PROJECT BLUE

Magnesia Industry Study

Euromines

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FINAL REPORT

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Definitions

- Magnesite = Magnesia ore
- CCM = Caustic calcined magnesia
- DBM = Dead burned magnesia
- FM = Fused magnesia
- AM = Asian Metals (price reporting agency)
- GTT = Global Trade Tracker (trade data aggregator)
- HHI = Herfindahl-Hirschman Index, where
    - <1500 is a competitive marketplace, and
    - 2500+ is a highly concentrated industry

1. Executive Summary

Magnesia (magnesium oxide, MgO) is a versatile compound which is used in a wide range of different applications. Magnesia is mainly sourced from magnesite mines (93%) but also from brines and deep salt beds (7%).

Magnesite – natural magnesium carbonate – is the largest feedstock for magnesia. Output is calcined or fused to produce three main magnesia grades – caustic calcined (CCM), dead burned (DBM) and fused (FM). Brines and salt beds typically produce magnesium chemicals such as magnesium chloride, but are also an important feedstock for magnesia production.

Global magnesite and magnesia production is highly concentrated among a few countries. China dominates magnesia production, consumption and exports. In 2023, China accounted for 70% of magnesia capacity and 68% of magnesia production (16Mt). Within China, supply is concentrated in just one province, Liaoning, where capacity has been built up aggressively over the last 20 years, increasing China's global production share from 47% in 2001 to 68% in 2023. Brazil, Turkey, and Russia are other leading producing countries.

The EU represents the third largest global magnesia-producing region, accounting for 7% of the magnesia production in 2023, down from 18% in 2008.

Demand for magnesia is growing globally. While nearly all DBM and FM are consumed in refractories for steel, cement and other industries, CCM has a wide range of applications in the construction, agriculture, environmental, health, industrial and chemical markets.

Refractories are indispensable in the production process for steel, cement, glass, and ceramics, as well as critical metals such as copper, aluminium and nickel. Strategically important sectors such as energy transition, aerospace and infrastructure require increasing volumes of these critical materials, and refractories are used whether these metals are produced from primary or recycled materials.
There is very limited ability to substitute DBM or FM in refractories, and no substitute for refractories themselves.

Magnesia is an internationally traded commodity and world trade was 4.5Mt in 2023. Chinese exports also dominate global trade flows and in 2023 represented 62% of magnesia shipped worldwide. Seven further countries, all with exports over 100kt, represent another 28% of global trade.

This concentration and dominance of world supply means that dynamics of the Chinese magnesia industry are reflected in global prices. Any state-driven measures such as production quotas or closures for environmental reasons, have can drive volatility in magnesia markets around the world.

The ability of European magnesia producers to meet domestic demand growth could be hampered by a confluence of challenges. The European industry is facing high energy prices, including a lack of alternative fuel sources, as well as technological and financing obstacles to meet sustainability and decarbonisation requirements. These challenges have driven escalating costs for European producers over the last five years, resulting in operations closing and reducing their supply base.

As a result, European imports of magnesia products and other finished products have increased, especially from China as they are very competitively priced relative to European production.

However, these challenges severely limit opportunities for expansion or upgrading of existing facilities and are even more restrictive for potential new entrants. It is also worth noting that these competitive issues could flow downstream, where these same challenges linked to energy and decarbonisation could drive traditional magnesia customers such as the refractories industry, and their customers, to relocate outside Europe to benefit from lower feedstock and production costs.

Given the above-mentioned challenges and the future growth of magnesia demand, the ambitions of net zero in Europe will be difficult to achieve without a secure and stable domestic supply of magnesia.

2. Magnesia Feedstocks

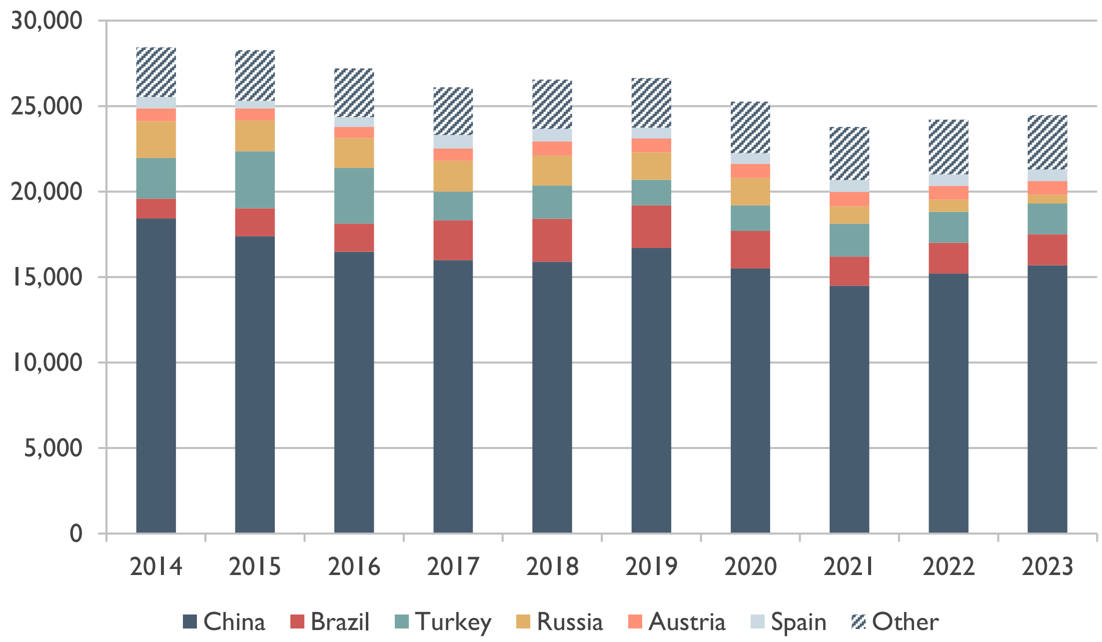
Natural magnesite accounts for 93% of feedstocks for global magnesia production. Brine or sea water production of magnesia is often termed "synthetic magnesia" to differentiate it from magnesia based on magnesite, represents the remaining 7% of the feedstock for magnesia production. Other magnesia chemicals are sourced from kieserite (magnesium sulphate), brucite (magnesium hydroxide) and a very small percentage from other sources, such as by-product streams. EU feedstock supply for magnesia is split between production based on magnesite (magnesium carbonate) and underground salt brines.

2.1. Magnesite as a magnesia precursor

World magnesite supply is estimated at 24Mt in 2023 and concentrated between relatively few countries. Magnesite mining is predominantly carried out in-house or by subsidiary mining operations, and therefore there is minimal trade of magnesite as a commodity. All the leading Chinese magnesia producers process captive feedstock, while more than 90% of the output from Russia, Turkey, Brazil, and all the Australian output is based on magnesite mined in-house.

China dominates global supply, accounting for 65% in 2023, although there have been lower levels of supply since 2018, mainly due to mining restrictions and increased environmental regulation of the industry. Brazil and Turkey are important producers accounting for 15% of the total in 2023, whereas Russian production has decreased in line with lower exports in 2022 and 2023. Trends in global magnesite production therefore reflect movements in Chinese output because of its significance to the sector.

Figure 1: Global production of magnesite 2014-2023 (kt)



Source: Project Blue, World Mining Data

In China, magnesite production is dominated by Liaoning Province, which has a total mining capacity of 22Mtpy. However, there is a quota system in place, limiting output to 18Mtpy in 2024.

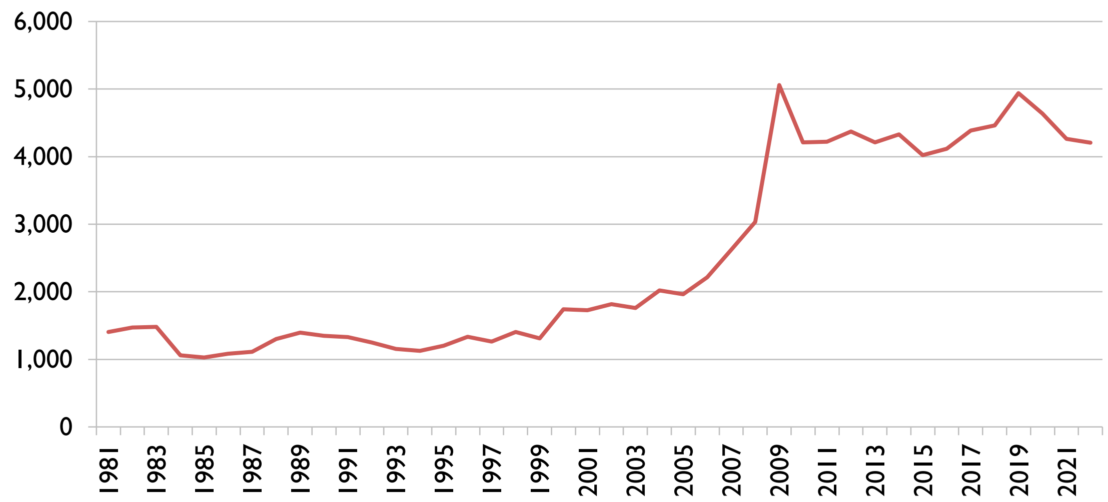
Following a period of high prices in 2017/2018, the industry attracted various new entrants that have invested heavily in developing new and modern projects and increasing capacity. However, like other mineral industries in China after a period of rapid capacity growth, the state has intervened to consolidate the sector and manage output levels. In 2020, the provincial government issued the "Opinions on Promoting the Sustainable and Healthy Development of the Magnesite Industry", along with the "Provincial Magnesite Mining Rights Integration Plan", both of which have driven the consolidation. These were followed in 2023 by the "Implementation Opinions on Promoting the High-quality Development of the Magnesite Industry" and the "Special Rectification Plan for the Magnesite Industry in Liaoning Province".

As a result, the number of mining enterprises dropped from 114 to 63 between 2020 and 2024. In turn, overall magnesite production has been declining, with the changes and closures in the industry resulting in a tightening of supply in 2023. Ongoing integration and reorganisation are expected to reduce the number of operators to 56 by the end of 2025. These measures are increasing the number of large- and medium-sized mines, which will represent 44% of Chinese production.

The effect of these changes will specifically impact the production of different grades of CCM or light-burned magnesia, as the light-burning reflex kilns will be phased out from city areas by the end of 2025. The implementation of strict environmental policies has also increased the transformation and production costs of magnesite operations. The upcoming legislation for material being imported into the EU customs territory is also being considered, as it will affect Liaoning exports and competitiveness, and is pushing up producer costs.

The production of magnesite has been concentrated into the hands of fewer countries. This can be shown using the Herfindahl–Hirschman Index, (HHI), which has been adapted to measure the concentration of production by country for the industry, and is used an indicator of the amount of competition between them. An HHI below 1500 indicates a competitive market, while an HHI above 2500 indicates a highly concentrated market. When applying this to the magnesite industry, there has been a marked rise in concentration since 2000 (Figure 2).

