Mining and quarrying

Sustainability and resource efficiency

SECTORS IN FOCUS

Alpha Bank Economic Research

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Executive summary of the study

The mining sector constitutes a vital component of the economy, serving as a fundamental pillar of primary production by supplying critical raw materials essential for construction, industrial operations, and numerous other economic sectors. The sector's sustainability has gained paramount importance, particularly as it provides essential materials for renewable energy systems, electric vehicle production, and digital infrastructure development - all crucial elements in decarbonization initiatives.

Given the sector's significant waste generation and extensive tailings production, mining operations can impact nearby ecosystems, water resources, and local communities. This underscores the need for responsible operational practices and highlights the importance of environmental stewardship and adopting circular economy principles. Advancing technologies in material processing, water resource management, and waste utilization is essential for minimizing environmental impacts while ensuring economic sustainability. In response to these challenges, mining companies must comprehensively integrate sustainability practices and circular economy principles across their operations.

- **Mining and quarrying involve extracting naturally occurring minerals as solids** (metal ores, non-metallic minerals, coal), liquids (petroleum), and gases (natural gas). While mining focuses on metallic minerals and energy resources, quarrying is related to non-metallic minerals like marble and limestone.
- **In 2022, over 2/3 of the sector's workforce was employed in metal ore mining** and other mining and quarrying activities, while coal and lignite mining, including Public Power Corporation operations, accounted for 22% of the labor force.
- **Fluctuations in crude oil and natural gas import prices have significantly** impacted the mining and quarrying import price index. By 2024, energy prices showed a clear downward trend, easing pressures from the extreme levels of the 2022 energy crisis.
- **In 2023, mineral materials made up 77% of total domestic extraction,** amounting to 73,917 thousand tonnes – a sharp decline of 29% since 2013 and 60% since 2008, highlighting the sector's contraction.
- **Domestic material consumption of mineral products, consisting of domestic** extraction (83%) and net imports (17%), totaled 88,824 thousand tonnes in 2023, marking a 22% drop since 2013 and a 58% decrease since 2008.
- **In 2022, domestic extraction of non-ferrous metals was mainly bauxite and** other aluminum ores, while nickel extraction declined. Non-metallic mineral production, heavily impacted by the Greek financial crisis, has yet to return to pre-crisis levels.
- **In 2023, mining and quarrying exports comprised 3.7% of total exports, while** imports, mainly petroleum (74%) and natural gas (25%), accounted for 21% of total imports, underscoring Greece's dependence on imported fossil fuels.
- **The shift from lignite power to cleaner energy cut lignite use by 81% between** 2013 and 2023, leading to the decommissioning of 21 lignite-fired power units and the closure of two major mines.
- **Greece is a leading producer of perlite, bentonite, and bauxite, ranking 2nd in** the EU-27 in nickel and marble production, and is among the top producers of magnesite and aluminum production. It also has strong potential for geothermal energy development and LNG expansion.
- **The mining and quarrying sector is highly capital intensive, with heavy costs** tied to exploration, deep mining, and machinery investment, resulting in high exit barriers.
- **Mining is regulated through multiple layers of laws, including core mining** legislation and environmental protections. The complex regulatory framework imposes entry barriers through strict state oversight and zoning requirements.

Structure and dynamics of the Greek mining and quarrying sector

Current landscape in the mining and quarrying sector

The subsectors of mining and quarrying per NACE Rev. 2

Mining of coal and lignite

Extraction of crude petroleum and natural gas

Mining of metal ores

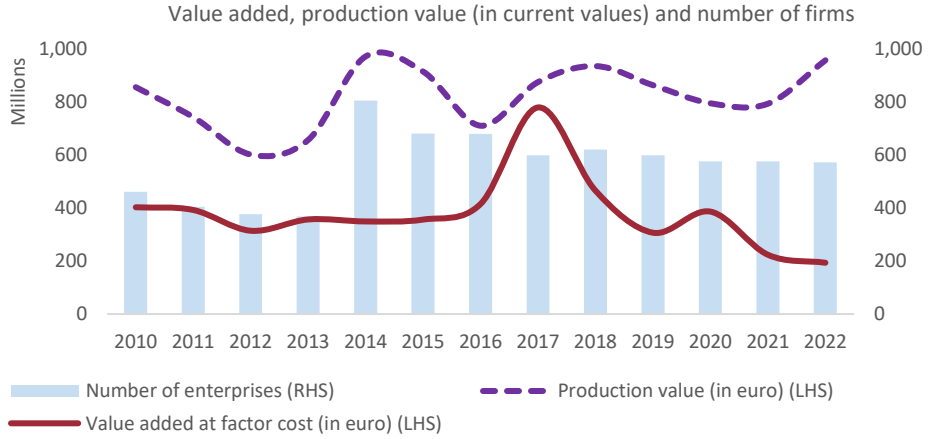
- Mining of iron ores
- Mining of non-ferrous metal ores

Other mining and quarrying

- Quarrying of stone, sand and clay
- Mining and quarrying n.e.c.

Mining support service activities

- Support activities for petroleum and natural gas extraction
- Support activities for other mining and quarrying



Source: ELSTAT, SBS

Mining typically involves extracting metallic minerals and energy resources, while quarrying focuses on non-metallic minerals like marble and limestone.

The sectors of mining and quarrying

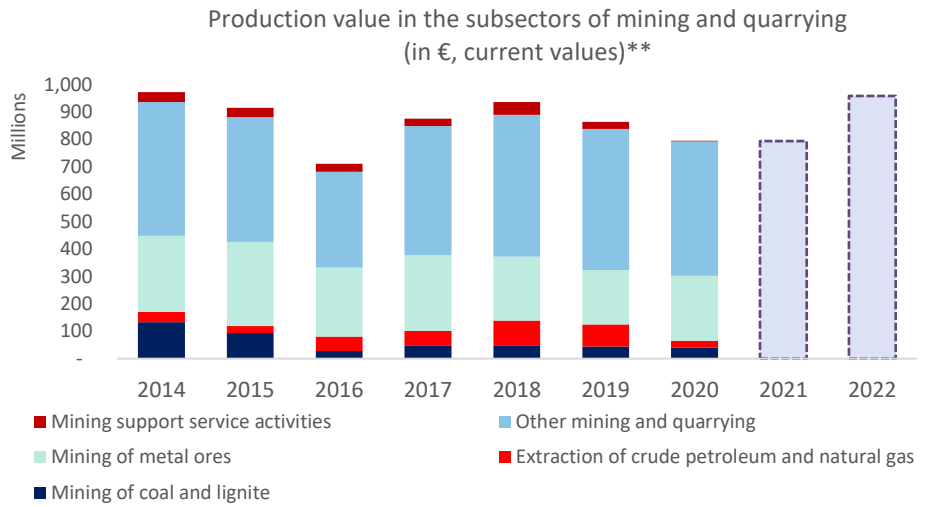
Mining and quarrying encompasses the extraction of naturally occurring minerals in solid (coal and ores), liquid (petroleum), and gaseous (natural gas) forms. The industry operates through five key subsectors. The first covers coal and lignite mining through underground or open-cast methods, while the second pertains to the extraction of crude petroleum and natural gas, including the operation of oil and gas field properties. The third involves metal ore mining, including iron and non-ferrous metals, through various extraction techniques.

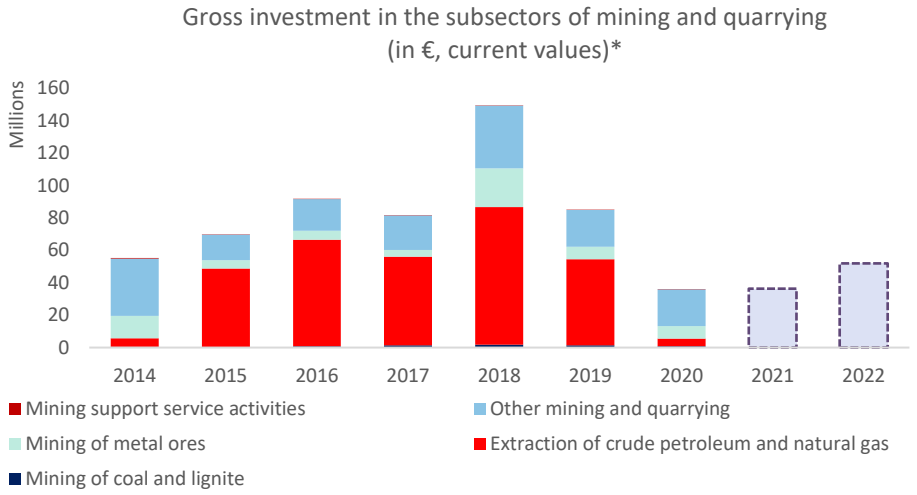
The fourth subsector, other mining and quarrying, includes activities such as quarrying stone, sand, and clay, dredging alluvial deposits, rock crushing, and utilizing salt marshes. It also encompasses the extraction of chemical and fertilizer minerals, peat, salt, and other materials not classified elsewhere. The fifth subsector provides mining support services, including those for petroleum and natural gas extraction (exploration, drilling, redrilling, liquefaction, regasification) and other mining/quarrying activities (e.g., test drilling).

Gross value added (GVA) and output value in mining and quarrying in Greece

In 2022, the sector's value added at factor cost stood at €194.3 million, marking a notable 13% decline from 2021 and remaining well below its 2017 peak of €780 million. Despite its role as a key resource supplier, the sector accounted for just 0.3% of total GVA of economic activities. While value added declined, production value rebounded strongly, reaching €957.9 million, reflecting a 21% annual increase and a 59% rise since 2012. This divergence between rising production value and declining value added indicates that the sector is expanding output but with diminishing returns. Structural shifts are evident in the number of enterprises, which grew from 377 in 2012 to 573 in 2022, shaping the sector's evolving landscape.

