every photovoltaic cell, was produced in the country. However, production ceased after privatization and foreign acquisition.

Participation of foreign investors in the mining industry of Ukraine

In Europe today, the mining industry is no longer common, which is why Ukraine's focus on the development of this sector has attracted the interest of foreign investors. Ukraine invites foreign investors to increase extraction activities on its territory due to its rich mineral deposits and the industry's long-standing history. The State Geological Survey conducts concession procedures, concludes cooperation agreements, and possesses other instruments to encourage investors. Several major Polish companies operate in Ukraine, including Cersanit, which mines kaolin and conducts wide-scale market sales of ceramic products. Before the war, there were discussions with KGHM Polska Miedź SA regarding investments, and the Ukrainian authorities are ready to resume these discussions. The Ukrainian government seeks to provide comprehensive assistance to investors by conducting webinars, providing maps, mostly in an online format today. Additionally, a memorandum has been signed with the Polish Geological Institute, which is evidence of the development of a strategic Polish-Ukrainian partnership.

Ukraine can prove to be an attractive market for LW Bogdanka SA, which is seeking future directions for business diversification. Seweryn Szwarocki, Director of Strategy and Sustainable Development at LW Bogdanka SA, emphasized that Lubelski Węgiel Bogdanka SA is the most efficient coal mine in Poland. In the face of the armed conflict in Ukraine, the demand for coal has increased, but the Management Board of LW Bogdanka SA, aware of the need for energy transformation associated with the new climate goals set by the European Union, has committed to phasing out coal production by 2049. The company is preparing for these plans to ensure the continuity of its operations.

As a result of conducted analyses regarding the possibility of mining other resources, on May 17th, the company published a new strategy. Its main objectives are to maintain production capacity,

sustain high profitability indicators, selectively extract type 34 coal, diversify revenues by expanding the areas of operation, and identify, assess and document new reserves of type 35 coking coal.

The main goal of LW Bogdanka's new strategy for the years 2023-2030 is to create an innovative multi-commodity corporation that drives green transformation and secures the economic development of the Lublin region and, more broadly, central-eastern Poland. Through business diversification, LW Bogdanka can potentially engage in the extraction of selected critical resources for the EU, including possibly in the Ukrainian market.

Given that the mining industry is capital-intensive and involves complex processes, Bogdanka SA has an advantage over its competitors due to its extensive mining experience. While the company's current activities are focused on the Lublin region, new mining projects are being sought. The western lands of Ukraine stand out as a potential area, considering their rich mineral deposits, especially those utilized in the energy transformation process. However, due to the ongoing armed conflict on Poland's eastern border, the current opportunities for cooperation are limited. Investments in a war-torn country carry the risk of uncontrolled destruction in the areas where the company operates.

Nevertheless, Bogdanka SA confirms that it is conducting analyses regarding the extraction of several potential resources, with the criterion being their inclusion on the list of critical raw materials for the European Union. LW Bogdanka also sees the prospect of cooperation with the existing mining industry in Ukraine, given the lower level of digitalization compared to its Ukrainian counterparts. The Polish company is also willing to engage in technological exchange. However, due to the nature of the company as a publicly traded entity, all planned investments have a long-term perspective, and the process of selecting investment locations can be time-consuming.

Considering the existing legislative difficulties related to the mining of critical resources, there is a need for legal acceleration of investment processes. Additionally, an important aspect for deciding on the exploration, assessment and mining of a specific resource is the size of the deposit and the estimated level of extraction difficulty.

Adapting Ukrainian Geological Law for Mining Investments

Recently, the Ukrainian government has introduced a package of numerous legal changes regarding the regulation of the mining industry. The practices of European countries served as a model for the legislative amendments. The experts knowledgeable in this field were also consulted. Many outdated regulations have been removed from Ukraine's legal system, which should facilitate business operations. In some cases, it will no longer be necessary to participate in tenders to start activities. The mining process can commence as early as one and a half years after obtaining an environmental impact assessment. Investment opportunities have been increased, among other things, by introducing electronic deposit maps. Upon selecting an area for investment, all necessary information about the area of interest can be obtained both online and in person.