Figure 2: HHI for global magnesite production

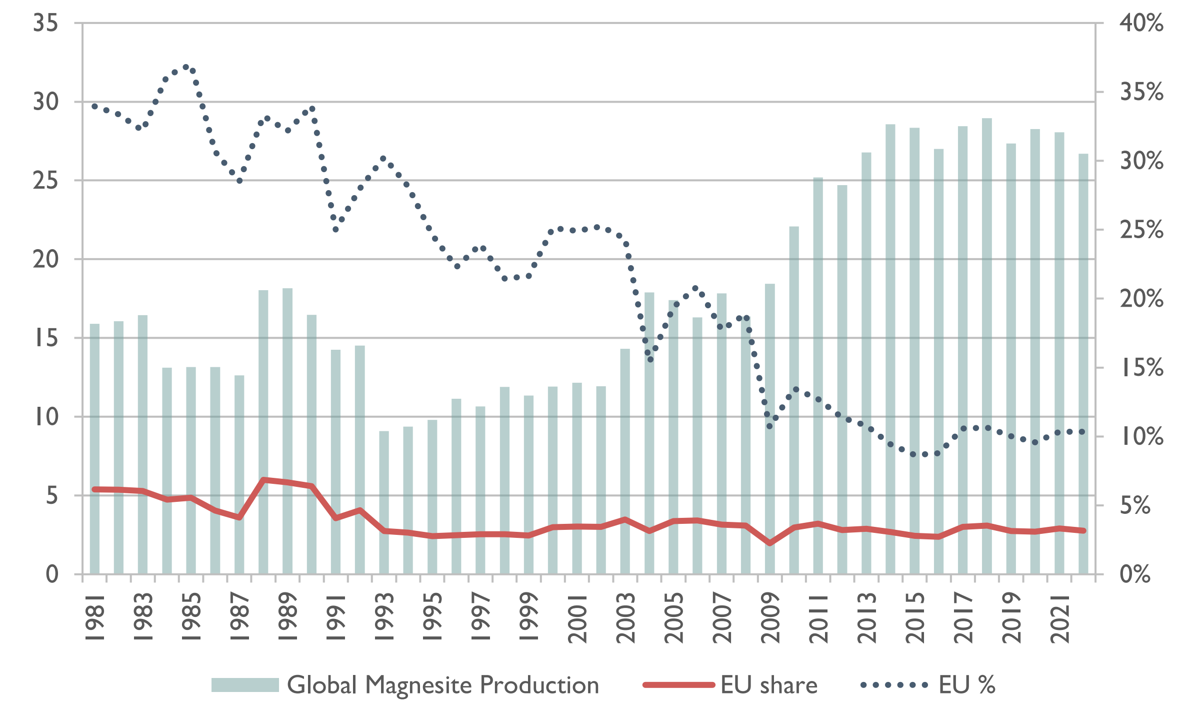


Source: World Mining Data, Project Blue

Looking at other producing countries outside of China, Turkish magnesite production has increased significantly over the last ten years, and Russia now also has significant capacity, with both Kűmas Manyezit and Magnezit having expanded their mining operations in recent years. However, there has been significantly decreased export activity from Russia since 2022, this in turn corresponding to a fall in Russian magnesite output.

The proportion of EU production against global supply is illustrated in Figure 3 showing how the share of production has fallen from 25% in 2001 to 10% in 2022.

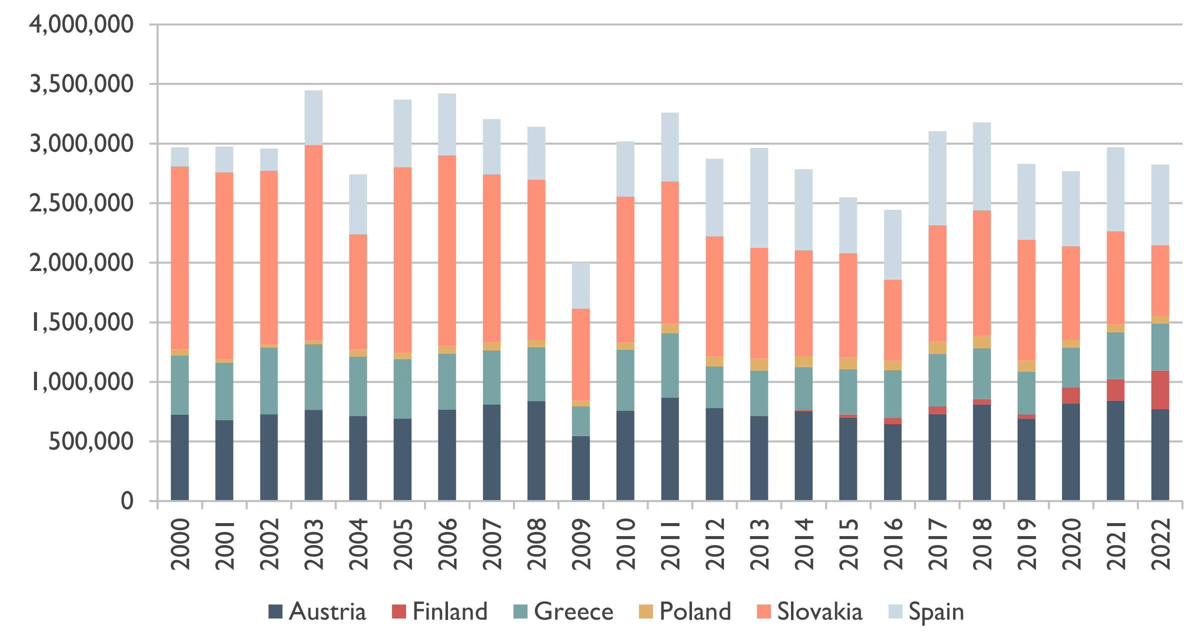
Figure 3: EU proportion of global magnesite production 1981-2022 (tM)



Source: World Mining Data

EU production of magnesite is shown in Table 1 and in Figure 4 showing its evolution over time. The EU countries that produce significant volumes of magnesite are Austria, Greece, Spain, and Slovakia. There is also some smaller amount of magnesite production in Poland serving domestic markets and Finland.

Figure 4: EU production of magnesite 2000-2022



Source: World Mining Data

Table 1: EU production of magnesite 2010-2022 (t)

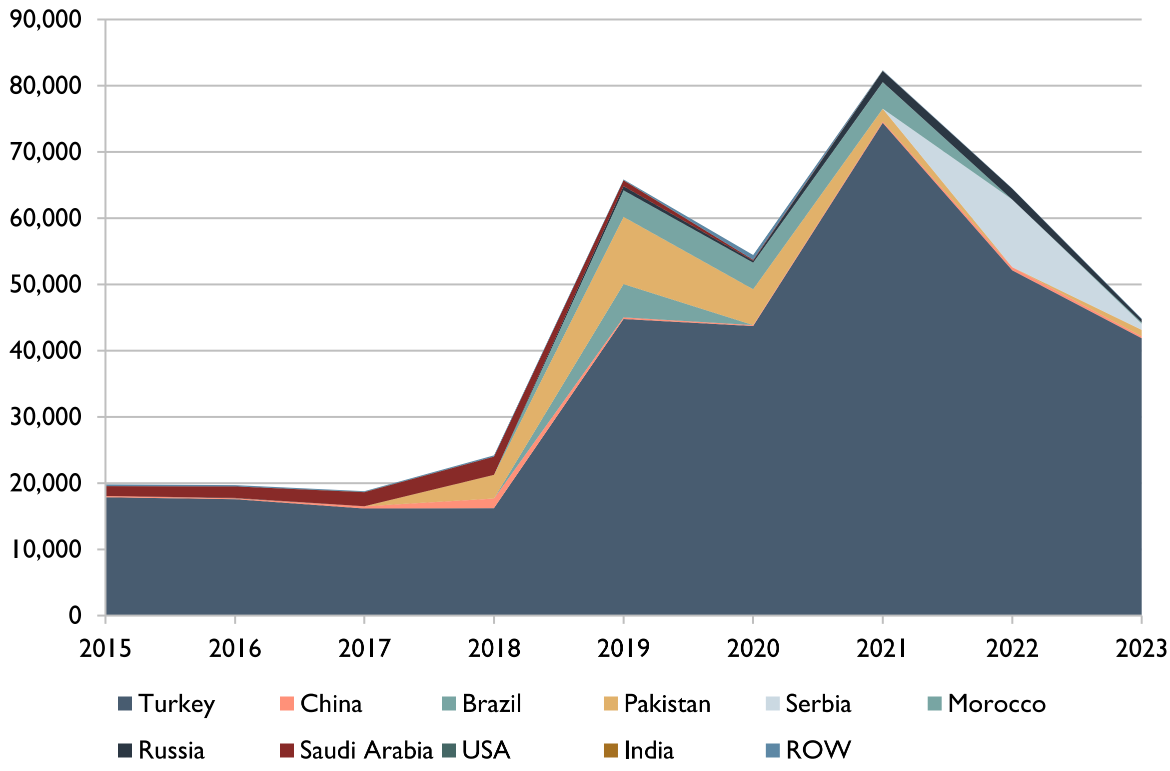
	2017	2018	2019	2020	2021	2022
Austria	730,482	808,239	691,909	816,370	844,226	771,043
Finland	63,850	49,601	37,002	136,167	179,781	324,226
Greece	442,680	425,882	358,841	335,943	393,715	393,287
Poland	101,920	102,110	91,490	65,250	65,820	66,380
Slovakia	975,100	1,053,900	1,015,800	787,476	781,600	592,900
Spain	788,991	738,994	634,580	626,055	703,834	676,699
Total	**3,103,023**	**3,178,726**	**2,829,622**	**2,767,261**	**2,968,976**	**2,824,535**

Source: World Mining Data

In Finland, there has been production of breunnerite since 2016, a form of magnesite associated with talc mineralisation. However, it is generally not recognised as a part of the magnesia supply chain in Europe. Breunnerite is a form of magnesium carbonate with a higher iron content where some magnesium atoms have been substituted by iron, and this iron content can range between 5 to 30%. This suggests that it is unsuitable as a magnesia feedstock, however, can be utilised as a lower quality flux in steel production. Magnesite exports from Finland have been recorded in recent years, with all trade data showing material flow to Russia. These exports have, however, dropped from 52kt in 2021 to 2kt in 2022, and no exports have been recorded since then.

Since 2021, imports of magnesite into the EU have mostly come from Turkey, but these only represent a very small amount of the regional magnesite processed into magnesia. In 2023, total imports were a mere 45kt, with Turkey's exports representing 93% of this total.

Figure 5: EU imports of magnesite 2015-2023 (t)



Source: GTT, Project Blue

2.2. Magnesium chloride

World synthetic magnesia capacity is estimated at 1.35Mtpy in 2023, concentrated in China, the USA, Japan, Mexico, and the Netherlands. China accounts for 500ktpy (37%) of global capacity, with North America at 400ktpy (30%). EU capacity represents 13% of the global total.

In Europe, magnesia from an underground brine feedstock is now solely produced in the Netherlands by Nedmag, following the closure of operations in Ireland and Norway.

The brine based magnesia is produced through solution mining, of the bischofite magnesium chloride and then a reaction with dolime (burnt dolomite), thus forming a magnesium hydroxide suspension which is dehydrated and calcined to produce CCM and/or sintered to produce DBM. The synthetic material generally has a higher purity at up to >99% MgO and can be produced with a tightly controlled chemical composition to improve strength and to optimise resistance to thermal shock and hydration. Nedmag's process in the Netherlands produces high grade DBM and CCM from bischofite magnesium chloride deposits in the Zechstein Sea.

3. Overview of global magnesia production

Over the last five years, the magnesia supply landscape has become more concentrated. There are now fewer primary refractory dead burned magnesia (DBM) and fused magnesia (FM) producers globally, particularly in Europe. For major producers, vertical integration is becoming increasingly important in the face of uncertain supply chains as countries compete for access to raw materials.