Structural indicators of mining and quarrying subsectors





** No data available for the sectoral breakdown for 2021-2022, only the totals are available

Source: ELSTAT, SBS

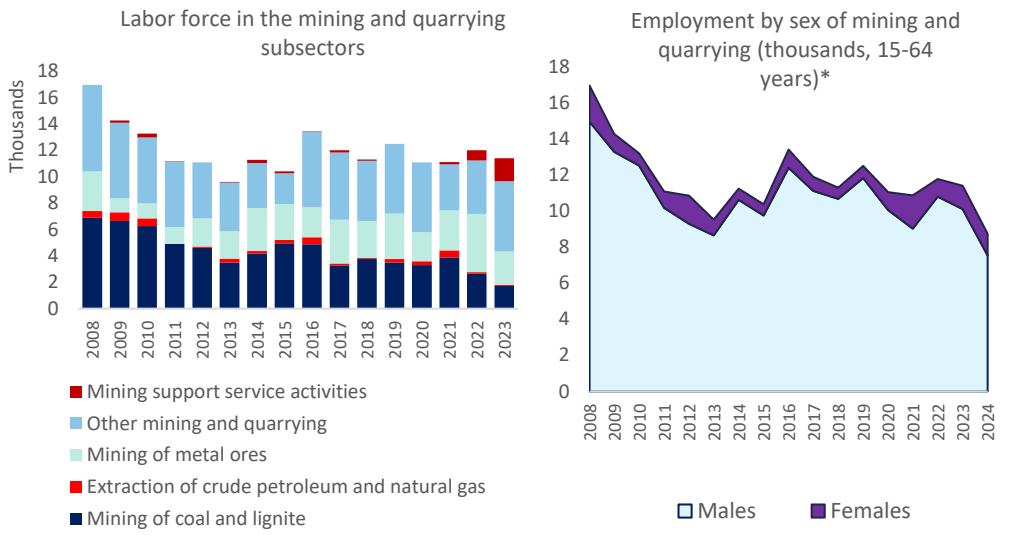
Although the mining and quarrying sector forms a small share of Greek GVA, it plays a crucial role in supplying primary materials to the economy.

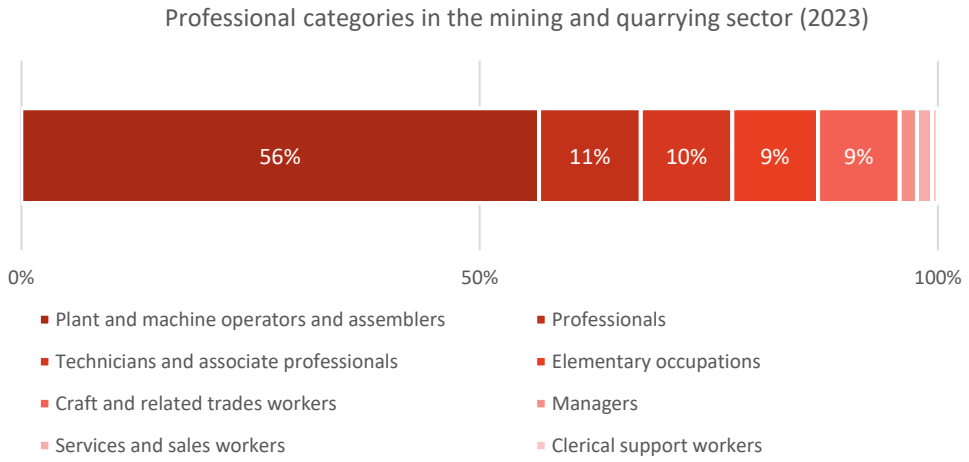
The mining and quarrying sector is highly capital-intensive, with substantial costs tied to exploration, deep mining operations, and heavy investment in machinery and equipment – resulting in high exit barriers (Eurostat 2024, Stochasis 2024). The COVID-19 pandemic severely disrupted economic activity, causing investment levels to plunge by 58% in 2020. This decline reflected significant uncertainty and an economic downturn. However, investment rebounded in 2022, aligning with the sector's increasing production value and signaling a partial recovery.

Among the various subsectors, other mining and quarrying accounted for two-thirds of both total production value and gross investment in 2020. This subsector underwent a growth phase between 2014 and 2018, during which production value rose by 6% and gross value added (GVA) increased by 20%. A key characteristic of this period was the expansion in the number of enterprises, particularly in ornamental and building stone extraction, which peaked at over 700 firms in 2014. However, by 2020, the number of firms had declined to 532, still representing 92% of all mining enterprises.

The metal ores subsector, the second-largest in the industry, accounted for 30% of total production value in 2020. This subsector contributed 22% of total gross investment but experienced a significant decline, losing two-thirds of its firms by 2020. Its GVA peaked in 2017, while gross investment reached its highest level in 2018. The coal and lignite subsector has been dominated by a small number of firms, but its production value has declined since 2014. Investment in this subsector has been limited, primarily due to the planned closure of lignite mines, reflecting Greece's transition away from coal-based energy. The oil and gas subsector saw the strongest increase in gross investment before 2018, reaching €150 million that year, likely driven by the development of the Revithousa LNG terminal, a crucial infrastructure project for Greece's energy sector.

Employment trends in the Greek mining industry





*Yearly averages; Data for 2024 are based on the quarterly average Q1-Q3 2024.

Source: ELSTAT, Eurostat LFS

The workforce in the metal ores subsector has witnessed significant growth over time, while employment in the coal and lignite subsector has declined.

Employment trends in the Greek mining and quarrying sector

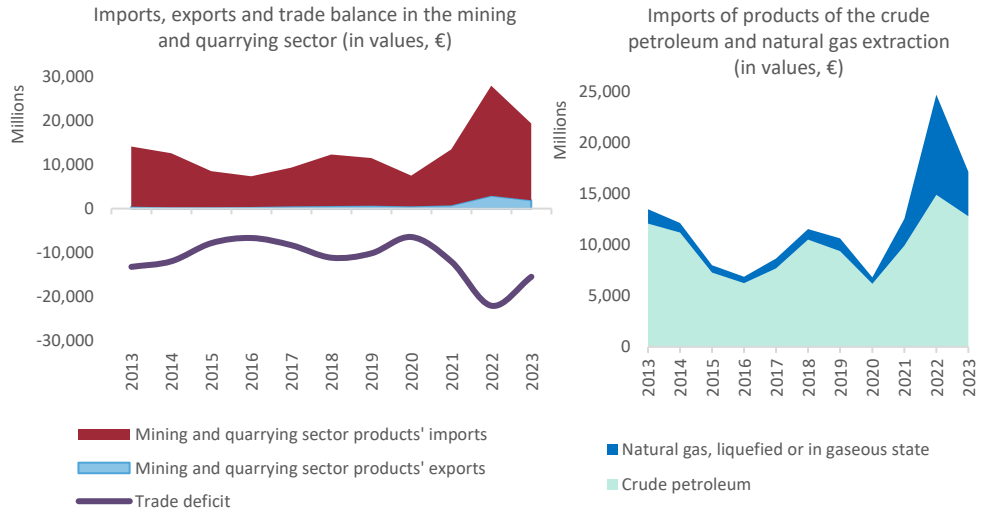
In 2024, the mining sector employed 9.3 thousand people*, with 86% male and 14% female, down from 11.4 thousand in 2023 and 12.0 thousand in 2022. Self-employment reached 15% in 2024. By sector, in 2023, nearly half (47%) of the workforce was in other mining and quarrying, up 32% from 2022. Metal ore mining employed 22%, declining by 43% in one year. While most subsectors shrank after 2008, with total employment nearly halving by 2023 (-45%), coal and lignite mining led the decline, losing 75% of jobs as the Public Power Corporation closed mines, cutting its share from 41% in 2008 to 15% in 2023. In contrast, mining support services expanded, making up 15% of the workforce in 2023, a 120% rise in one year to 1,750 workers.

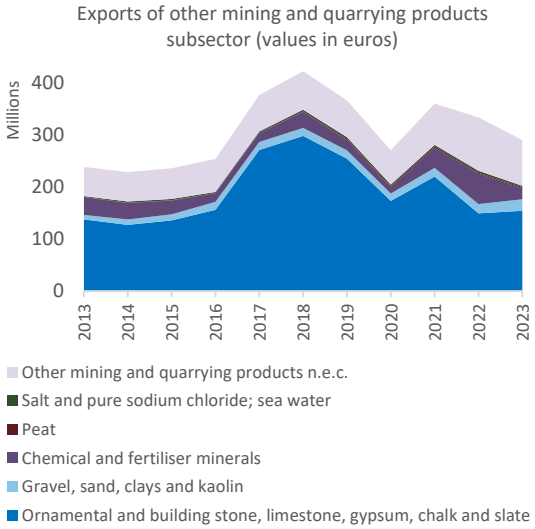
Plant and machine operators and assemblers dominated the sector's workforce in 2023, accounting for 56% of employees. The remaining workforce consisted of professionals (11%), technicians (10%), elementary occupations (9%), and craft workers (9%), with managers, sales workers, and clerical staff each representing 2% or less.

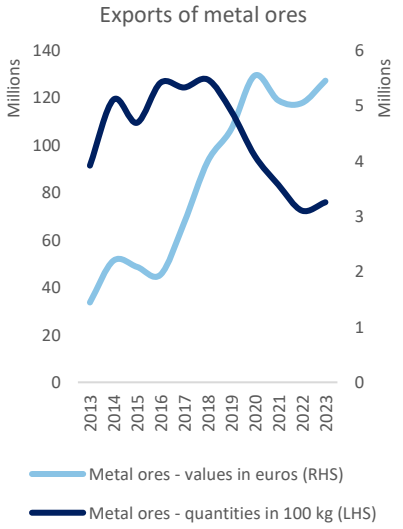
Workforce safety in the mining and quarrying sector

Although the accident frequency rate in Greece's mining sector due to technical failures, mechanical issues, or geological factors (oryktosploutos.net) has declined, and the country reports one of the lowest non-fatal accident rates in the EU, workplace safety remains a concern. Specifically, in 2022, non-fatal accidents had dropped by 68% since 2012, reaching 3.88 per 1,000 workers. Among subsectors, coal and lignite mining recorded the highest non-fatal accident rate at 18.39 per 1,000 workers. This decline in workplace accidents is linked to increased employee training by mining and quarrying companies, underscoring the importance of education and skill development (IOBE, 2018).

Trade dynamics in the mining and quarrying sector







Source: Eurostat – EU trade since 2002 by CPA 2.1

The value of exports and imports in the mining sector peaked in 2022, significantly impacted by surging natural gas and oil prices.

Exports value of mining and quarrying

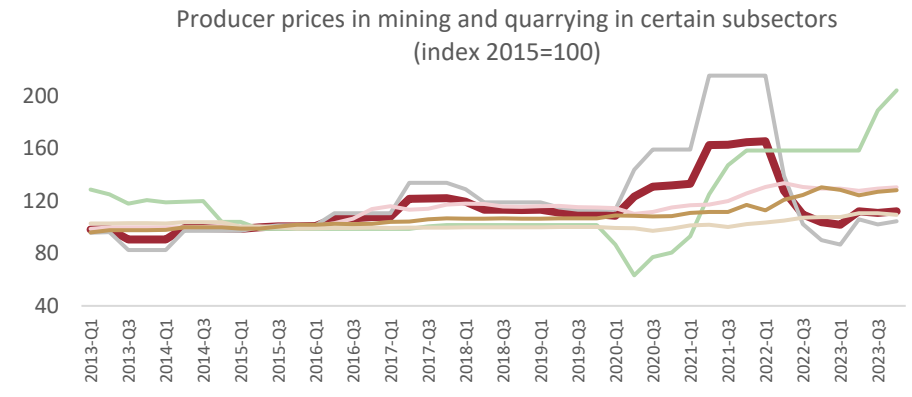
In 2023, Greece's mining sector recorded €1.899 billion in exports, accounting for 3.7% of the country's total exports. The sector's export value peaked in 2022, reaching its highest level in at least 11 years, primarily driven by soaring energy prices. However, in 2023, exports declined by 34% as energy prices stabilized and global demand shifted. Natural gas constituted 74% of mining exports, while crude petroleum accounted for 3%, down from 33% in 2013.