The State Service of Geology and Subsoil of Ukraine expects increased international cooperation,

especially with the EU, regarding planned initiatives. A cooperation agreement has been signed within the framework of a memorandum with the European Bank for Reconstruction and Development regarding a three-year program for the digitalization of services, particularly those related to geological information. Another important task for the project is to adapt Ukrainian counterparts of government portals to the English language version, aiming to professionalize international cooperation (as all information desired by investors is currently available only in Ukrainian).

Goals of the Industrial Alliance between Ukraine and the European Union

Anna Burkowicz, an expert from the Department of Mineral Resources Economy at the State Academy of Sciences' Policy Laboratory, explained that Ukraine's plans for cooperation with the European Union also involve rare earth metals, which have extensive potential applications. Rare earth metals, also called rare earth elements (REE) are a family of 17 chemical elements, including two scandium group elements (scandium and yttrium) and all lanthanides (lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium). They occur in minerals and possess similar chemical properties. Due to their catalytic properties, they have numerous applications, including the petrochemical industry. Lanthanum and cerium, in particular, are widely used in the refining of crude oil for gasoline production.

Examples of applications for rare-earth elements (according to Wikipedia):

Scandium: alloys for aerospace and space industry

Yttrium: phosphors, ceramics, alloys

Lanthanum: batteries, X-ray films, catalysts in oil refining processes

Cerium: catalysts, alloys

Praseodymium: minor component in alloys used for magnets (corrosion prevention)

Neodymium: strong neodymium magnets, lasers

Promethium: beta radiation source

Samarium: magnets for high-temperature operation, control rods in reactors

Europium: liquid crystal displays, fluorescent lighting

Gadolinium: production of green phosphors in CRT screens and scintillators in X-ray imaging

Terbium: phosphors for lamps and displays

Dysprosium: strong magnets, lasers

Holmium: strong magnets

Erbium: lasers, optical amplifiers

Thulium: ceramic magnetic materials

Ytterbium: optical fibers, solar cell plates

Lutetium: x-ray-luminophores

In the United States, approximately 60% of lanthanides are used in refining, but REEs are utilized in a wide range of industries. These include ceramics, glazes, metallurgical alloys, rocketry, aviation, modern technologies, the IT sector, screens, lasers, diodes, the energy industry, and permanent magnets. The People's Republic of China is responsible for 93% of the world's production of all permanent magnets using rare earth metals, while Japan accounts for 6%, and the European Union for 1%.

The possibility of ending China's monopoly for the moment is not realistic. According to participants in the roundtable discussion, unfortunately, the world's economies themselves are responsible for the current state of the raw material market division, since the Chinese have built their current advantage de facto over the past several years. China naturally also has a huge raw material potential. In this context, the chance to return to European production may be provided by the very beginning of exploration of deposits in Ukraine.

Polish-Ukrainian Cooperation in the mining industry?

According to the opinion of Roman Dryps, the Chief Operating Officer of the Business Advisory Center of the Polish-Ukrainian Chamber of Commerce, which has been operating as a bilateral chamber for 30 years, the Polish government or Polish companies are unlikely to be Ukraine's partners in the mining and processing of rare earth metals. Poland lacks the technology and the deposits themselves. There are only a few domestic enterprises that could be significant players in this area, including the already mentioned KGHM Polska Miedź SA and LW Bogdanka. According to the expert, Polish entrepreneurs working in the mining industry have had success in the field of new technologies, but mainly in the market of coal, liquid fuels, or gas extraction. Two main minerals, that were extracted in Ukraine until 2014 are coal and iron ore. The cycle of operation was simple - they were used for steel production or for energy purposes. At that time, most coal mines operated on a concession basis. The concessionaires of these mines were mostly owners of private machinery industry plants for mining machinery construction. Profit was simply the absolute priority at that time, and new technologies in the mining industry were not developed. The Polish-Ukrainian Chamber of Commerce actively collaborates with the Ukrainian Ministry of Energy, and based on unofficial information from "first-hand sources," it is known that the coal mining industry will not be restored in the classic sense after the war. Furthermore, based on data presenting the resources on the territory of Ukraine, it can be learned that as of spring 2023, 63% of coal deposits, 11% of oil deposits, 20% of natural gas, 42% of metals, and 33% of rare earth metals were under the occupation of the Russian aggressor. Their overall value, according to geological studies, is estimated at 12.5 trillion US dollars. Therefore, it is difficult to avoid the impression that Ukraine's natural resources could be a dominant factor that prompted Russia to launch a military attack.