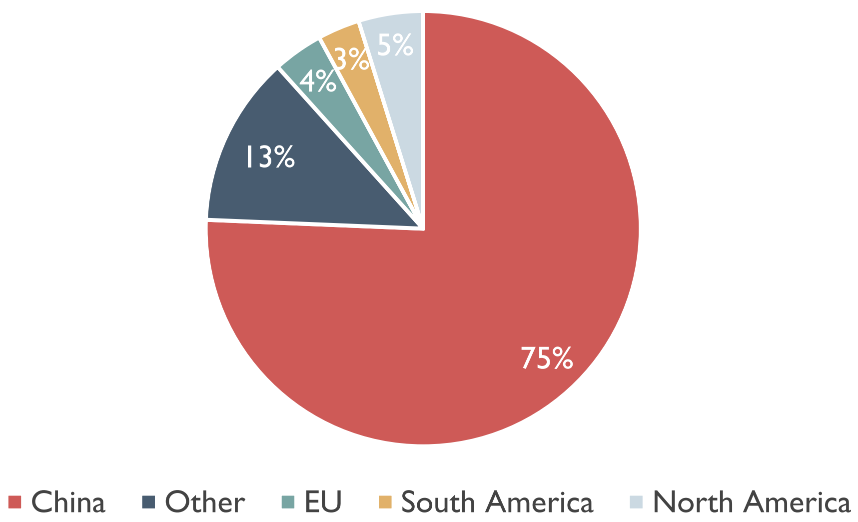
3.1. Capacity

The estimated world capacity for magnesia is 24Mt, of which 70% is based in China. The EU represents 7% of this with 1.7Mt of the total. These can be split into separate capacities related to the three different types of magnesia.

3.1.1. CCM Capacity

Global capacity for CCM is 10.5Mt, again dominated by China with a share of 75%, DBM capacity is 11.3Mt, 62% located in China and FM capacity is 2.3Mt with 82% based in China. It should be noted that ambiguity exists within these volume splits as small amounts of production are interchangeable between CCM and DBM, depending on market demand, while FM producers may switch between fused products. Despite this, one thing remains certain, China dominates global magnesia production.

Figure 6: Estimated world CCM capacity by region 2023 (%)

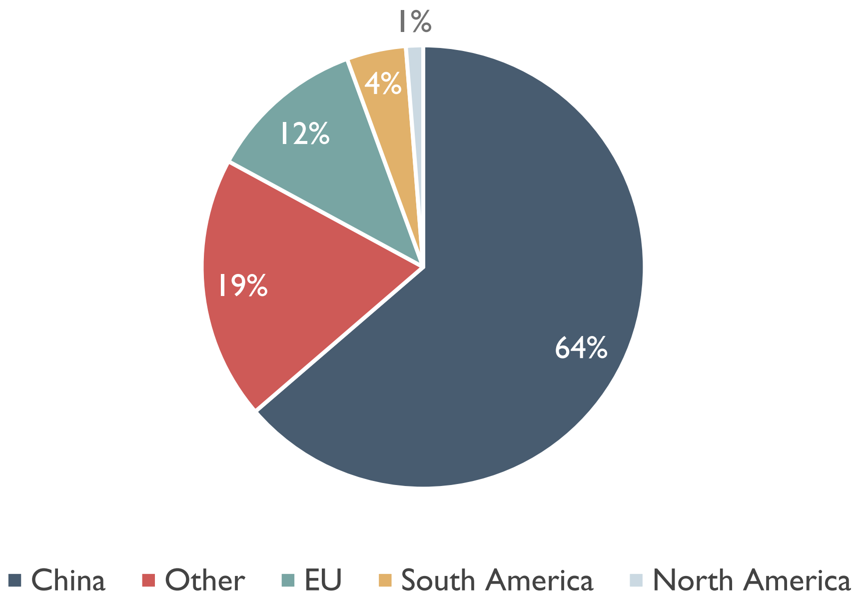


Source: Project Blue

3.1.2. DBM Capacity

The proportion of Chinese dominance for DBM is lower, due to meaningful capacity in Brazil (480kt), Turkey (765kt) and Russia (780kt). The capacity in the EU represents 11% of global DBM capacity, but production levels show it is not fully utilised. Within the EU, DBM production takes place in Austria, Greece, the Netherlands, Slovakia, and Spain.

Figure 7: Estimated world DBM capacity by region 2023 (%)

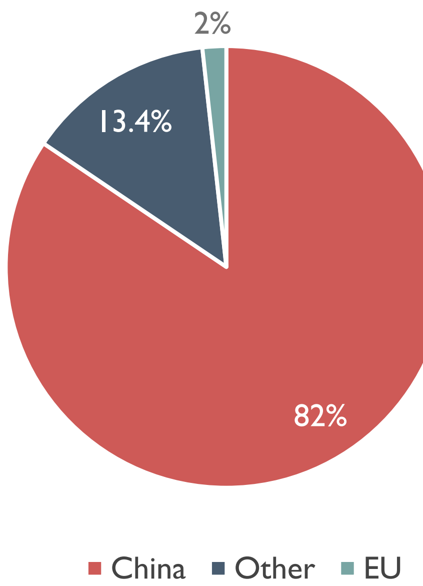


Source: Project Blue

3.1.3. FM Capacity

Most of the global FM capacity is in China, accounting for around 82% in 2023. Other significant capacity is in Russia, South Korea, and Turkey. The FM plant in the UK is included in the EU capacity, the other two FM producers in the EU include Austria and Poland.

Figure 8: Estimated world FM capacity by region 2023 (%)



Source: Project Blue
Note: UK capacity included in the EU total

3.1.4. European capacity

European magnesia capacity is listed in the accompanying table and totals roughly 1600kt. Between 2018 and 2023 there has been a decrease in DBM and FM capacity in the EU and a slight decrease in CCM capacity of around 60ktpy. Capacity is stable for fused magnesia, but output today is much lower.

Table 2: European magnesia production capacities 2023 (kt)

Country	Company	Asset	CCM	DBM	FM
Austria	RHI Magnesita	Radenthein	45		20
Austria	RHI Magnesita	Breitenau	20	220	
Austria	RHI Magnesita	Hochfilzen		140	
Austria	Styromag	Oberdorf	32		
Greece	Grecian Magnesite	Yerakini; Chalkidiki	95	85	
Greece	Ternamag	Mantoudi	60	60	
Netherlands	Nedmag	Veendam	15	160	
Poland	Magnezyty Grochow	Braszowice	10		
Poland	ZM Ropezyce (ZMR)	Ropczyce			6.5
Slovakia	SMZ	Jelšava; Bočiar	40	260	
Slovakia	Magnezit Group (Slovmag)	Lubenik		45	
Spain	Magnesitas Navarras	Eugui, Borobia	65	150	
Spain	Magnesitas De Rubian	Monte Castelo	85		
UK	NICHE	Hull			12

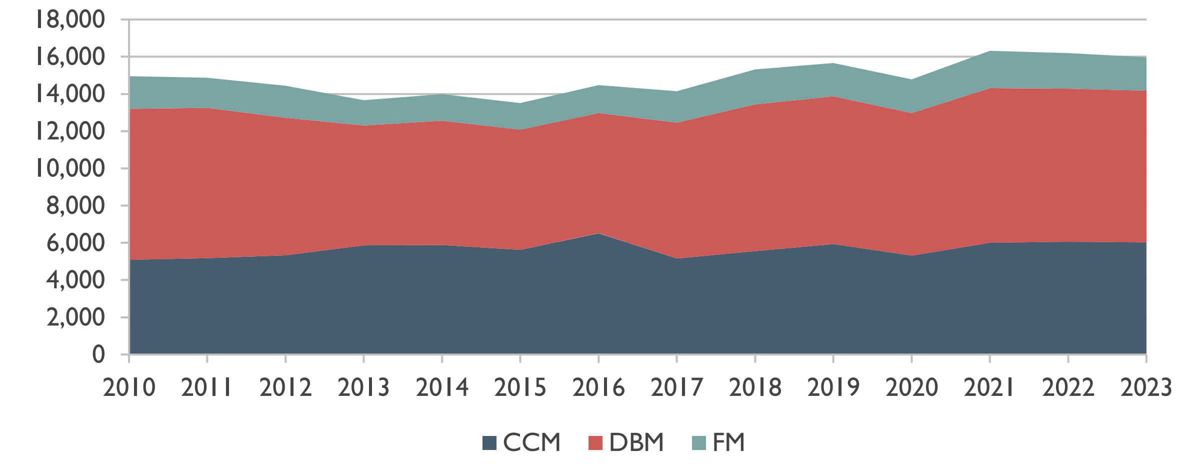
Source: Project Blue, company information, press reports

3.2. Production

Global magnesia production is estimated to be 16Mt in 2023 (Figure 9), illustrating the relative production of DBM, CCM and FM. Exact production levels are not published anywhere, as a high proportion is consumed captively in refractory operations. Furthermore, a risk of double counting exists owing to the conversion of CCM to DBM or FM. The figures from Project Blue are compiled from demand usage, capacities and known production where it has been published. World production is significantly lower than capacity primarily related to low operating rates in China, as well as in North Korea, Russia, and India.

In terms of the overall split, DBM production is estimated at 8.2Mt (51%), CCM at 6.0Mt (38%) and FM the remaining balance of 1.8Mt (11%) in 2023. DBM and FM are collectively known as the refractory magnesias, as a high proportion of global output is destined for this application.

Figure 9: Total magnesia production by type 2010-2023 (kt)

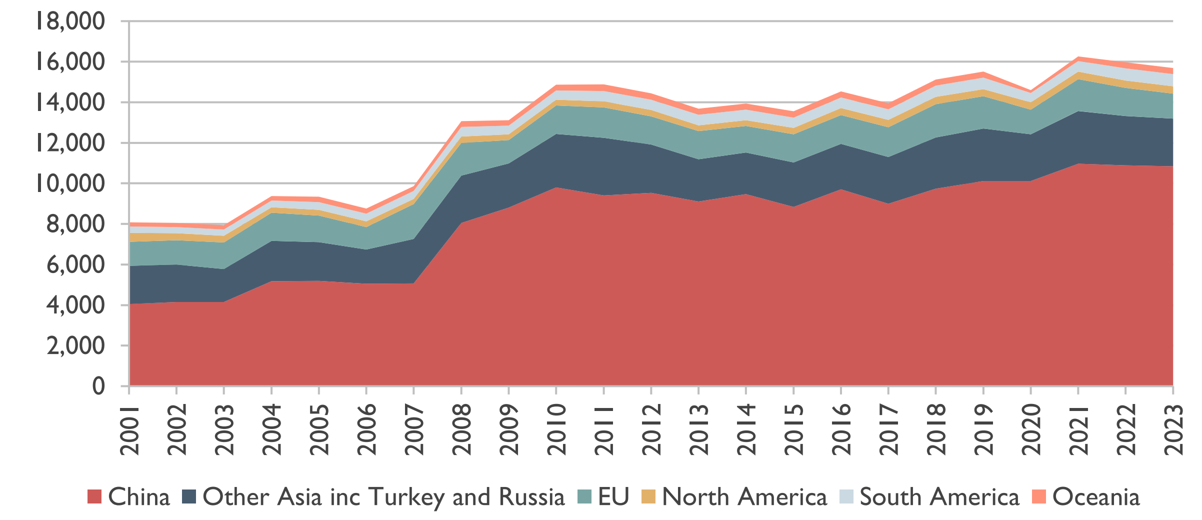


Source: Project Blue

China leads the world in global magnesia production and has built its capacity and increased its production share over the last twenty years (Figure 10). Magnesia production in China was 10.8Mt in 2023, up from 4.2Mt in 2001. This has mainly been driven by China's ability to leverage abundant magnesite reserves, lower labour and energy costs, mineral extraction incentives, and technological developments to maintain low production costs. This growth can also be linked to the implementation of aggressive export strategies that generated rest-of-world market dependence. These factors have increased China's global production share from approximately 47% in 2001 to 68% in 2023 (Figure 11). Magnesia production was further stimulated by the rapid growth of the Chinese steel industry which saw domestic demand for refractory products increase.