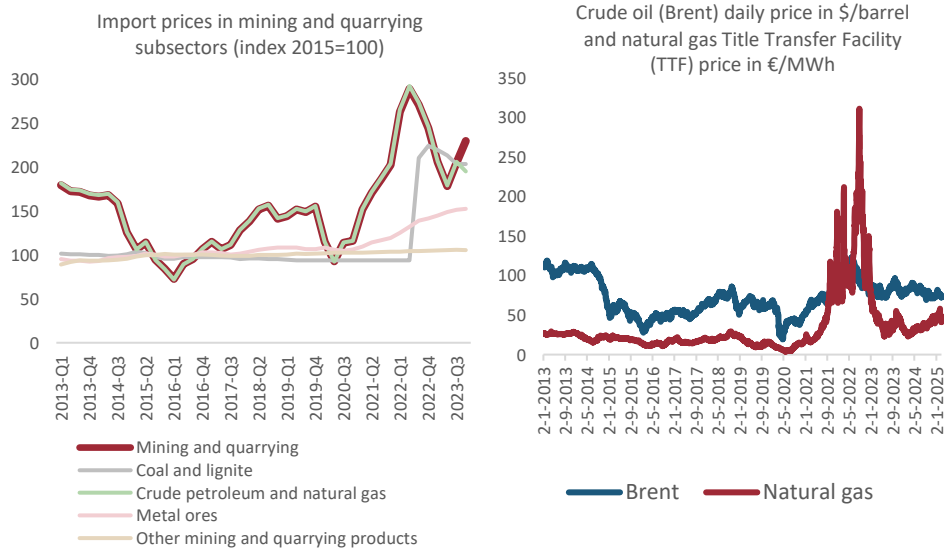
The other mining and quarrying subsector contributed 15% of exports, with marble and travertine (part of the ornamental and building stone category) making up half of this share. Among these, 39% were crude or roughly trimmed, and 10% were cut into slabs. Metal ores represented 7% of total exports, predominantly composed of other precious-metal ores and concentrates (excluding silver), which accounted for 75% of this segment. In terms of quantities, other precious-metal ores and concentrates (excluding silver) held 47% of total metal ore exports, while aluminum ores made up 42%, with a value share of 7%. Greece directed 57% of its mining exports to Bulgaria, followed by China (9%), Romania (6%), Italy (6%), and Moldova (5%).

Imports value of mining and quarrying

In 2023, Greece's mining and quarrying sector imports totaled €17.4 billion, accounting for 21% of the country's total imports. This represented a 30% decline from the 2022 peak, which had been driven by surging energy prices. The 2023 import value was more than double that of 2013. As a result, the sector's trade deficit in 2023 stood at €15.5 billion, down 30% from €22 billion in 2022, when it had nearly doubled from 2021. Crude petroleum (74%) and natural gas (25%) comprised nearly all mining and quarrying imports by value, underscoring Greece's strong dependence on energy imports.

Price trends affecting mining and quarrying





Source: Bloomberg, Eurostat – Producer price, Import price

The link between global energy prices and producer prices in Greek mining underscores the sector's vulnerability to energy markets fluctuations.

In Q4 2023, Greece's producer price index for mining and quarrying nearly returned to pre-COVID levels. Lignite production prices, peaking during the COVID-19 and energy crises, played a key role in this trend. Crude petroleum extraction prices reached their highest levels in over a decade, reflecting global energy market pressures. The producer price of non-ferrous metals experienced a slight increase in mid-2022 compared to energy price indices, while the producer price of other mined products also rose modestly. Both indices reached their highest levels in the 2013-2023 decade.

Fluctuations in crude oil and natural gas import prices heavily influenced the mining and quarrying import price index. Although this index eased from its 2022 peaks, driven by the Russia-Ukraine conflict, it remained above 2020 levels. Despite some moderation, natural gas and crude oil prices are still above pre-crisis levels, highlighting ongoing global energy market volatility.

By 2024, energy prices displayed a clear downward trend, offering some relief from the extreme levels seen during the energy crisis of 2022. Natural gas prices, in particular, saw a significant reduction, although they remained above pre-crisis averages. The Title Transfer Facility (TTF) natural gas price averaged $35/MWh in 2024 ($49/MWh in Jan-Feb 2025), a noticeable decline from $41/MWh in 2023 and far below the record-high $132/MWh in 2022. Similarly, crude oil prices stabilized but remained slightly elevated compared to pre-crisis benchmarks. Brent averaged $80 per barrel in 2024 ($77 in Jan-Feb 2025), down from $82 in 2023 and $99 in 2022, though still above the 2021 average of $71 per barrel. These price trends reflect a gradual normalization in global energy markets, aided by factors such as increased supply, reduced geopolitical tensions, and a milder winter in Europe. However, the lingering effects of the 2022 energy crisis continue to keep prices high, underscoring the need for energy diversification and enhanced market resilience.

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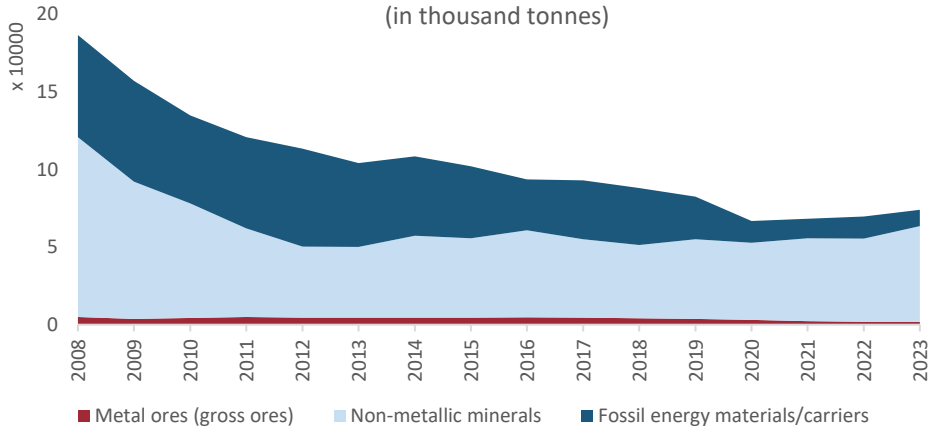
Mining and quarrying materials and products

Domestic extraction and key categories of mineral products

Key categories of mineral products

Metal ores	Non-metallic minerals	Fossil energy materials
Iron ores	Ornamental and building stone, limestone, gypsum, chalk and slate	Lignite
Non-ferrous metal ores	Gravel and sand pits, clays and kaolin	Crude oil
	Chemical and fertiliser minerals	Natural gas
	Salt and other non-metallic minerals	

Domestic extraction of the key mineral product categories (in thousand tonnes)



Source: Eurostat - Material flow accounts

Mineral materials are categorized into three main groups: metal ores, non-metallic minerals, and fossil energy materials.

Material Flow Accounts (MFA) and key categories of mineral products

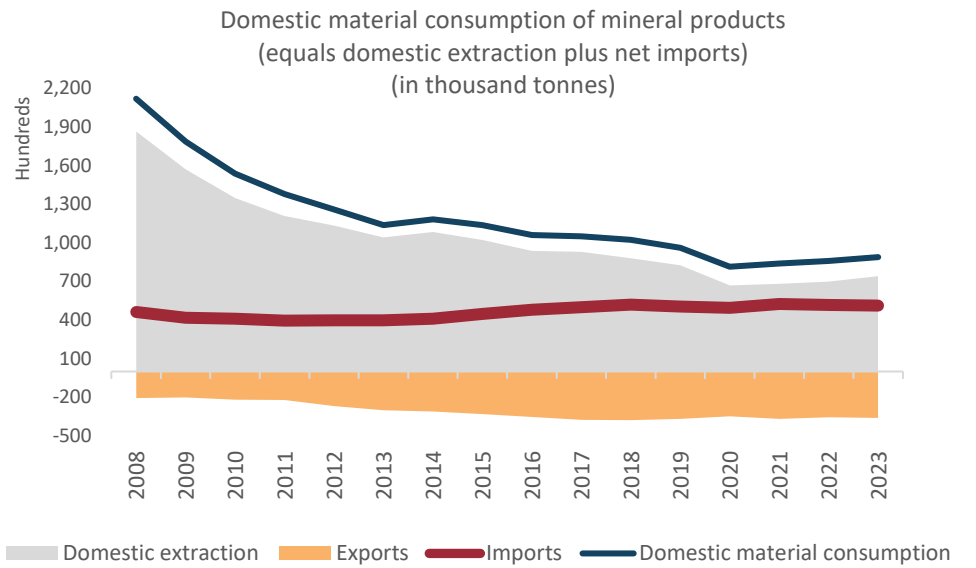
Economy-wide Material Flow Accounts (EW-MFA) track the physical movement of materials entering and leaving an economy. These accounts categorize materials by flow type and material type and form part of the International System of Environmental-Economic Accounting (SEEA-Central Framework) (Eurostat, 2018). They encompass solid, liquid, and gaseous materials. According to the MFA classification, mineral materials – products of mining and quarrying – are divided into three primary groups: (a) metal ores, (b) non-metallic minerals, and (c) fossil energy materials, representing the diverse range of raw materials essential for industrial processes and energy production.

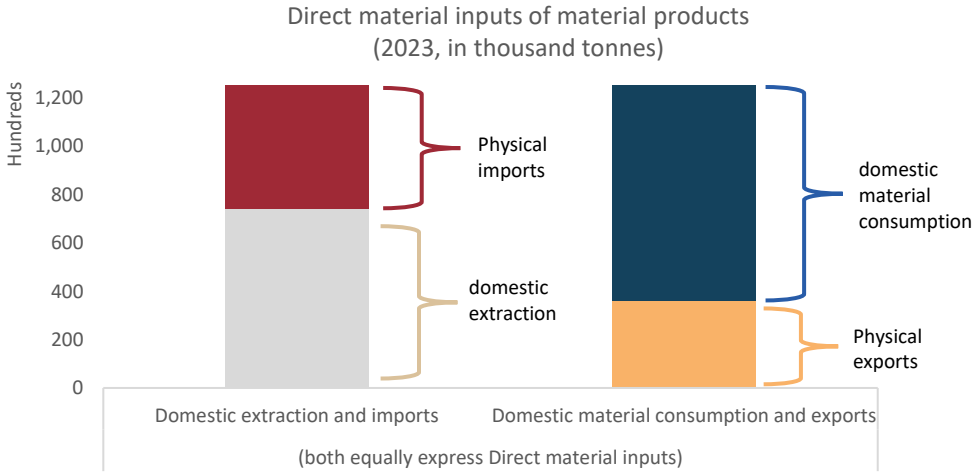
Domestic extraction of mineral products

Domestic extraction represents a critical indicator that quantifies the raw materials extracted from a country's domestic environment, providing insights into resource availability, economic potential, and sustainability. In Greece, mineral materials constitute a significant share of domestic extraction, alongside biomass, waste for final treatment and disposal, and other products.