Sources of financing of mining industry in Ukraine

The European Union (EU) has only recently begun working on support programs for investors to encourage them to invest capital in the development of advanced extractive and processing industries, particularly in the context of critical raw materials. So far, only recommendations have been issued at the EU level, regarding environmental decision-making related to the assessment of projects and concessions for the mining of rare earth metals. At the same time, it is likely that whether with the participation of EU programs, or even if there were none, or if they were insufficient, (assuming that the demand for these raw materials will grow, and thus, in the absence of supply), the price of these raw materials will increase and the profitability of these projects will also increase exponentially. This opens up the opportunity to obtain bank financing from European institutions in a situation where the elements in question are identified by the EU as key in the green transition and fit in with the requirements of sustainable development, or ESG strategies.

The Ukrainian public administration is currently undergoing a period of increased digitization, with a significant portion of public affairs being handled electronically. This will undoubtedly facilitate dialogue regarding potential financing and project cooperation as well.

Collaboration with the world of science

Scientists from the Polish Academy of Sciences utilize a wide range of literature in their studies on rare earth metals and stay up to date with the geopolitical situation regarding mineral resource economy worldwide. There is a possibility of assisting entrepreneurs in market research and identifying potential avenues of operation. So far, no Polish company has applied for a concession to operate in the Ukrainian market, which holds immense potential. In Poland, there are universities that educate mining engineers, metallurgists, and technologists.

By observing the specific nature of the mineral resource market, one can notice a decline in the trade of low-processed raw materials. For example, in the case of iron ore, concentrates are produced, and there are also technological changes occurring, with developed sintering and granulation processes for these ores. It is no longer bulk ore that would be transported over significant distances. With the next generation of resources, processing is increasingly concentrated in one place. In the case of rare earth metals, Chinese companies generate approximately 60% of global production, but their real advantage lies in processing, specifically separation. The ore is complex, consisting of several coexisting elements, usually around 7 to 8 types. China has specialized in individually extracting 7 to 8 minerals, rather than processing them comprehensively. In this situation, China has a monopoly in production, offering separated oxides and specific metals in the form of powders or semi-finished products worldwide. Recognizing the potential associated with deposit extraction in Ukraine, it can be observed that its owner, the State, should endeavor to establish comprehensive processing and ore extraction plants. However, this would not have significant implications due to China's dominant position in the market. In Europe, at best, a concentrate could be produced, which would still need to be sent to China for further processing. China also holds a monopoly in battery and photovoltaic production due to low production costs. This has been the main reason for relocating facilities from the United States and Western Europe to China. Twenty years ago, the People's Republic of China specialized in only a few resources. Now there are dozens, including those considered critical. Therefore, Ukraine certainly has potential, but parallel planning for the local processing and

production market should be considered. In this context, collaboration with research and development is necessary.

Would synthetic elements be a solution?

Synthetic crystals such as silicon, sapphires, or synthetic diamonds are produced using the method developed by the Polish scientist, Professor Jan Czochralski. Synthetic products can serve as substitutes for natural ones. Synthetic diamonds, for example, are widely used in the abrasive and drilling industries. Materials engineering is rapidly advancing, and in this field, there is a vast potential for collaborative research that can contribute to the future reduction in the use of natural resources. Mining production may be minimized in the future. New composite materials are being discovered that have comparable strength to steel, but do not contain metal in their structure. One such example is the indium tin oxide alloy (ITO) used in touch screens. Indium used in production is not sourced from its own deposits. Therefore, if there is a forecasted increase in demand for this material, the mining process will need to be accelerated and expanded from the ore it is derived from. Forecasts related to the implementation of the Fit for 55 program suggest that demand for certain minerals may increase 50-fold. Some deposits will be depleted, making it impossible to meet the demand for certain elements. This opens up opportunities for the development of alternatives.