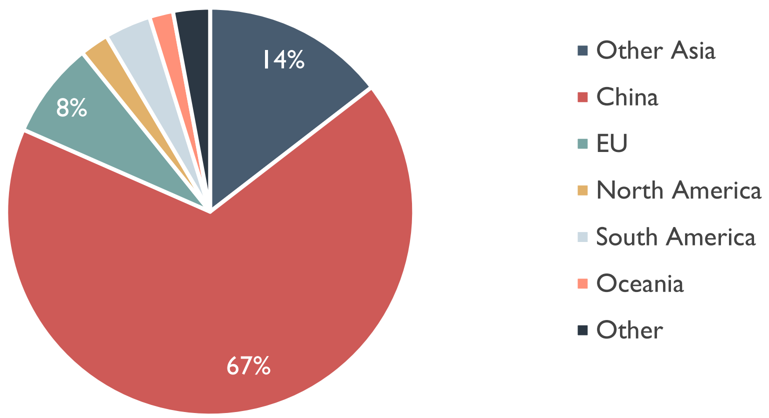
After Other Asia, which includes Russia and Turkey, the EU represents the third largest global magnesia-producing region, accounting for 7% of the magnesia production in 2023, down from 18% in 2008. This decline in production share is mostly related to the limited expansion of the magnesia industry in Europe over the last 20 years, relative to the rapid capacity growth in China, in addition to European plant closures.

Figure 10: Global magnesia production by region (kt) 2001-2023



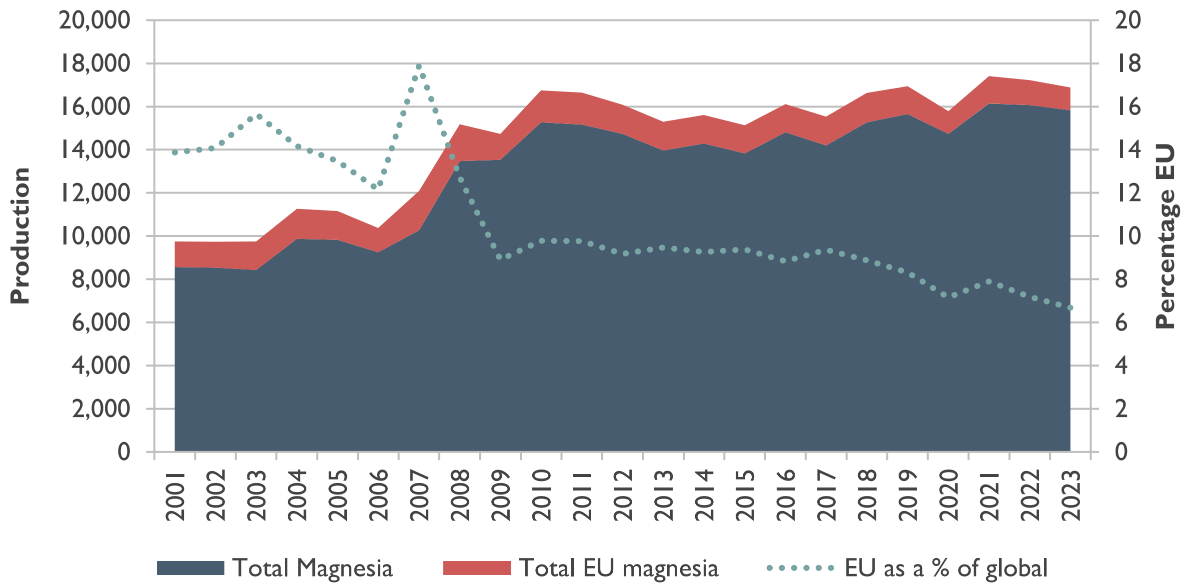
Source: Project Blue

Figure 11: Global Magnesia Production 2023 (%)



Source: Project Blue
Note: Other Asia includes Russia and Turkey

Figure 12: EU magnesia production vs world (kt) and percentage share

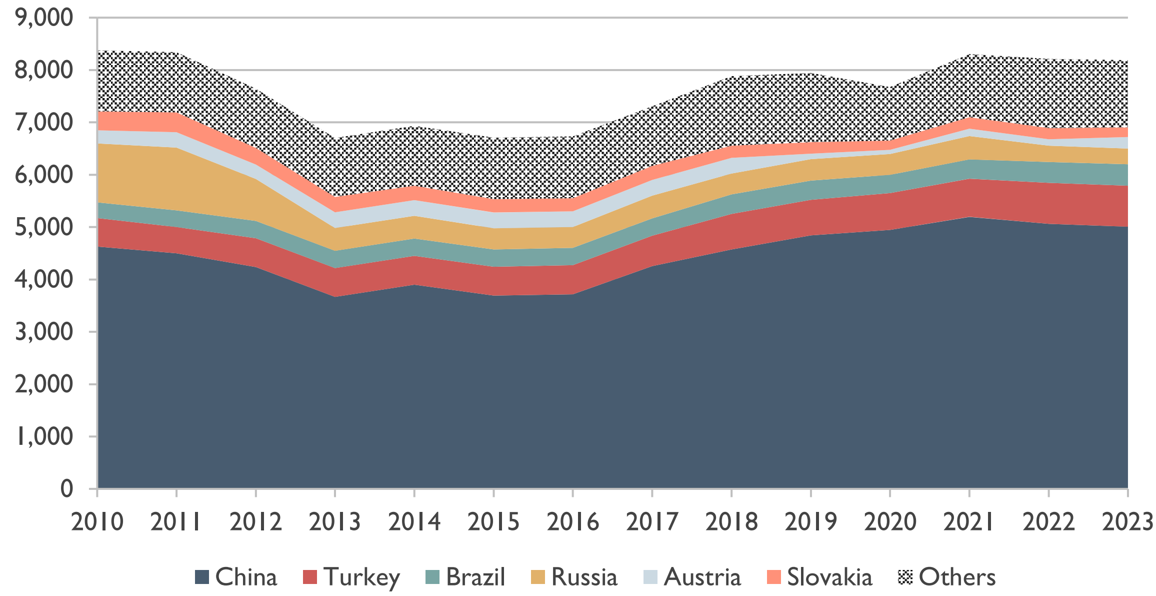


Source: *Project Blue*

3.2.1. DBM production

DBM accounts for 46% of nameplate global magnesia capacity. Low grade DBM is used to produce monolithics and refractory masses. Supply is sourced from natural magnesite deposits in China, Brazil, Slovakia, Austria, and Russia. Supply of high-grade DBM for higher performance refractories is more limited. Leading producers include Greece, Turkey, and Australia, where output is based on cryptocrystalline magnesite deposits, while production in the Netherlands, Japan, Mexico and the USA is based on brine or seawater sources. In Addition, high grade DBM is produced in Brazil based on macrocrystalline magnesite in combination with flotation to purify the ore. High grade DBM can usually not be produced from macrocrystalline magnesite without expensive grinding and flotation stages. However, Chinese capacity for high grade magnesia has increased dramatically in recent years following strategic investments towards the construction of flotation plants with capabilities to upgrade low grade magnesite raw materials, to meet the growing Chinese demand for the material.

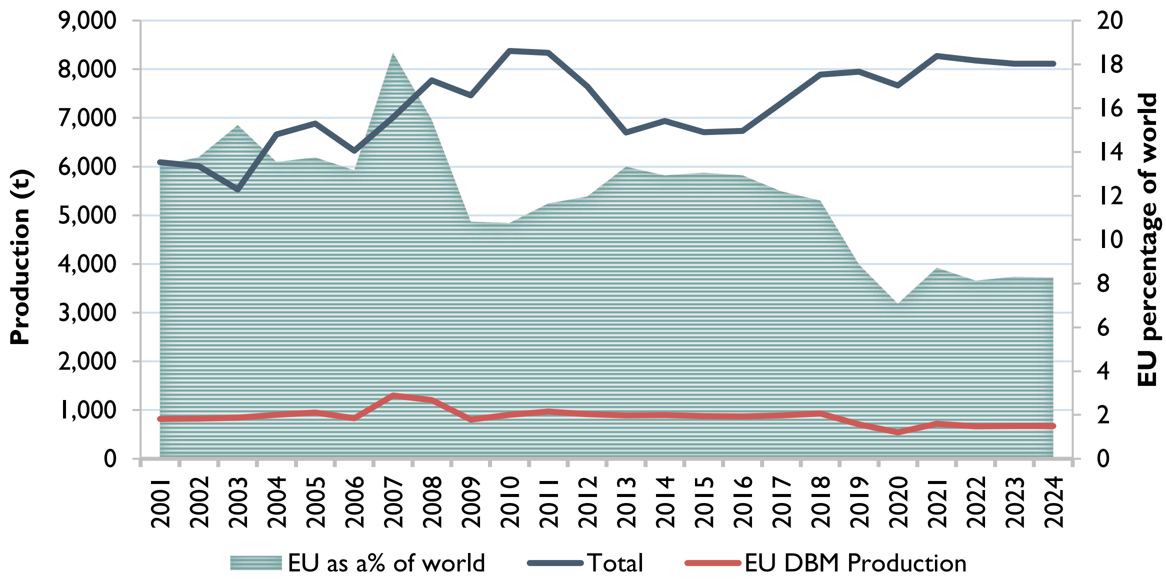
Figure 13: Global DBM production (kt MgO equivalent)



Source: Project Blue

EU DBM production against world production is shown in Figure 14, which shows the declining share of global production of DBM of the EU producers especially since 2013-2014.

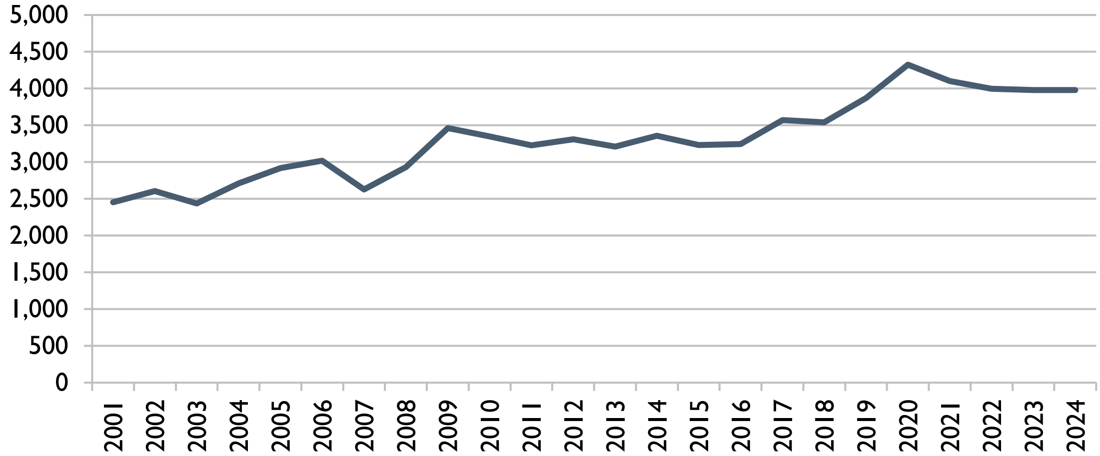
Figure 14: EU DBM production and EU percentage share of global production



Source: Project Blue

The HHI graph for DBM shows that there has always been high levels of concentration of supply in the industry by country, but that it has also increased over the last twenty years from 2,437 in 2003 to 3,980 in 2023.