The total domestic extraction is predominantly composed of mineral materials, which amounted to 73,917 thousand tonnes in 2023. This figure represents a substantial decline of 29% since 2013 and a more dramatic 60% reduction compared to 2008, signaling profound shifts in the country's resource extraction strategies. Metal ores, i.e., mineral resources containing metallic elements essential for industrial and manufacturing applications, made up 3% of mining extraction. Non-metallic minerals, the largest category of mined resources at 83%, encompass materials such as ornamental and building stones, limestone, and gypsum. Fossil energy materials, pivotal for energy production, accounted for 14% of mining domestic extraction in 2023.

Domestic material consumption of minerals





Source: Eurostat - Material flow accounts. Data processing Alpha Bank

Domestic material consumption measures the extent to which mineral materials sourced locally or imported are utilized for domestic purposes.

Physical trade balance (physical imports minus physical exports)

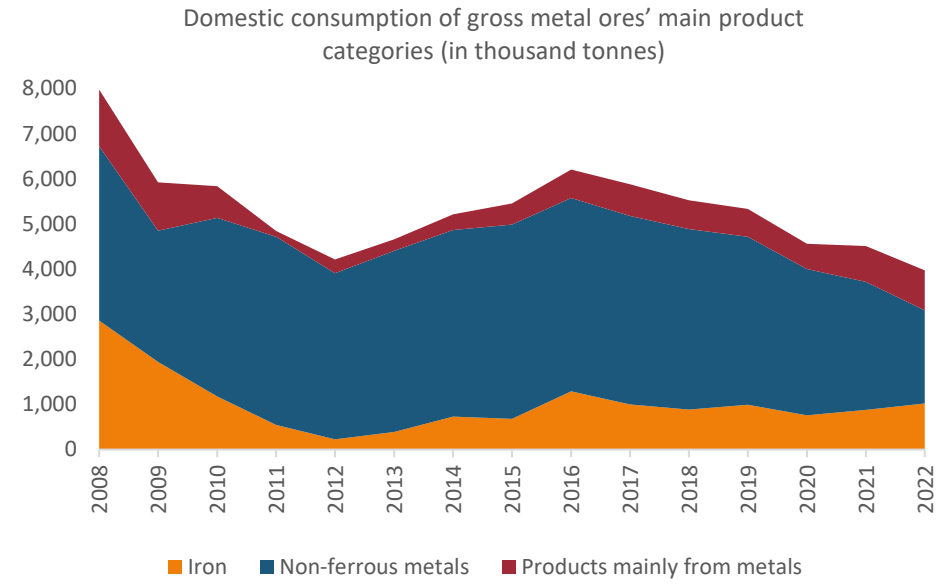
Material trade flows encompass the imports and exports of materials in addition to the domestic extraction of natural resources. According to Eurostat, physical imports contribute to material inputs, while physical exports are categorized as material outputs. These flows are classified by (a) material type, using the same categories as domestic extraction, and (b) manufacturing stage, dividing products into raw, semi-finished, and finished goods based on their primary material composition (Eurostat, 2018). Unlike traditional product classifications, goods are assigned to categories based on their dominant material. In 2023, mineral product imports totaled 51,120 thousand tonnes, a 29% increase since 2013. Exports reached 36,213 thousand tonnes, growing by 20% over the same period, with a physical trade balance of 14,907 thousand tonnes.

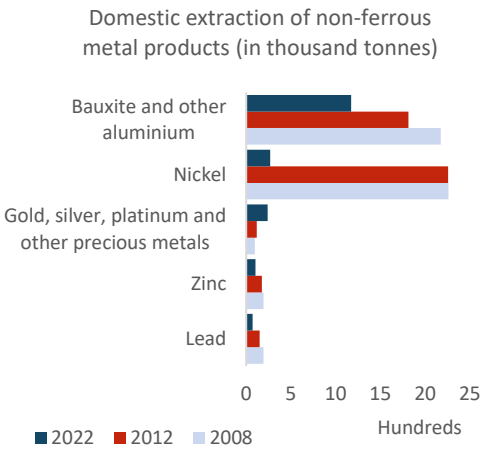
Domestic material consumption and direct material inputs

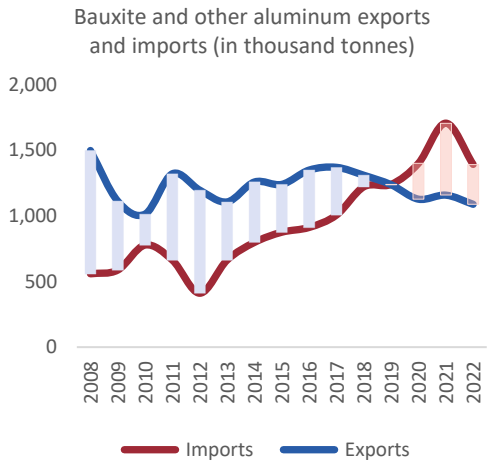
Domestic material consumption (DMC) measures the total quantity of materials used within an economy. It is calculated as the sum of domestic extraction and the physical trade balance (net imports) and reflects the amount of the extracted and the imported raw materials used domestically. In 2023, DMC of minerals totaled 88,824 thousand tonnes, representing a 22% decline since 2013 and a 58% reduction since 2008. Of this total, 83% came from domestic extraction, while the remaining 17% was contributed by the physical trade balance.

Direct material inputs (DMI) provide a key indicator of the total materials available for economic activities within an economy. DMI is calculated as either the sum of domestic extraction and material imports or the sum of domestic material consumption and material exports. For mining and quarrying, DMI reached 125,037 thousand tonnes in 2023, reflecting a 13% decrease since 2013 and a 46% decrease since 2008.

Iron ores and non-ferrous metal ores







Source: Eurostat - Material flow accounts

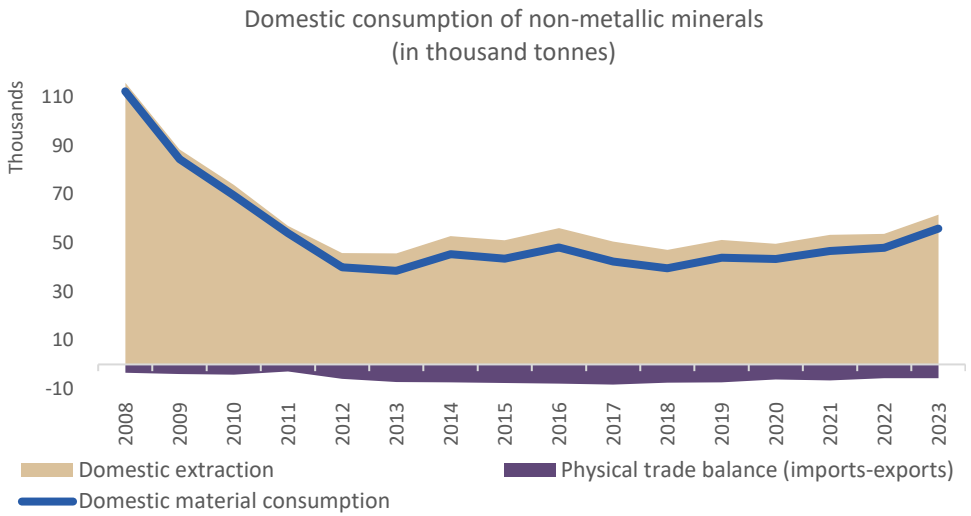
Domestic extraction of non-ferrous metals in 2022 was primarily composed of bauxite and other aluminum ores, as nickel extraction declined.

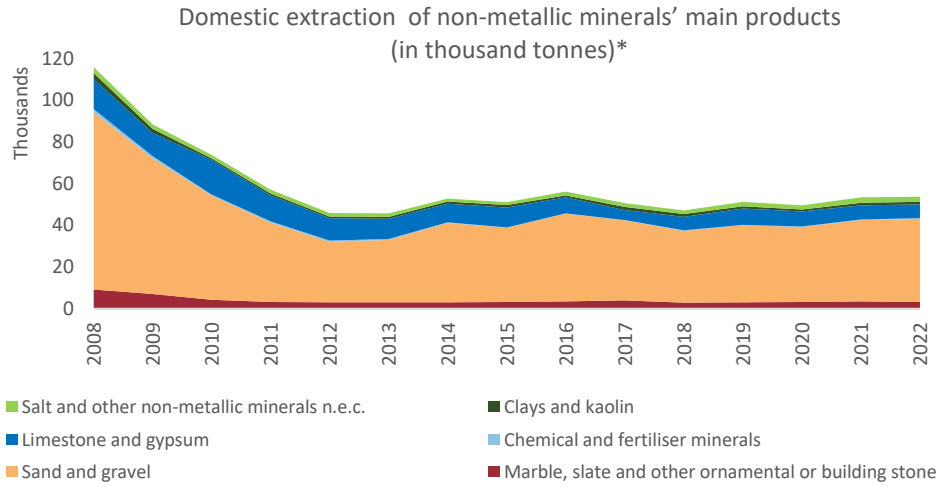
Metal ores are classified into a) iron and b) non-ferrous metals and are essential for industries like metallurgy, construction, and jewelry. In Greece, metal ores consumption totaled 4.6 million tonnes in 2023, up from 3.9 million tonnes in 2022, significantly lower than the 7.9 million tonnes in 2008. Iron is the most widely used metal globally and forms the backbone of industry, with its primary application being steel production, as approximately 98% of all iron is converted into steel (weforum.org).

Greece relies heavily on imports of iron and iron ore products to meet its domestic needs, as it does not extract iron domestically. In 2022, the country consumed one million tonnes of iron ore. To satisfy this demand, Greece imported 2.6 million tonnes of iron ore and exported 1.5 million tonnes of steel or other iron-based alloy products. The steel industry has struggled in recent years, due to reduced demand during the Greek economic crisis and substantial debt. This led to the closure of Halivourgiki, one of Greece's major steel manufacturers. However, there are recent signs that the steel industry is beginning to recover (newmoney.gr).