Figure 15: HHI for DBM by country 2001-2024

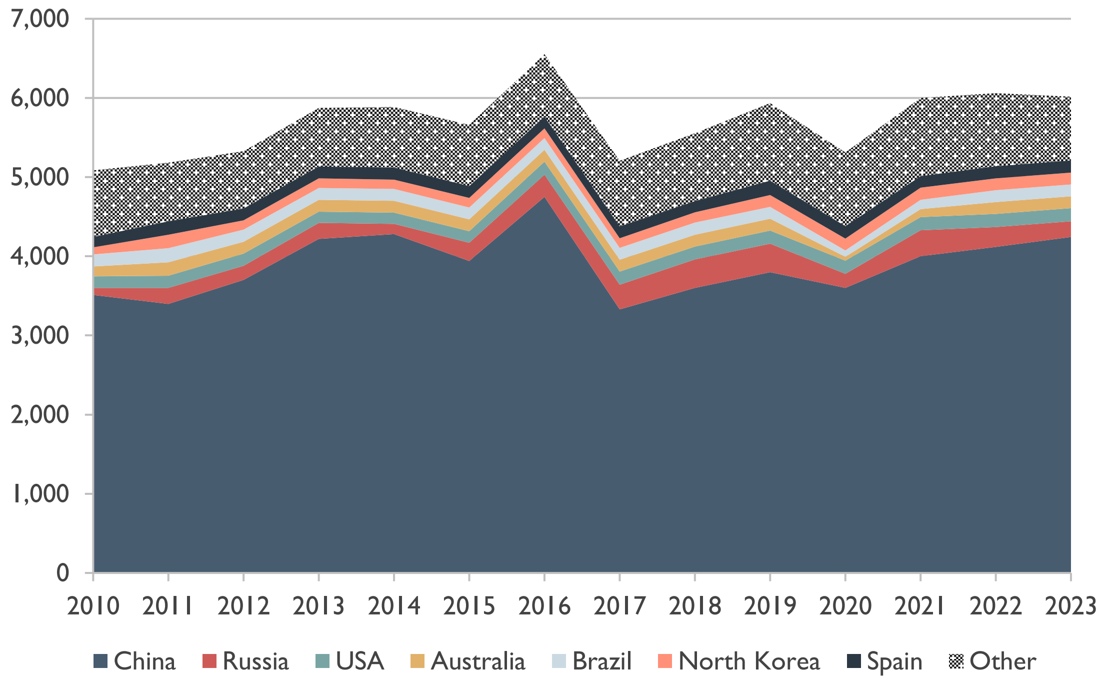


Source: Project Blue

3.2.2. CCM production

Global CCM production and exports are also dominated by Chinese activity. China is the largest producer of CCM (Figure 16), accounting for about 70% of global production. Other leading producers are Brazil, Greece, Spain, Turkey, Iran, Russia and Australia, mainly sourced from magnesite deposits and mixed matrix membranes (MMMs) in the USA which processes well brine raw materials.

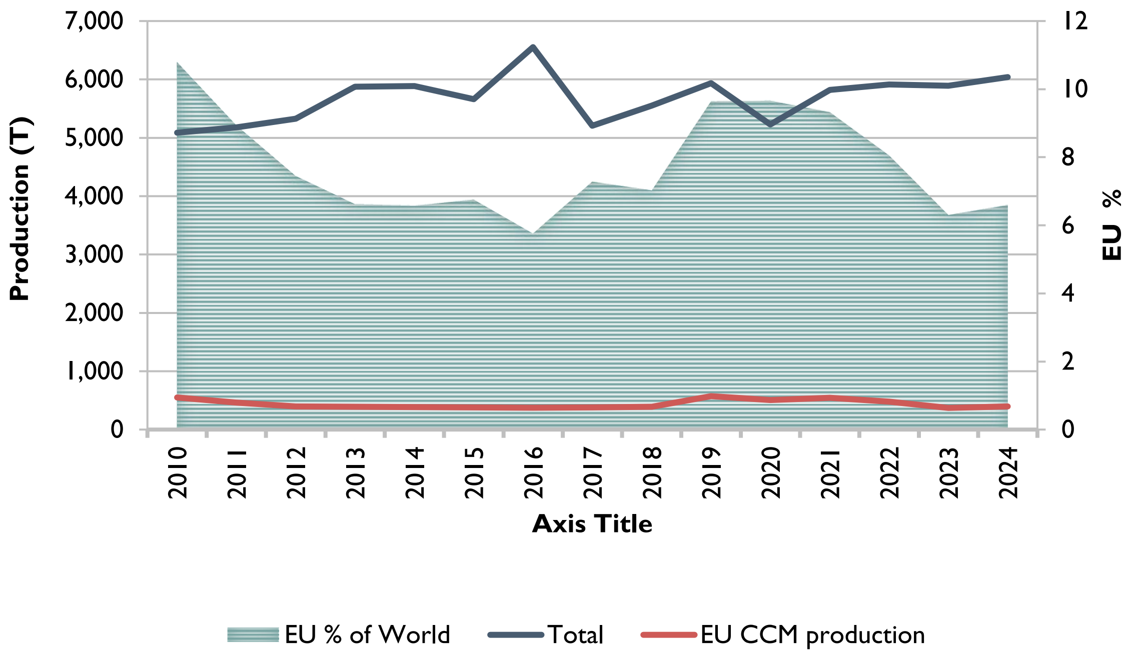
Figure 16: Global CCM production (kt MgO equivalent)



Source: Project Blue

Figure 17 shows the proportion of EU CCM production against the world total, and the percentage of EU production which ranges from 6% up to 10%, only reaching a peak when Chinese supply was curtailed owing to environmental inspections.

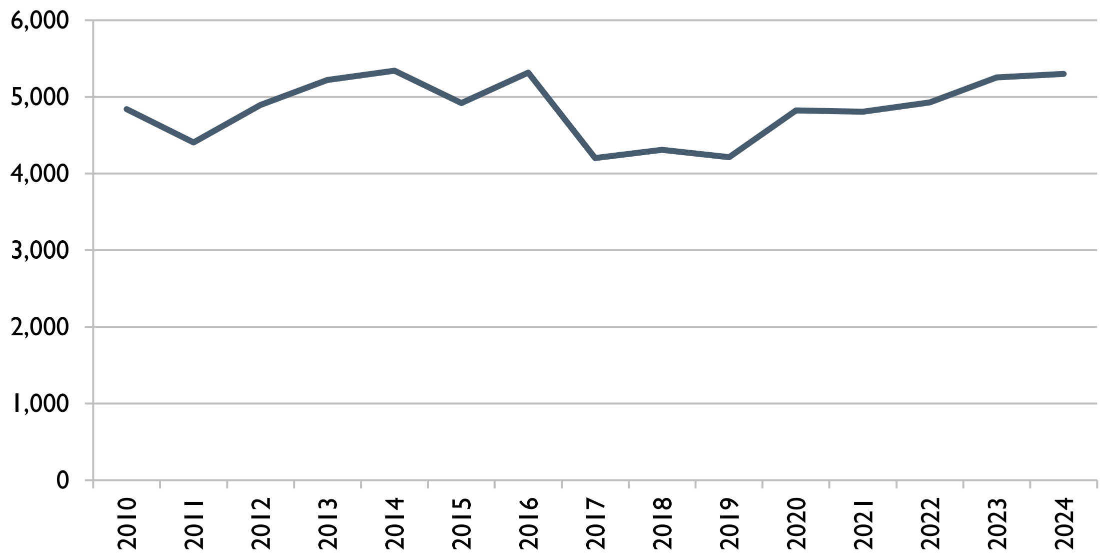
Figure 17: EU CCM production vs world total and EU %



Source: Project Blue

The HHI for CCM is stark with a concentration of factor of over 5,000 in 2024, and consistently between 4,000 and 5,340 over the last ten years.

Figure 18: HHI for global CCM industry 2010-2024

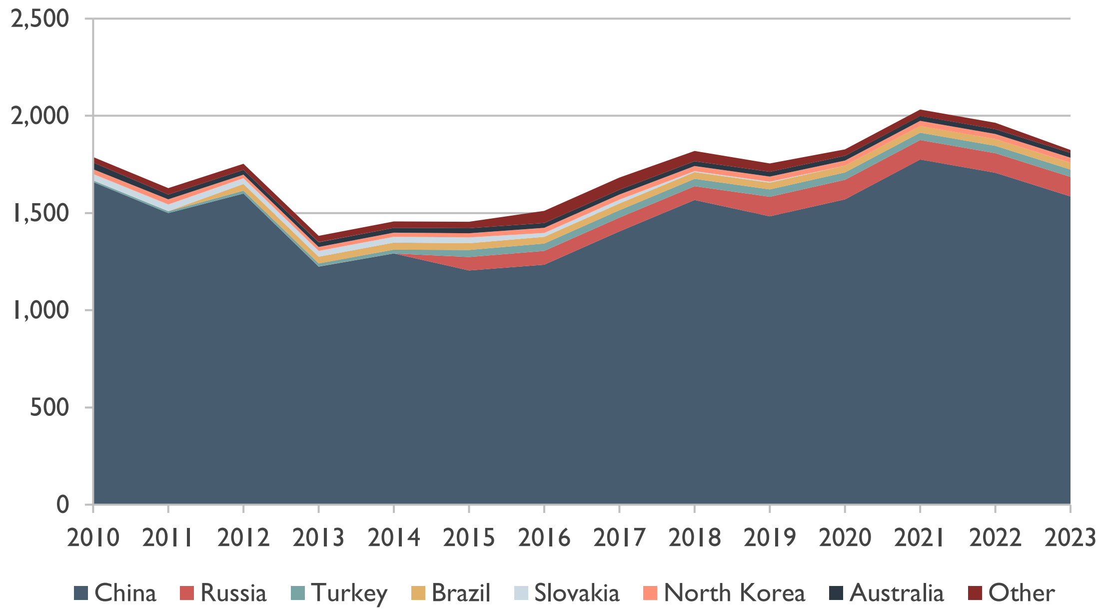


Source: Project Blue

3.2.3. FM production

FM production based on magnesite is concentrated in China and to a much smaller extent, Russia ( ). Synthetic FM is produced in Japan, South Korea, and Mexico. The entry of South Korea into the marketplace in 2019 was in response to a shortage in the supply of Chinese materials.

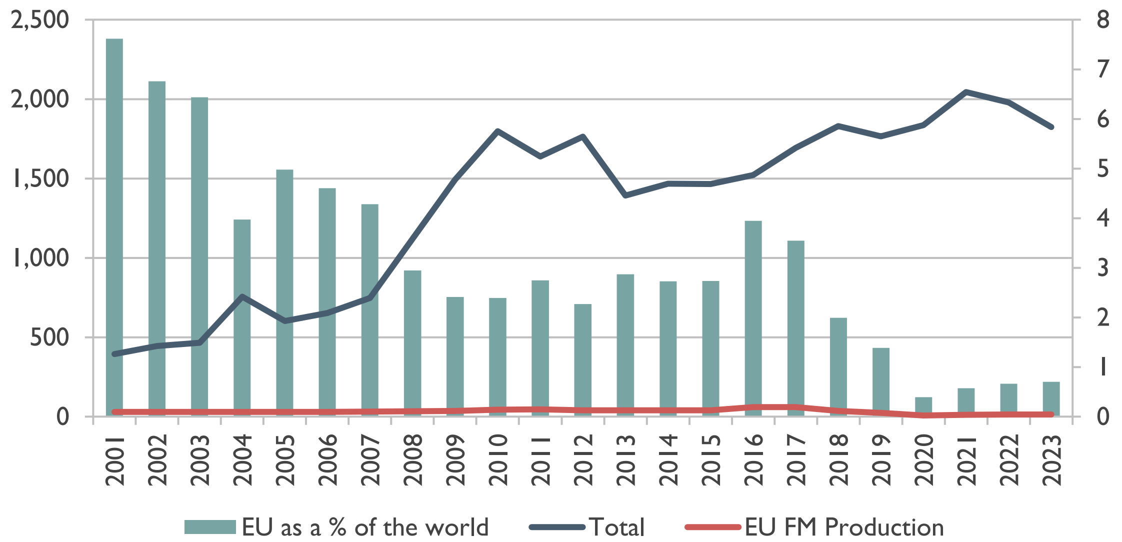
Figure 19: Global FM production (kt MgO equivalent)



Source: Project Blue

shows EU FM production compared with global production. The growth in FM production in China has eclipsed the European industry and in 2023 EU FM production represents under 1% of global production, and has done so for the last 5 years.

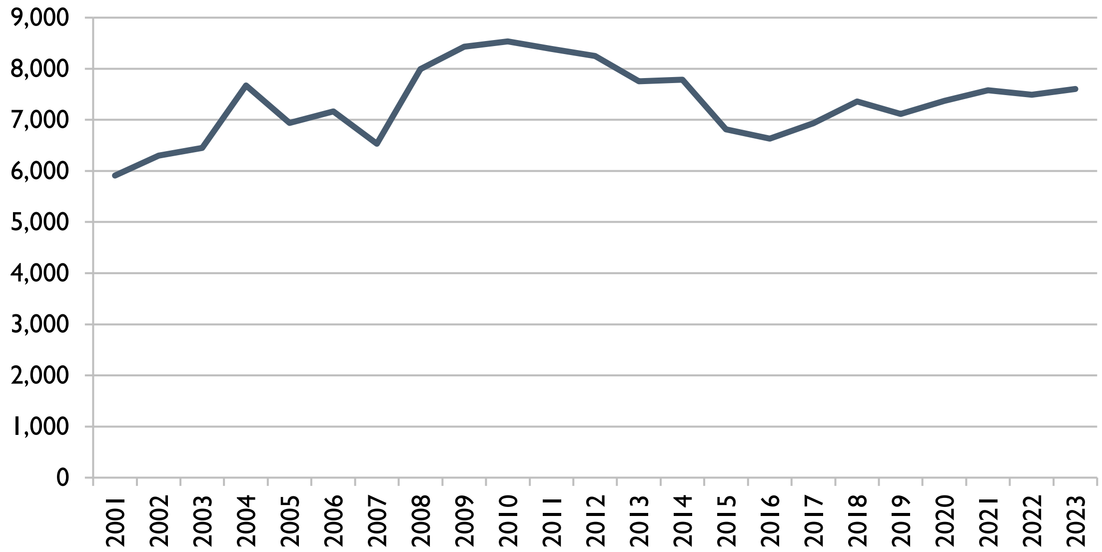
Figure 20: EU FM supply and global output, plotted against % EU share



Source: Project Blue

The HHI for FM is revealing, increasing from 5,911 in 2001 to 7,605 in 2023 indicating a heavily concentrated industry in terms of the majority of production being held in a dominant country.

Figure 21: HHI for FM 2001-2023



Source: Project Blue

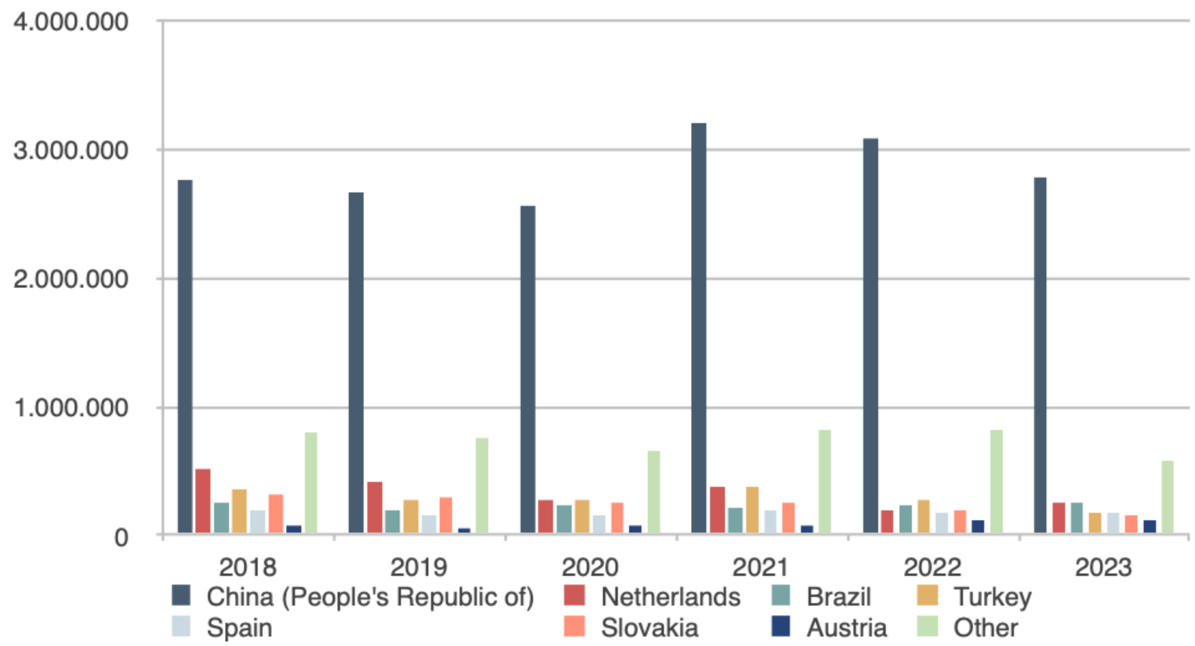
4. Global supply routes for magnesia

Magnesia is an internationally traded commodity, and world trade was 4.5Mt in 2023, lower than 5.1Mt in 2022 mainly due to lower supply from China, Turkey, and Slovakia. Magnesia exports are concentrated among relatively few suppliers. In 2023, China exported 2.7Mt of magnesia products, representing 17% of global production and 62% of the world's international trade flows. Seven further countries, all with exports over 100,000t collectively represented another 28% of global trade.

The main trade flows for Chinese magnesia supply are to Asia - Japan, India, South Korea, and Taiwan – and the USA. In Europe, the Netherlands is the main entry point. Other major trade routes are from the Netherlands to Germany, from Turkey to Austria and Germany, and from Brazil to the Netherlands and the USA. Within Europe, there are smaller trade flows from Spain to France and Slovakia to Germany.

Magnesia exports from North Korea, primarily to China, averaged 150kt between 2013 and 2017, but dropped to 33kt in 2018 and ceased in 2019 following the implementation of international sanctions on magnesia exports.

Figure 22: Global trade in magnesia: Leading countries (t) 2018-2023



Source: Global Trade Tracker

Table 3: Chinese exports of magnesia by type (t) 2018-2023

	2018	2019	2020	2021	2022	2023
CCM	747,072	794,111	819,632	881,167	937,521	854,103
DBM	989,230	1,011,204	897,037	1,239,618	1,126,552	1,078,144
FM	523,922	365,800	375,099	615,473	564,612	446,530
Total	2,260,224	2,171,115	2,091,768	2,736,258	2,628,685	2,378,777

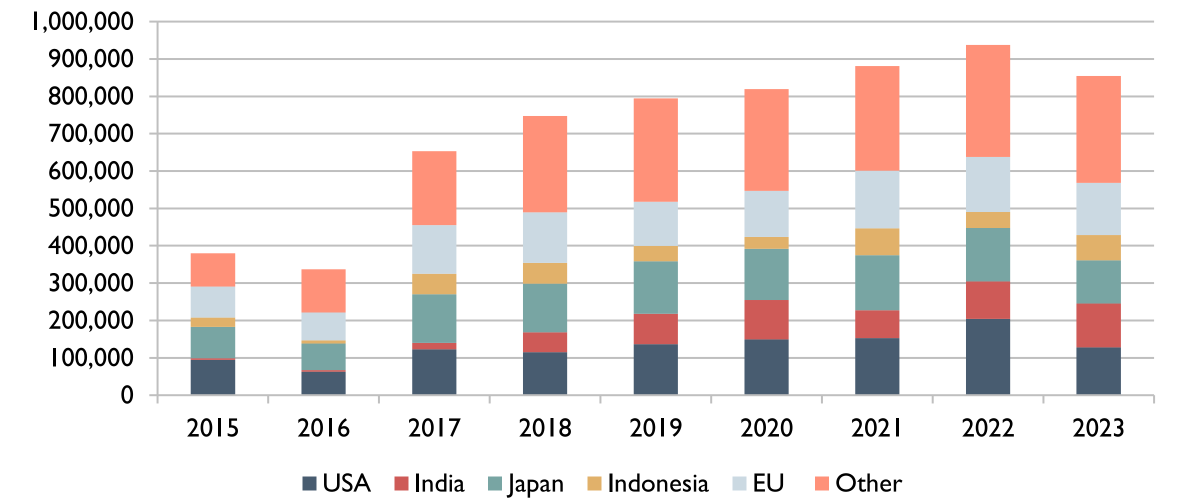
Source: Global Trade Tracker (GTT), Project Blue
Note: total also includes low grade material used in steel fluxing

4.1. CCM trade

Most CCM supply is consumed domestically, but around 1.53Mt, or 25% of global production, was exported in 2023. Export volumes have declined over the last five years, from 1.87Mt in 2018. Chinese exports have significantly increased since 2016 (Figure 23), growing from 330kt in 2016 to 854kt in 2023, peaking in 2022 at 930kt. In 2023, Chinese exports of CCM now represent 55% of global trade, up from 40% in 2018.