Non-ferrous metal ores, such as aluminum, copper, lead, zinc, and nickel, do not contain iron and are valued for their lightweight properties, high conductivity, and corrosion resistance, making them essential for industries like electronics and aerospace (metaldetector.com). Domestic extraction of non-ferrous metals in 2022 primarily consisted of bauxite and other aluminum ores, totaling 1.9 million tonnes. Greece was a net exporter of bauxite and aluminum products until 2019, but domestic production decreased by 35% between 2012 and 2022, leading to a notable rise in imports. Historically, nickel accounted for half of Greece's non-ferrous metal production, but its extraction has sharply declined since 2019 due to global nickel price fluctuations affecting profitability, as well as significant financial difficulties in the Greek ferronickel industry (Zografidis et al 2024).

Non-metallic minerals for industrial and construction purposes





*Salt production data are missing after 2016 and have been estimated based on total production.

Source: Eurostat - Material flow accounts

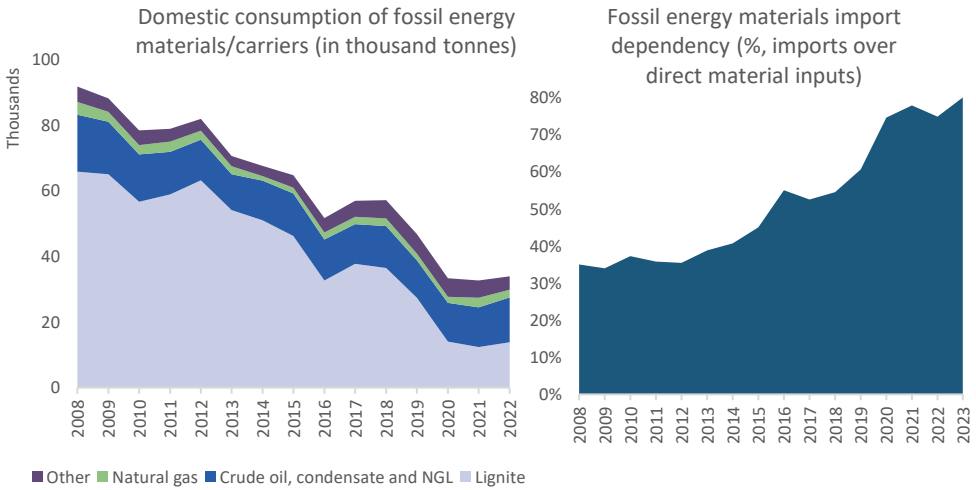
Non-metallic minerals performance was significantly impacted during the Greek financial crisis and has not recovered to pre-crisis levels.

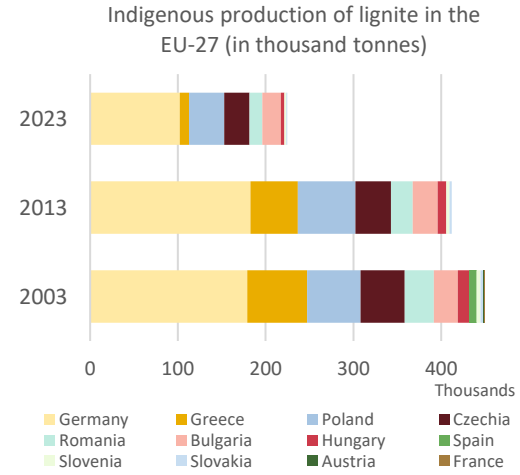
Non-metallic materials, or ores without metal elements, make up the largest share of mined resources, valued for their chemical and physical properties. Unlike metal ores, domestic extraction of non-metallic minerals has shown an upward trend, reaching 61.53 million tonnes in 2023 – a 35% increase since 2013 but still 47% below 2008 levels. The 2009 economic crisis appears to have profoundly impacted non-metallic minerals, as their output was closely tied to the construction sector, which suffered severely during the downturn.

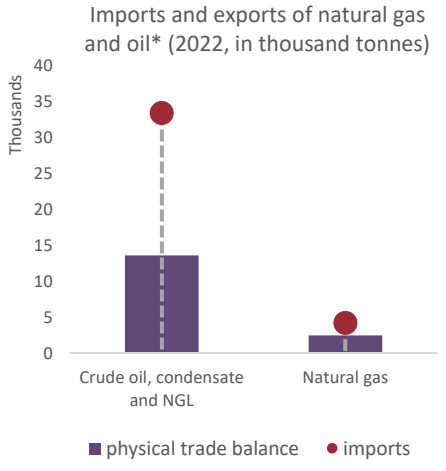
Non-metallic minerals can be categorized based on their intended use (e.g., industrial minerals such as clays and gypsum) or their chemical and physical properties (e.g., salt or aggregates like limestone and sand) (Ministry of Energy and Environment, 2022). According to Eurostat's Material Flows framework, sand and gravel – crucial materials for construction that form the foundation of infrastructure projects – represented 75% of non-metallic mineral extraction in Greece in 2022. Their extraction reached 40 million tonnes in 2022, marking a 38% increase since 2012, reflecting a recovery in construction activity. Limestone and gypsum, essential for cement production and other industrial applications, make up another significant category, accounting for 12% of non-metallic mineral extraction. Ornamental and building stones, including marble, granite, and other decorative stones, comprised 6% of non-metallic mineral extraction in 2022. While Greece has a long history of using these materials in architecture and art, their extraction has decreased by 66% since 2008.

Greece has historically been a net exporter of non-metallic minerals products in terms of quantities, with a trade surplus of 5.7 million tonnes in 2023. Exports reached 8.7 million tonnes (down 9% since 2013), while imports rose to 3 million tonnes (up 28%). Domestic consumption of non-metallic mineral products stood at 55.85 million tonnes in 2023, a 45% increase over the past decade, driven by demand for construction and industrial applications.

Fossil energy materials and carriers of oil, natural gas, and lignite







* Mainly refined petroleum exports, as crude oil is the raw material in refineries to produce petroleum products, such as gasoline and diesel.

Source: Eurostat - Material flow accounts, Supply, transformation and consumption of solid fossil fuels. Data Processing Alpha Bank.

Greece's reliance on energy imports is evident in its material import dependency ratio, which rose from 39% in 2013 to 80% in 2023.

Fossil energy materials and carriers include: a) coal and other solid energy materials, b) liquid and gaseous energy materials, and c) products primarily derived from fossil energy sources. In 2023, total domestic consumption of fossil energy materials in Greece reached 28,419 thousand tonnes, marking a 60% decrease since 2013. Greece's reliance on energy imports is evident in the material import dependency ratio, which measures the share of imported energy materials in direct material inputs (imports plus domestic extraction). This ratio has increased significantly from 39% in 2013 to 80% in 2023.

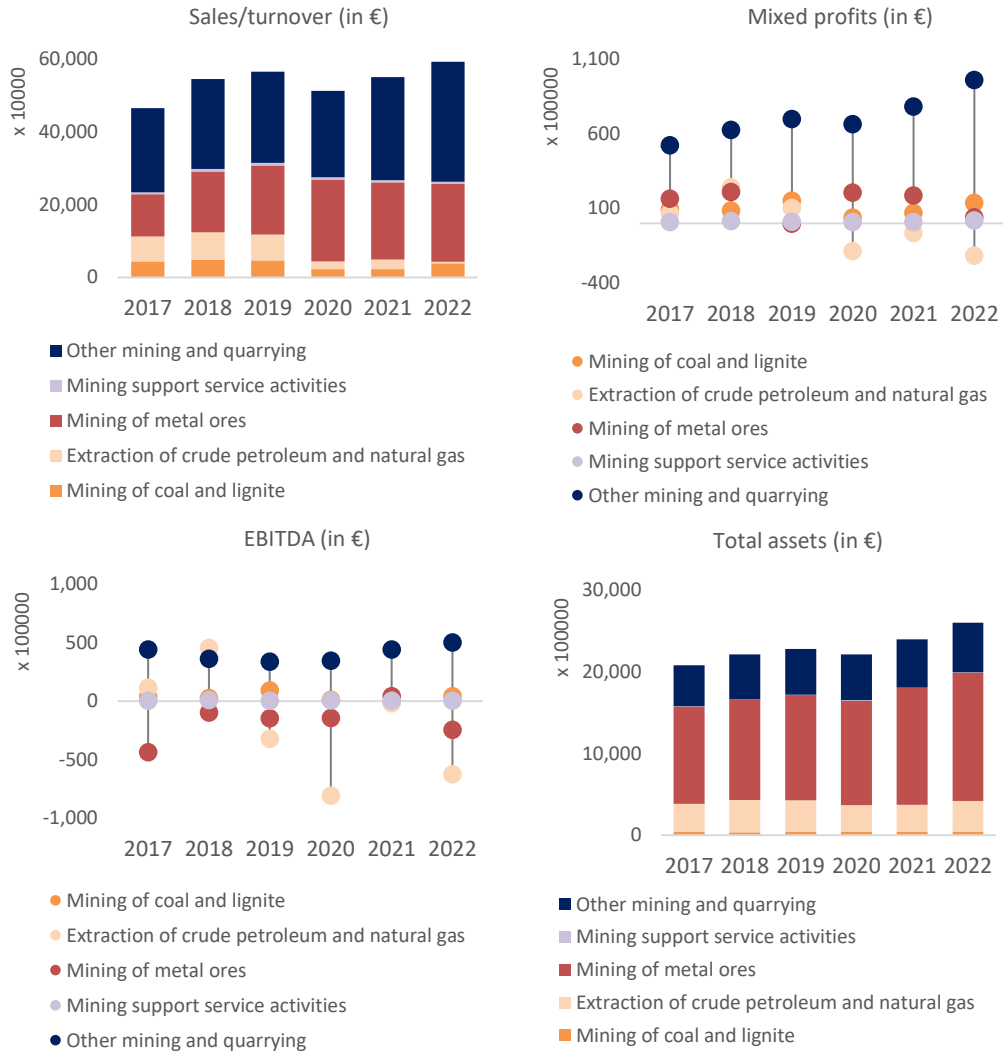
In 2022, lignite accounted for 41% of domestic consumption (77% in 2012), crude oil, condensate, and natural gas liquids made up 40% (15% in 2012), natural gas comprised 7% (3% in 2012), and other products, including bunkered fuels for land, water, and air transport, accounted for 12% (4% in 2012). In Greece, lignite is the only domestically extracted fossil fuel, with its production declining by 81% between 2013 and 2023. This steep reduction, driven by changes in the energy mix, rising carbon costs, and climate policies to reduce the role of lignite, marks the sharpest decline among EU producers. In 2022, Greece increased lignite extraction and consumption for electricity production to avert an energy crisis amid geopolitical tensions, delaying full mine closure until 2028 to reduce reliance on natural gas (Stochasis 2024, ekathimerini.com).

Liquid and gaseous energy carriers, such as crude oil, condensate, natural gas liquids, and natural gas, along with solid fuels like peat, are primarily imported by Greece. In 2022, crude oil and related product imports totaled 33,348 thousand tonnes, up 23% since 2012, while petroleum exports reached 19,773 thousand tonnes. Natural gas imports rose to 4,135 thousand tonnes in 2022, marking a 41% increase since 2012, with Liquefied Natural Gas (LNG) comprising over half of the imports in 2023. Greece's natural gas exports nearly tripled in 2022 compared to 2019.