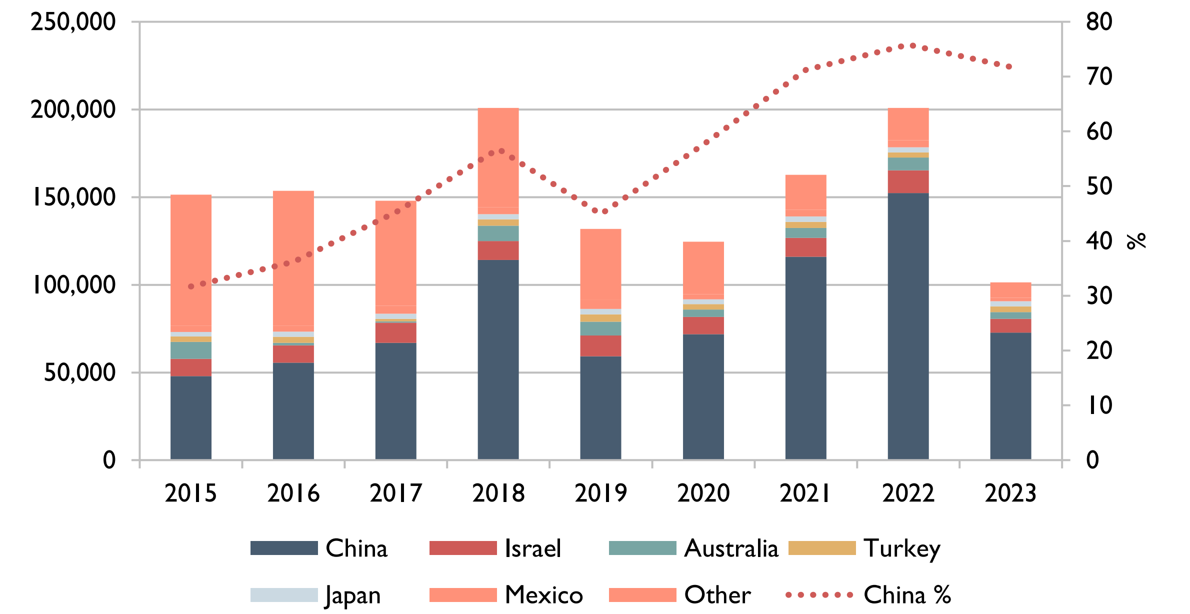
EU imports of CCM have remained relatively stable at around 150kt, peaking in 2022 at 200kt. More significantly, the increase of Chinese imports into Europe has increased to more than 70% by 2023 (, from roughly 30% in 2015.

Figure 23: Chinese CCM exports 2015-2023 (t)



Source: Global Trade Tracker (GTT)

Figure 24: EU CCM imports 2015-2023 (t)



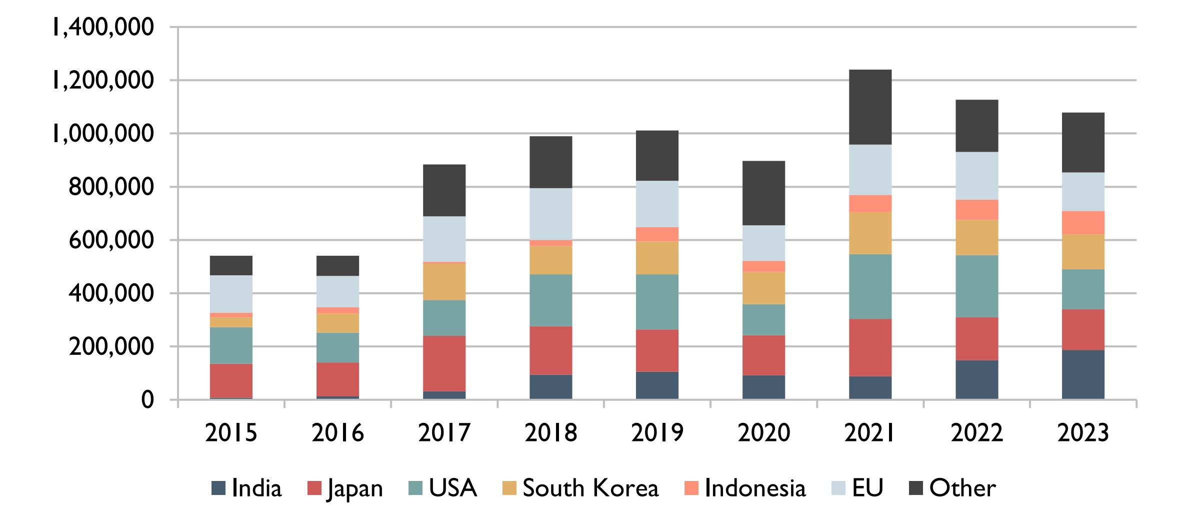
Source: Global Trade Tracker (GTT)

4.2. DBM trade

Chinese exports of DBM have grown from 54kt in 2015 to 1.2Mt in 2021, before declining slightly in 2022 and 2023, but still over 1Mt. Trade in DBM is difficult to quantify as some countries do not distinguish between different forms of refractory magnesia in trade data, classification of various types of magnesia can vary between countries, and DBM is classified under different tariff numbers. The picture has been built up with the knowledge of producers and main consuming industries as well as using partner country records.

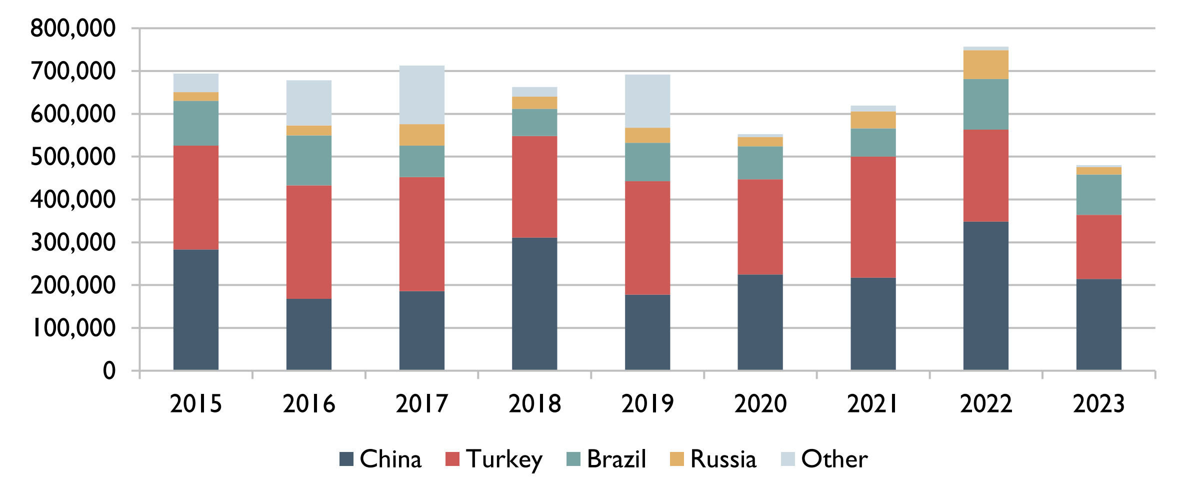
European imports of DBM are shown to be dominated by China, Turkey, and Brazil, which accounted for roughly 458kt in 2023, with a peak in 2022 of 681kt. This represents a total of 94% of imports into the EU, with China accounting for 44%, Turkey accounting for 31%, and Brazil accounting for 19%. Additionally, this dominance has grown over the last 5 years, with other producers such as Russia decreasing exports to the EU, although this is also due to sanctions in place because of the ongoing Russia-Ukraine war.

Figure 25: Chinese DMB exports to all countries 2015-2023 (t)



Source: Global Trade Tracker

Figure 26: EU DBM imports* 2015-2023 (t)

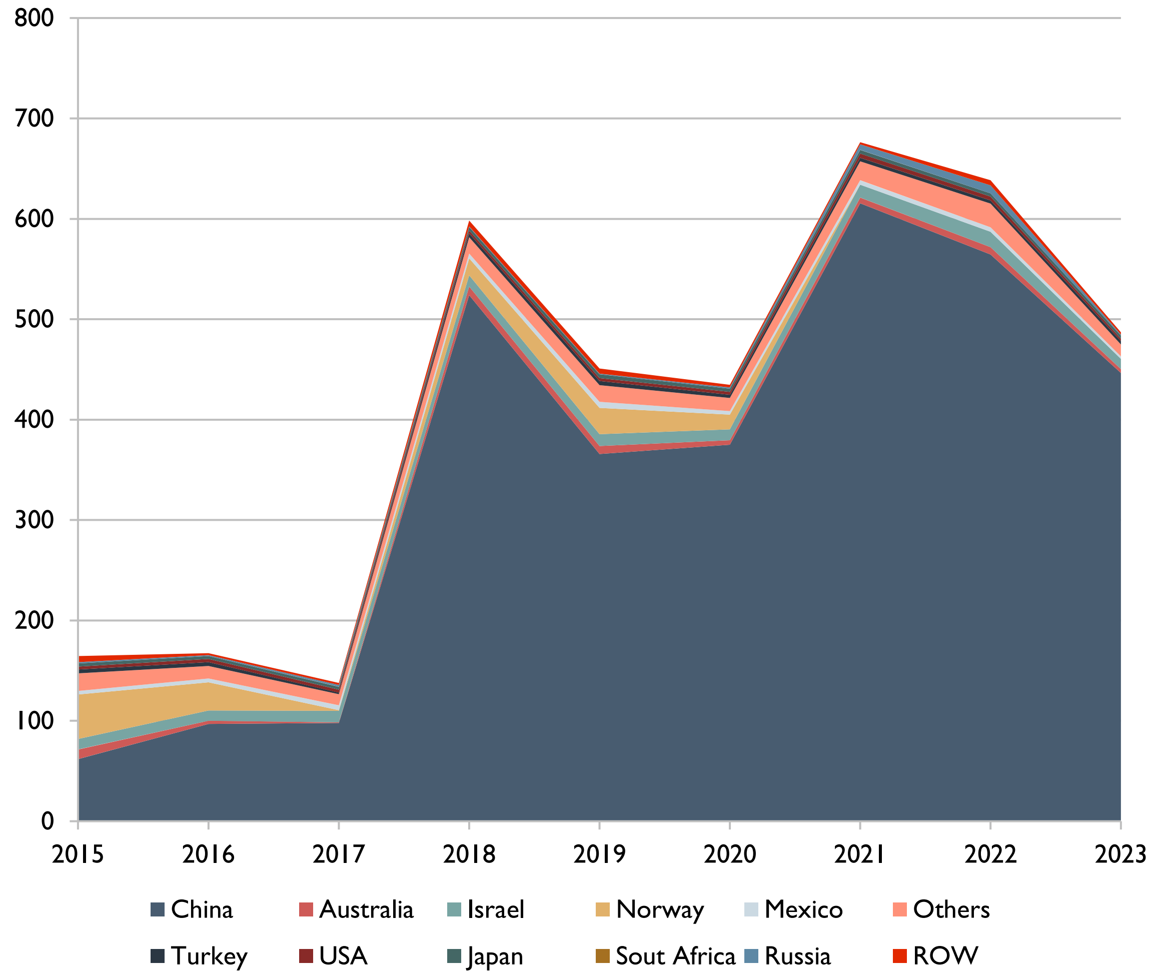


Source: Global Trade Tracker Note: Imports from outside the -EU. Excludes Intra-EU trade

4.3. FM trade

Recorded world exports of FM was 487kt in 2023, representing 27% of global production. This is down 28% from 676kt in 2021, although still higher than 2019-2020. Like CCM and DBM, China is by far the most important supplier to the world trade in FM – but in this case represents 92% of world exports in 2023 (Figure 27).