ALPHA BANK

Business activity of Greek mining and related industries

Financial performance of mining companies



Source: ICAP – Dataprisma

Greece's extraction sector is characterized by high market concentration.

ICAP's financial database, Dataprisma, compiles data from companies within the extraction industry, providing valuable insights into the financial performance of various mining and quarrying subsectors. Overall sales of the sector have been relatively stable over the period 2017-2022, with a slight dip in 2018 and 2020. In 2022, total revenues across the five subsectors of the extraction industry reached €592.7 million, reflecting an 8% increase from 2021 and a notable 27% rise since 2017. Other mining and quarrying companies involved in the extraction of ornamental and building stone, limestone, gypsum, chalk, slate, gravel, sand, clays, and kaolin, accounted for 90% of the sample in 2022 and generated 56% of total sales. Firms extracting metal ores contributed 36% of total turnover, while coal and lignite mining accounted for 6%.

The combined mixed profits of the sampled companies fell by 4% to €93.9 million in 2022, marking a 9% increase since 2017. Total assets of mining firms reached €2.6 billion in 2022, up 8% from 2021 and 25% since 2017. EBITDA remained negative for metal ore mining and crude oil/natural gas extraction, indicating higher operating expenses than revenues. Coal, lignite, and other mining companies saw improved ROA (Return on Assets) at 6.6% and 5.2%, respectively. However, overall ROE (Return on Equity) dropped to -51% in 2022 from -7.7% in 2021, reflecting inefficiencies in utilizing shareholder equity.

The leading 10 companies within the extraction sector generated 65% of the total industry revenues, and the top 20 companies accounted for 79%, highlighting a significant level of market concentration and suggesting that a relatively small number of firms dominate the industry. Notably, Hellas Gold S.A. played a major role, accounting for a substantial 26% of the sector's total revenues in 2022, which amounted to €152.4 million. Market concentration is also evident in certain subsectors, such as the mining of coal and lignite, and the extraction of crude oil and natural gas, where the presence of only a few firms implies an oligopolistic market structure.

Mining business activity and interconnectedness with construction and industry

Business activity of major mining companies in Greece

Construction, infrastructure, and various industries heavily rely on mining materials, including industrial non-metallic minerals such as gypsum, bentonite, clays, and perlite; aggregates like sand, gravel, and limestone; ornamental and building stones such as marble; and metal ores like nickel and bauxite. For example, limestone is crucial for cement production, construction aggregates, and soil conditioning. Gypsum is used in plaster, drywall, and cement, while perlite is utilized in lightweight concrete, insulation, and soil amendments. Bauxite is the primary source of aluminum, clays are essential for pottery, and perlite has applications in construction, agriculture, and gardening.

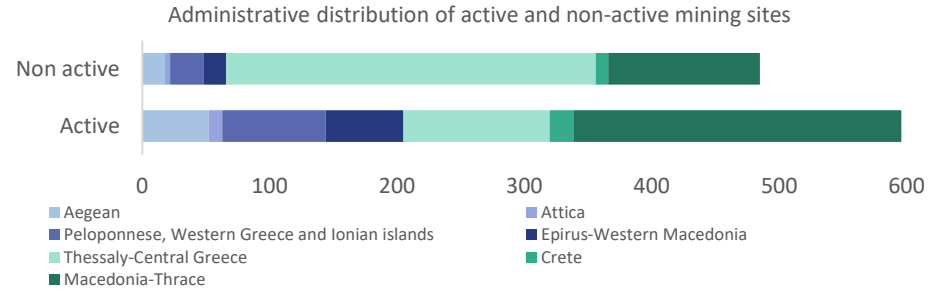
Greece's mineral resources are vital for meeting construction needs, supporting industrial production, and boosting exports. The country is renowned for its marble, including varieties like Pentelic and Parian marble, which are highly sought after for architectural and decorative purposes both domestically and internationally. Greek marble companies lead the EU-27 in exports and maintain a strong global presence, with China as the primary importer of Greek marble blocks (Ministry of Environment and Energy, 2024).

In addition to marble, Greek cement companies are key players in the export market. For example, TITAN, a major Greek cement producer, exports significant quantities to the United States, its largest cement market (USGS, 2022). In the aluminum sector, METLEN, a prominent bauxite and aluminum producer, is developing technologies for gallium production – a critical raw material for the EU used in smartphones, cars, and semiconductors – to meet EU demand (metlengroup.com, naftemporiki.gr). Meanwhile, Hellenic Saltworks, a leading extractor and primary supplier for Greek salt manufacturers, is currently undergoing privatization (ot.gr, capital.gr). Conversely, LARCO, Greece's state-owned nickel producer and operator of one of Europe's last nickel smelters, ceased operations in 2022 due to financial losses and debts, reflecting challenges in some mining industries (USGS, 2022; SME, 2024).

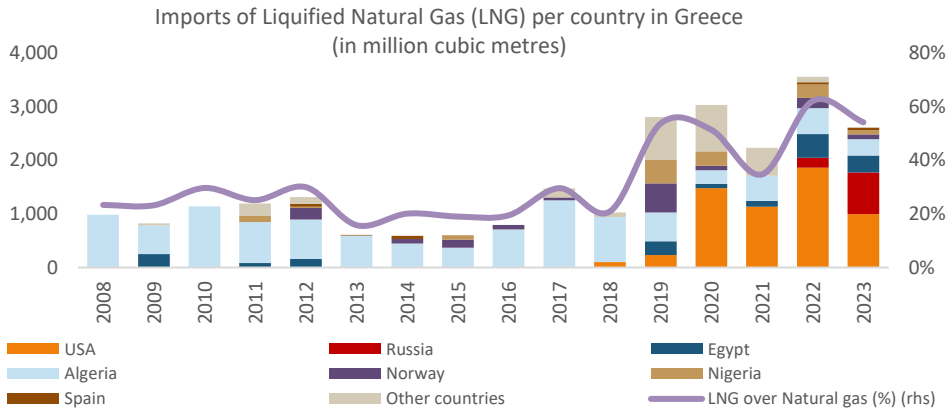
Greece is a leading EU producer of perlite, bentonite, and bauxite, ranking among the top 10 producers worldwide.

Within the EU-27, Greece leads in the production of perlite, bentonite, and bauxite, while ranking 2nd in nickel and marble production, 4th in magnesite, 5th in aluminum, and 6th in lignite (2021). On a global scale, Greece holds 2nd place in perlite production, 5th in bentonite, and 10th in magnesite (2021) (Stochasis 2024, Ministry of Environment and Energy 2024).

In 2022, Greece had a total of 1,081 mining sites, including 596 active and 485 non-active sites where operations are currently suspended. The active sites, predominantly located in Macedonia-Thrace (43%) and Thessaly-Central Greece (19%), comprise 11% mines and 89% quarries and primarily extract marble and slate (53%), aggregates (25%), industrial minerals (11%), metal ores (8%), and energy minerals (3%). Among the non-active sites, 300 previously extracted metal ores, compared to 47 active mines in the same category, indicating that significant metallic mineral deposits remain untapped and therefore do not contribute to the national economy (Ministry of Environment and Energy, 2024). In Greece, the right to explore and exploit metal ores belongs to the State, which can lease or grant these rights. Quarrying minerals belong to the landowner, who has the exclusive right to exploit them, subject to the restrictions imposed by specific quarry regulations (Stochasis 2024).



Source: Ministry of Energy and Environment (2024)



Source: Natural gas trade data – Eurostat

Geothermal energy potential in Greece

Geothermal energy focuses on harnessing the Earth's heat for energy production and utilization. Geothermal energy is included in the energy ores catalogue by the Greek Ministry of Energy and Environment, as its exploration involves drilling and extraction processes from the Earth's crust. In 2022, Greece's installed geothermal capacity reached approximately 266.5 MWth, used exclusively for direct, low-enthalpy applications such as greenhouse heating, balneotherapy, and ground-source heat pumps, the latter being the largest application, accounting for 180 MWth (Papachristou et al., 2023).

Currently, geothermal energy contributes nothing to power generation, as the only geothermal plant on Milos ceased operation in the early 1990s. The Public Power Corporation - Renewables SA, in partnership with ELECTOR S.A., is exploring high-enthalpy geothermal areas in Milos-Kimolos, Lesvos, Methana, and Nisyros under the 'Geothermal Objective II' project (Papachristou et al., 2023). Greece's National Energy and Climate Plan (NECP) identifies geothermal energy as critical for achieving 2030 renewable energy targets, supported by EU programs like Horizon 2020 and the Recovery and Resilience Facility (RRF).

Greece has the opportunity to develop its geothermal energy potential and expand its LNG infrastructure.

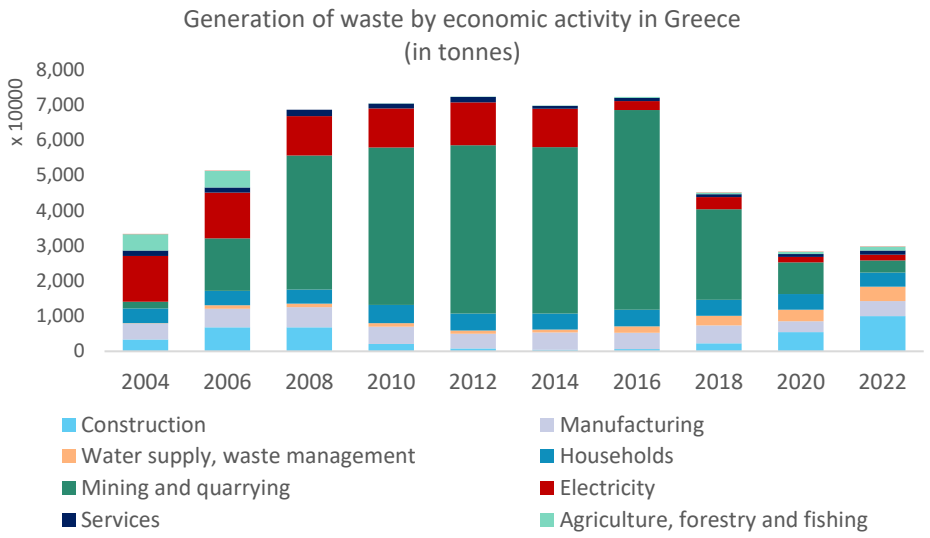
Investments and infrastructure of natural gas and Liquefied Natural Gas (LNG)

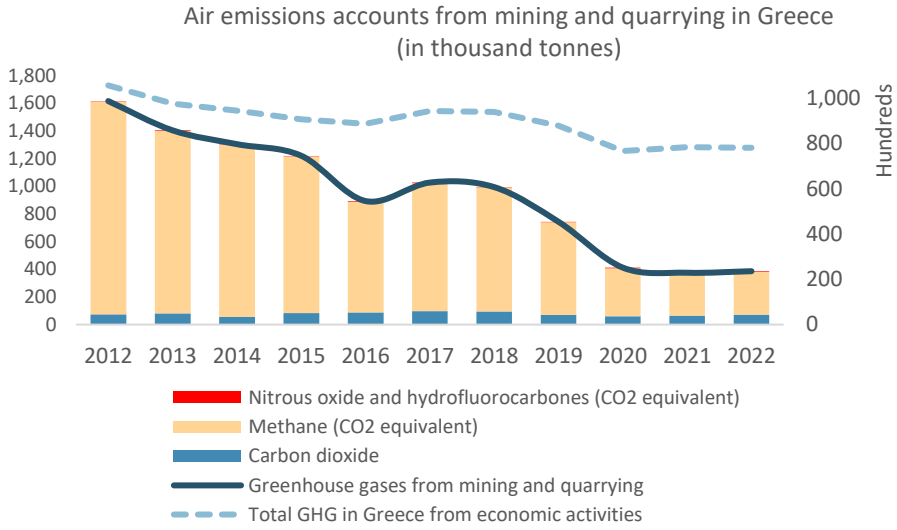
Greece, strategically located, is increasingly pivotal in the energy security of the Eastern Mediterranean and Balkan regions. Greece currently does not produce significant quantities of its own natural gas or oil. However, ongoing explorations are assessing the potential for domestic hydrocarbon reserves. While these efforts have not yet resulted in large-scale production, estimates suggest potential reserves of around 680 billion cubic meters of natural gas (HEREMA 2024). At present, Greece has eight active hydrocarbon exploration and production contracts with prominent companies including ExxonMobil, HELLENiQ ENERGY, and Energean. The primary focus of these contracts lies in offshore blocks situated in the Ionian Sea and the Aegean Sea, particularly in the regions west and southwest of Crete (keeptalkinggreece.com).

The potential for natural gas is set to grow, driven by various infrastructure projects. The National Natural Gas System Operator (DESFA) plans to invest €1.27 billion by 2032, with €458 million allocated for new projects (Alpha Bank Economic Research, July 2024). To strengthen its role as a regional energy hub, Greece operates two LNG terminals, enabling the country to access gas from global suppliers and support regional energy security. LNG imports have more than doubled since 2010, now accounting for 54% of Greece's natural gas imports, sourced from countries like the USA, Algeria, Russia, and Egypt. The LNG arrives in liquid form via specialized tankers at terminals such as Revithoussa (operational since 2019) and Alexandroupolis (since 2024). It is stored at cryogenic temperatures, regasified as needed, and injected into the National Natural Gas System (NNGS) for distribution in Greece or re-export. Planned FSRU terminals include Dioriga Gas in Corinth (Motor Oil Group), Argo FSRU in Volos (Mediterranean Gas), and Thrace LNG in Alexandroupolis (Gastrade) (enterprisegreece.gov.gr, dioriga.gr).

Regulatory framework, environmental impact and sustainability

Environmental impact of the mining and quarrying sector





Source: Eurostat – Generation of waste, Air emissions accounts

Mining and quarrying are low GHG emitters but large waste generators.

Mining impacts are typically categorized as environmental, social, political, and cultural, though these often overlap. These impacts vary based on location, geology, and mining type, occurring at different spatial scales and across all mining stages – even early exploration can have significant social effects (European Parliament 2022). Mining activities can generate substantial environmental impacts through water contamination, release of harmful substances, deforestation, biodiversity loss, land degradation, and noise and dust pollution (European Parliament 2022, citizensustainable.com). While modern mining operations often implement mitigation strategies, the scale and intensity of these operations raise significant concerns for affected communities and ecosystems.

In Greece, mining historically dominated waste generation among economic sectors, peaking at 78% of total waste in 2016. However, by 2022, mining waste had decreased dramatically – falling 93% from 2012 levels to 3,446.3 thousand tonnes, its second-lowest volume since 2004. This reduction largely reflects Greece's energy transition away from coal, particularly the decrease in lignite mining, which typically generates substantial waste through overburden removal (topsoil and rock extraction required to access coal seams) (epa.gov). By 2022, mining had become only the fifth-largest waste contributor, following construction (34%), manufacturing (14%), water supply and waste management (14%), and household waste (13%). The majority of mining waste is non-hazardous, consisting primarily of overburden, waste rock, and tailings (environment.ec.europa.eu, EC 2006, ourworldindata.org).

The sector's environmental impact has diminished in other areas as well. Mining and quarrying now account for just 0.5% of air emissions from Greek economic activities, following a 76% reduction since 2012. Within these emissions, methane is dominant (81%), followed by carbon dioxide (18%), with methane emissions having decreased by 80% between 2012 and 2022.

Regulatory framework and policies for mining activities

EU policy for strategic and critical raw materials

The EU aims to secure a stable supply of critical raw materials – resources essential to the economy but vulnerable to supply disruptions due to limited sources outside the EU. Some of these materials are classified as strategic due to their key role in renewable energy, the digital industry, and the defense and aerospace sectors. In 2024, the EU identified 34 critical raw materials and 17 strategic raw materials (EU 2024). To strengthen supply security, the EU has set specific targets for annual consumption by 2030: at least 10% sourced from domestic extraction, 40% processed within the EU, and 25% supplied through recycling. Additionally, to reduce dependency on single suppliers, the EU aims to cap reliance on any third country at 65% for any strategic raw material (EU 2024). In Greece, more than 15 raw materials – including bauxite, baryte, nickel, cobalt, magnesium, gallium, germanium, manganese, copper, and light rare earths – have been classified as both strategic and critical (Ministry of Environment and Energy, 2024).

EU directives on waste management for extractive industries

EU Directive 2006/21 on waste from extractive industries, incorporated into Greek law in 2009 (Government Gazette, 2009), aims to minimize the environmental impact of mining and quarrying by preventing waste abandonment, improper disposal, or uncontrolled release. It establishes measures for the safe management of waste generated during mineral extraction, treatment, and storage. Extractive industries must develop a waste management plan, reviewed every five years, addressing waste minimization, treatment, recovery, and disposal. This includes operating a waste facility with a permit covering pollution prevention (soil, air, and water), as well as closure, rehabilitation, and post-closure management procedures. Additionally, EU regulations on waste management extend to sectors such as batteries and end-of-life vehicles, emphasizing efficient recycling and raw material recovery (environment.ec.europa.eu).

European and Greek mining policies focus on sustainability, the management of critical materials, environmental protection and the reduction of waste.

The Greek regulatory framework of mining and quarrying activities

The mining and quarrying sector is governed by multiple layers of regulation, including core mining laws and environmental protections. At its center is the Mining Code, established by Law 210/1973 and updated by Law 4512/2019, which works alongside urban planning regulations to manage mining locations and operations (greeklawdigest.gr, Stochasis 2024). Environmental regulations add further requirements around waste management, forest protection, and conservation of Natura habitats and biodiversity (Stochasis 2024, IOBE 2018).

For mining minerals, exploration and exploitation rights are owned by the state, leased to private entities through auctions or Presidential Decrees. For quarry minerals, these rights belong to the landowner or those to whom the rights are transferred. Public quarry rights for industrial minerals and marble are leased or directly granted under certain conditions. The 4512/2018 law has simplified and consolidated quarrying legislation (Stochasis 2024). However, the regulatory framework remains complex, imposing entry barriers through strict state oversight and zoning requirements (Stochasis 2024).

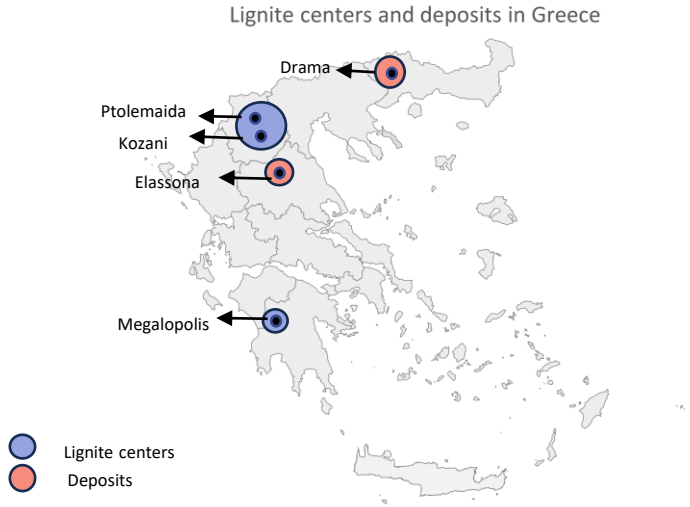
The Greek National Energy and Climate Plan (NECP) on mineral resources

Greece's National Energy and Climate Plan (NECP) sets out the country's strategy for a sustainable energy transition, with significant implications for the mining sector. A central objective is the delignification of the energy sector, requiring the complete shutdown of lignite-fired power plants by the end of 2028. This aims to reduce Greece's carbon footprint and support EU climate goals. The NECP also emphasizes the sustainable management of critical minerals, promoting both their exploration and use while ensuring competitive, transparent processes for granting exploration and exploitation rights to support responsible resource development.

Decommissioning of lignite mines and sustainable rehabilitation

Territorial Just Transition Plan

The Just Transition Mechanism supports coal and mining regions in meeting European Green Deal goals through social and economic assistance. Central to this is the Just Transition Fund (JTF), which facilitates the transition of fossil fuel-dependent areas into sustainable economies, ensuring an inclusive green transition for workers, businesses, and communities (commission.europa.eu). Greece will receive €1.38 billion in JTF grants, targeting decarbonization in Western Macedonia, Megalopolis, and the phase-out of fossil fuel power plants in the North-South Aegean islands and Crete (ec.europa.eu). Over half of the funds will support new businesses, infrastructure, and innovation, while 20% will focus on workforce development and sustainable employment skills. The JTF will also fund energy transitions, land-use changes, and circular economy initiatives. Key projects include the "Innovation Zone" in Western Macedonia, promoting entrepreneurship and infrastructure, and the "Bioeconomy 360° Hub" in Megalopolis, advancing sustainable bioeconomy practices.



Source: ppcgroup.com. Data processing Alpha Bank

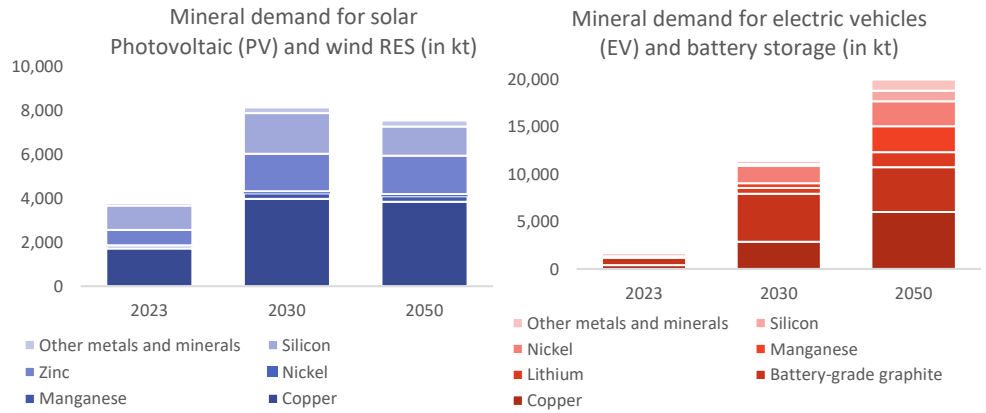
Key priority is to promote a sustainable post-mining reclamation of lignite sites.

Decarbonization era: lignite phase-out and rehabilitation of the mining sites

Public Power Corporation (PPC) stands as the principal owner of lignite mines in Greece, with private companies possessing a considerably smaller share of the operations. PPC has been active in this sector since 1955 (ppcgroup.com). Historically, lignite has served as the primary fuel source for electrification across the country. However, as part of a broader strategy to transition to greener energy sources, a significant restructuring has taken place. As of 2021, a total of 21 lignite-fired power generation units were decommissioned and removed from operations, alongside the closure of two major mines, the Amyntaio-Lakkias and Kardia mines, located within the West Macedonia Lignite Center. Despite these closures, the South Field Mine and the Mavropigi Mine continue to operate, providing lignite to the Agios Dimitrios Thermal Power Plant (TPP) and Unit V of the Ptolemaida TPP. In addition, the Choremio mine in Megalopolis remains operational, supplying lignite to the sole thermal power unit in the region, the Megalopolis B power plant.

The transition from lignite power generation to cleaner energy sources focuses on promoting sustainability in former mining regions. This involves developing substantial renewable energy and energy storage projects in former mining areas to replace the retired lignite facilities, ensuring a smooth social, environmental, and economic transition for these regions. Key priorities include restoring and reforesting mined lands to rehabilitate ecological balance, establishing green energy projects such as combined-cycle gas turbine plants, hybrid systems, solar parks, and energy storage facilities (ppcgroup.com). Additionally, equally important is community integration, ensuring rehabilitated lands are returned to local communities to support new development activities and foster a sustainable and inclusive transition. Circular economy principles offer a framework for mine closures, encouraging resource and material reuse from decommissioned facilities (Pavloudakis et al. 2023).

Transition to sustainable mining and circular economy practices



Source: IEA - Critical Minerals Dataset. Data processing Alpha Bank

Increasing materials demand for clean energy technologies

Mined metals and minerals are essential for renewable energy and energy storage, offering substantial recyclability potential. Since 1970, global resource extraction has surged from 23.7 billion tons to almost three times that amount by 2017, with mineral demand expected to double by 2060, putting further pressure on ecological limits (Jose et al. 2024). The shift towards a low-carbon economy will depend on mineral security, as clean technologies like solar panels, wind turbines, and electric vehicles require rising amounts of critical minerals such as copper, lithium, nickel, cobalt, and rare earth elements. In a scenario aiming for net-zero emissions by 2050, as provided by the International Energy Agency (IEA), global mineral demand for solar PV and wind energy is predicted to grow from 3,780 kt in 2023 to 8,148 kt by 2030, and 7,555 kt by 2050, with copper leading. Similarly, for electric vehicles and battery storage, demand is forecast to rise from 1,758 kt in 2023 to 11,430 kt in 2030, and 19,954 kt in 2050, primarily driven by copper, graphite, manganese, nickel, lithium, and silicon. This rising demand is likely to cause price volatility, supply chain disruptions, and geopolitical tensions (IEA 2022).

Embracing circular economy principles in the mining industry can move the sector towards a more sustainable and resilient future.

Minimizing mining waste

Waste generated from mining and quarrying activities is one of the largest waste sources in the EU-27, accounting for 23% of total waste in 2022, second to construction and demolition waste (38%) (ec.europa.eu). In primary metal mining and refining processes, valuable materials are separated through metallurgical procedures designed to optimize metal recovery. However, these processes generate substantial water waste, which contains low levels of acids and large quantities of mining residues, known as tailings. These tailings often include heavy and toxic metals, as well as valuable and strategic metal ions (Machairas and Varouchakis, 2023). Proper management of mining waste is essential, as tailings can harm the environment, contaminate water sources, and negatively impact local communities and economies (Jose et al. 2024).

Circular economy in mining and quarrying

Integrating circular economy principles helps maximize resource use at every stage of a product's lifecycle, transforming waste into valuable inputs, reducing overall waste, and supporting local economies and communities (Jose et al. 2024). The circular economy represents a transformative model for resource management, promoting economic growth while safeguarding the environment. By adopting closed-loop practices, it minimizes waste and encourages the reuse and recycling of materials, turning waste into valuable resources, and replacing the traditional linear "take-make-dispose" model with a cyclical system that maximizes materials lifespan (PwC 2021). In mining, circular economy principles focus on: a) Process Circularity, targeting waste reduction, resource efficiency, and by-product recovery via re-mining tailings and upgrading equipment, and b) Product Circularity, aimed at extending material lifecycles through recycling, reuse, and creating markets for secondary materials (ICMM, 2024).

Policy recommendations and SWOT analysis

Policy recommendations and future prospects

Sustainability and circular economy principles on mining

Sustainability has become a core strategic priority in the mining and quarrying sector, fundamentally shaping its future trajectory and operational longevity. This evolution encompasses comprehensive changes across the value chain, from resource stewardship and extraction techniques to environmental impact management of metals, minerals, and fossil fuel operations. In this evolving landscape, mining companies must integrate sustainability practices and circular economy principles across their organizational structure.

The sector's sustainability is crucial for several reasons. First, mining operations provide essential raw materials for renewable energy technologies, electric vehicles, and digital infrastructure – all critical components of decarbonization efforts. Second, the industry's operations significantly impact local ecosystems, water resources, and communities, making responsible practices indispensable for maintaining social license to operate. Third, the sector's substantial waste generation positions it as a critical focus area for environmental improvement initiatives, resource management and waste reduction. Circular economy principles can transform traditional mining practices through several approaches, such as maximizing resource recovery from existing mines and reprocessing mining waste and tailings to extract valuable materials.

Advancing the role of mining on energy transition

Energy transition is driving substantial growth in mineral demand, particularly for critical minerals such as lithium, nickel, and rare earths. These minerals are essential for renewable energy infrastructure, with magnets required for wind turbines and specialized cells for solar panels, as well as batteries for electric vehicles (WEF 2023). Geothermal energy represents an underutilized resource in Europe's energy transition strategy. It offers distinct advantages: minimal greenhouse gas emissions, efficient land and resource utilization, low import dependency, and consistent power generation independent of weather conditions (eesc.europa.eu).

Looking ahead, the industry's sustainability challenges will intensify as demand grows for materials essential to green energy transition.

Innovation and technology developments impacting the mining sector

Mining can benefit from Mining 4.0, which aligns with Industry 4.0 by aiming to enhance safety and productivity, reduce costs, and address challenges posed by complex geologies and depleting ore deposits. This is achieved through the integration of unmanned technologies, remote process control, and digital simulation in mining operations (Skenderas, D. and Politi, C. 2023). The technological transformation goes beyond basic automation, incorporating comprehensive digital solutions such as artificial intelligence (AI) for predictive maintenance and advanced sensor networks for real-time monitoring (mining-technology.com). Additionally, innovations in processing technologies, water management systems, and waste utilization methods are critical for reducing environmental impact while maintaining economic viability.

Geopolitical trends affecting resource supply and demand

Geopolitical trends are shaping a complex landscape for global mining. Governments increasingly regard mineral resources as critical national assets, driving "resource nationalism" through measures like export controls on critical minerals, stricter oversight of mining operations, and occasional nationalization of assets (WEF 2023). These measures reflect growing concerns over securing domestic supply chains amid forecasts of significantly higher demand for critical minerals in the coming decades. Geopolitical tensions, export restrictions, and supply chain disruptions jeopardize the steady supply of mined resources and contribute to price volatility. Moreover, such risks can discourage investment in new mining projects, potentially exacerbating long-term supply shortages (csis.org). To navigate these challenges, the industry must focus on diversifying supply chains, fostering international cooperation, promoting sustainable mining practices, and advancing innovative resource extraction.

SWOT analysis of the mining and quarrying sector

STRENGTHS

- Rich in mineral resources, valuable for domestic use and exports
- EU leader in the production of perlite, bentonite and bauxite
- Strong ties with construction and metal industries
- Strategic reserves of 15+ critical raw materials
- Established natural gas and LNG infrastructure
- Strategic location with easy access to European and international markets
- Low greenhouse gas emissions compared to other sectors

WEAKNESSES

- Environmental concerns including soil erosion, water pollution and deforestation
- High waste generation from mining operations
- Potential social challenges from lignite mines closures if not effectively managed at local and regional levels
- Heavy reliance on fossil fuels, such as oil and natural gas
- Complex regulatory framework, imposing entry barriers

OPPORTUNITIES

- Green mining initiatives embracing sustainable practices and circular economy principles
- Rising demand for minerals to support energy transition
- Regulatory focus on waste reduction from extractive activities
- EU policies ensuring a secure and sustainable supply of critical raw materials
- Just Transition Mechanism supporting the shift of fossil fuel-dependent regions to sustainable economies
- Estimated 680 billion cubic meters of natural gas reserves
- Technological advancements enhancing efficiency and reducing environmental impact

THREATS

- Resource depletion reducing long-term availability
- Economic crises affecting construction and metal industries
- Global market volatility and commodity price fluctuations affecting profitability
- Competition from countries with abundant mineral resources and lower production costs
- Geopolitical risks threatening operational stability and resource supply
- Public opposition to mining activities due to environmental and social concerns

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Appendix: list of abbreviations

EU: European Union	**NECP**: National Energy and Climate Plan
EC: European Commission	**NNGS:** National Natural Gas System
DMC: Domestic Material Consumption	**PPC**: Public Power Corporation
DMI: Domestic Material Inputs	**PV**: Photovoltaic
EBITDA: Earnings Before Interest, Tax, Depreciation and Amortization	**RES**: Renewable Energy Sources
EV: Electric Vehicles	**ROA**: Return On Assets
GHG: Greenhouse Gas	**ROE**: Return On Equity
GVA: Gross Value Added	**RRF**: Recovery and Resilience Facility
IEA: International Energy Association	**TTF**: Title Transfer Facility
JTF: Just Transition Fund	**TPP**: Thermal Power Plant
LNG: Liquefied Natural Gas	**WEF**: World Economic Forum

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