Figure 27: World exports of FM 2015-2023 (t)

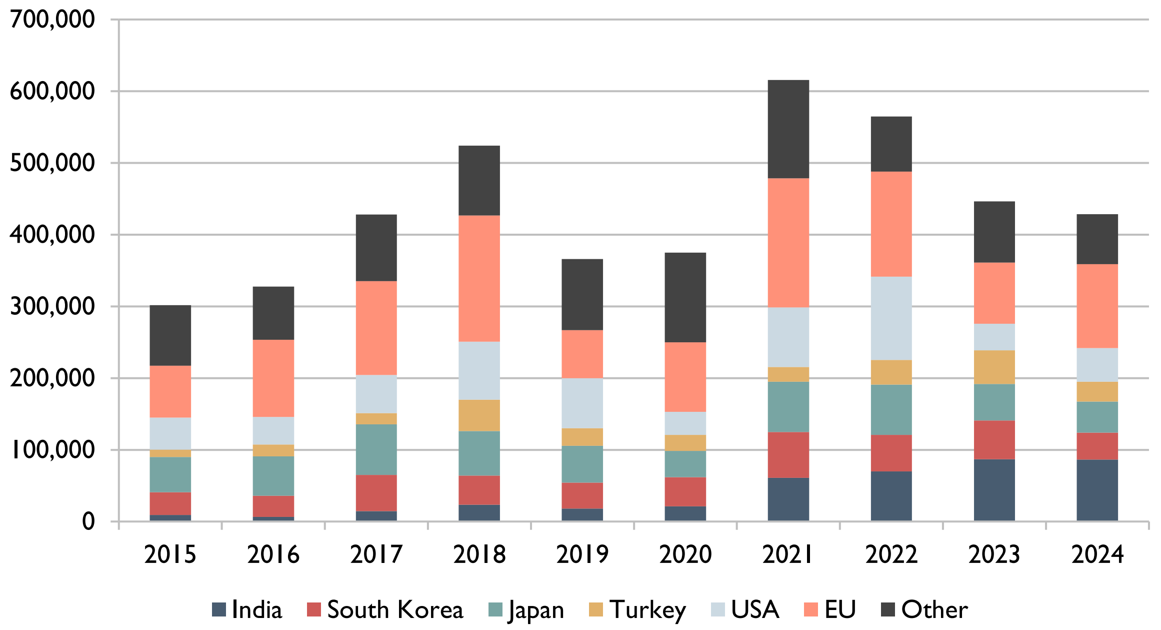


Source: Global Trade Tracker

Chinese export volumes of FM have fallen since 2021, from 615kt to 447kt in 2023 (Figure 27). However, this is a recent phenomenon, masking the overall trend of rising exports that have steadily grown over the last decade from 302kt in 2013 at the expense of capacity closures in other parts of the world such as Norway.

The downturn in 2019 was specifically related to FM feedstock constraints rather than demand, as restrictions on domestic magnesite mining resulted in a shortage of high-grade raw materials required for FM production.

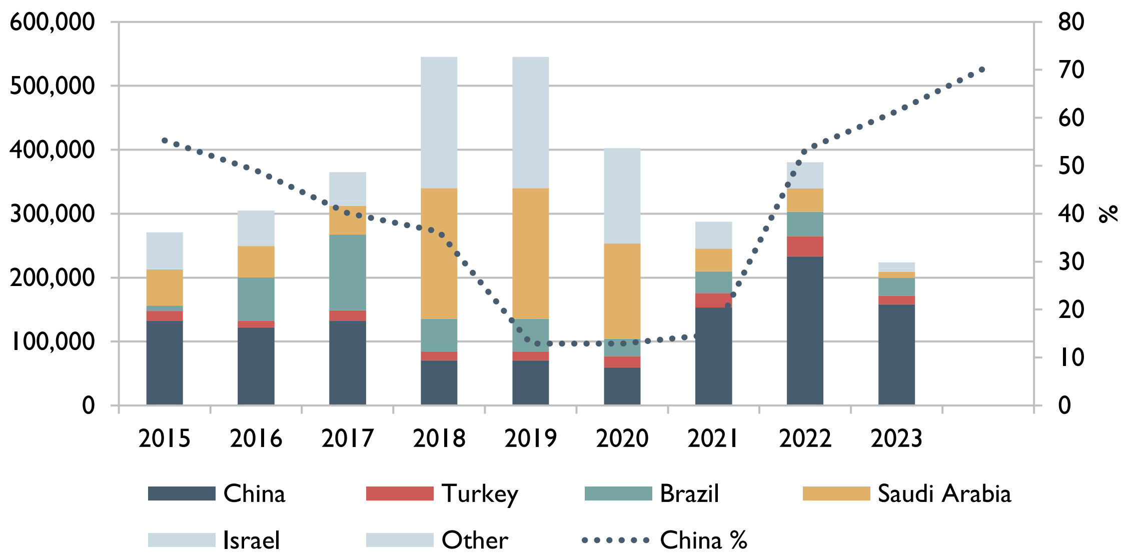
Figure 28: Chinese FM exports 2015-2023 (t)



Source: *Global Trade Tracker*

The EU FM import landscape has changed significantly over the last decade. Despite ongoing Chinese imports over this period, The EU imported quantities from Brazil throughout 2016 and 2017, which were then replaced by large imports from Saudi Arabia over the period 2018 to 2020. However, since 2020, imports from Brazil, Saudi Arabia, and other countries have declined, giving way to increased Chinese FM imports. China's share of EU imports has grown from roughly 50% in 2015 to 70% in 2023, whereas between the period 2018 to 2020, this share shrank to about 20%, related to feedstock constraints in China.

Figure 29: EU Imports of FM by country 2015-2023 (t)



Source: *Global Trade Tracker*

5. Magnesia prices

Magnesia is not an exchange-traded product, nor are any of its raw materials. Most sales are conducted under long-term contracts between producers, traders and consumers. A small proportion is traded on a spot basis, typically in the form of one-off lots or parcels.

Long-term contract prices are generally not disclosed publicly by industry participants but can be inferred by the average values of imports and exports of magnesia. Price reporting agencies such as Asian Metal report on spot transactions in the marketplace, which theoretically reflects the marginal price at a given point in time.

China's dominant position in the world magnesia supply means that Chinese producers effectively set world prices for magnesite-based products, though not synthetic ones. Chinese pricing is affected by several internal factors in addition to the prevailing global market balance for magnesia. Over the past five years, these factors have included:

- rising production costs associated with higher energy, labour, freight and environmental compliance costs
- depletion of high-grade reserves
- disruption of magnesite supply due to the suspension of mining while inspections or rectification work was undertaken.

Chinese export licences and quotas were removed at the beginning of 2017 following cases filed with the World Trade Organisation by the USA and the EU against the export duties. Prior to the removal of the license and quota system, export duties of 5% on CCM and 10% on DBM and FM were levied, while producers had to bid for export tonnages under the licence system.

This system led to price rises and price instability as producers bid competitively to win licences, while illegal trading to avoid payments was also reportedly taking place. When these trade barriers were removed, prices collapsed due to oversupply. Then, closures to meet environmental regulations resulted in supply curtailments, lifting prices to record levels. In mid-2018 the Chinese 97% DBM increased to US$1,225/t compared to a historical average price of roughly US$525/t.

Since 2018, intermittent supply restrictions and resulting price fluctuations have been driven by the actions of the Liaoning Provincial government, either through rationalisation and closures or as an effect of pollution reforms, especially air pollution.

5.1. CCM prices

The Chinese export price also represents the benchmark for many CCM products, especially the commodity grades used in agriculture. Over the last five years pricing levels have fluctuated (Figure 30), similarly peaking at the end of 2018 as demand exceeded supply, before falling. The introduction of Chinese environmental inspections and air pollution regulations led to tightening supply and rising prices before these higher price levels encouraged new capacity into the market, and prices began to fall again. In late 2020, and early 2021, prices reached US$165/t as Chinese operating rates were reduced.

CCM prices tend to follow similar trends as refractory magnesia prices due to producer costs, but with more moderate fluctuations as agriculture, food, health, and environmental markets are slightly less sensitive to economic trends.

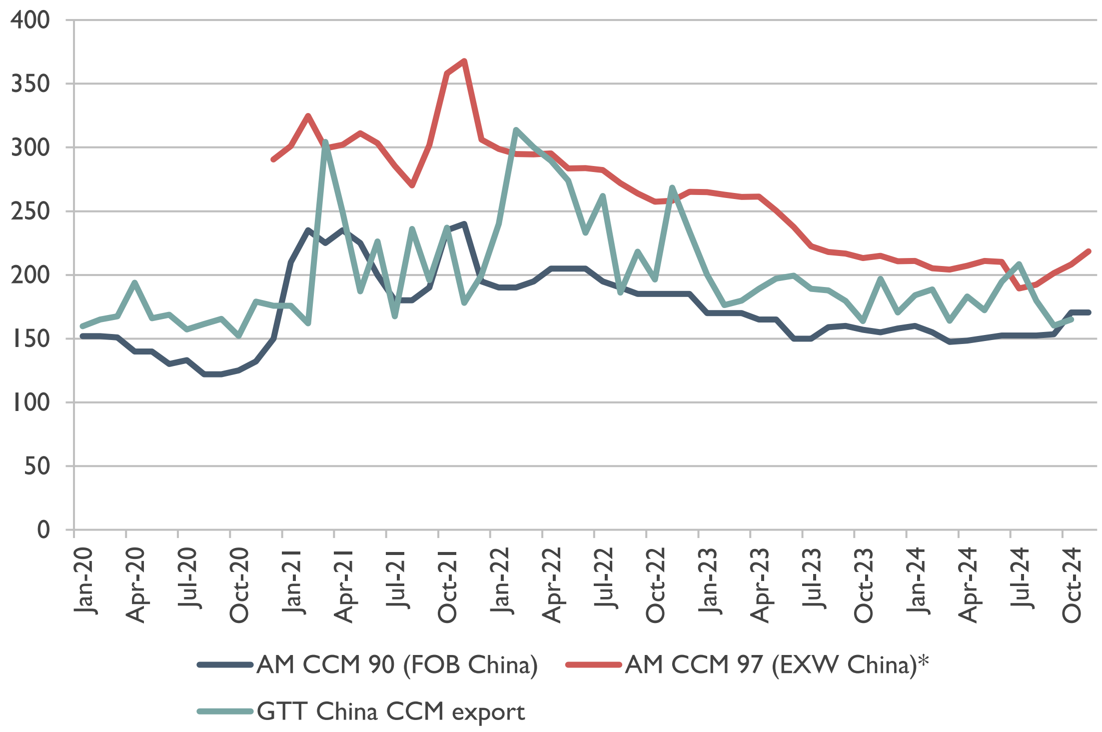
In Europe, CCM prices have been negatively affected from two fronts – both from consumers' ability to pay, and by lower priced imports.

The growing dominance of supermarkets and therefore retailer pricing power has resulted in the average price paid to farmers in the EU for products such as meat and milk in 2023 declining by 6.5% compared with 2022. Some countries saw an even more pronounced drop in prices, for example, Germany and the Netherlands, where prices declined by 14% and 18%, respectively.

Imported CCM into the EU, including Chinese, Brazilian and Turkish material, continues toput downward pressure on prices as well. It should be noted that even Turkish suppliers are also struggling to compete with Chinese CCM prices due to high energy costs.

Figure 30 shows the premium of the higher grade 97% MgO CCM over 90% MgO CCM, which has narrowed as prices receded over the last three years. However, Chinese 90% MgO CCM FOB prices have fluctuated between US$150-170/t over the last year, which are the main grades used in agriculture. The higher priced material is used in industrial markets.

Figure 30: China: CCM pricing (US$/t)



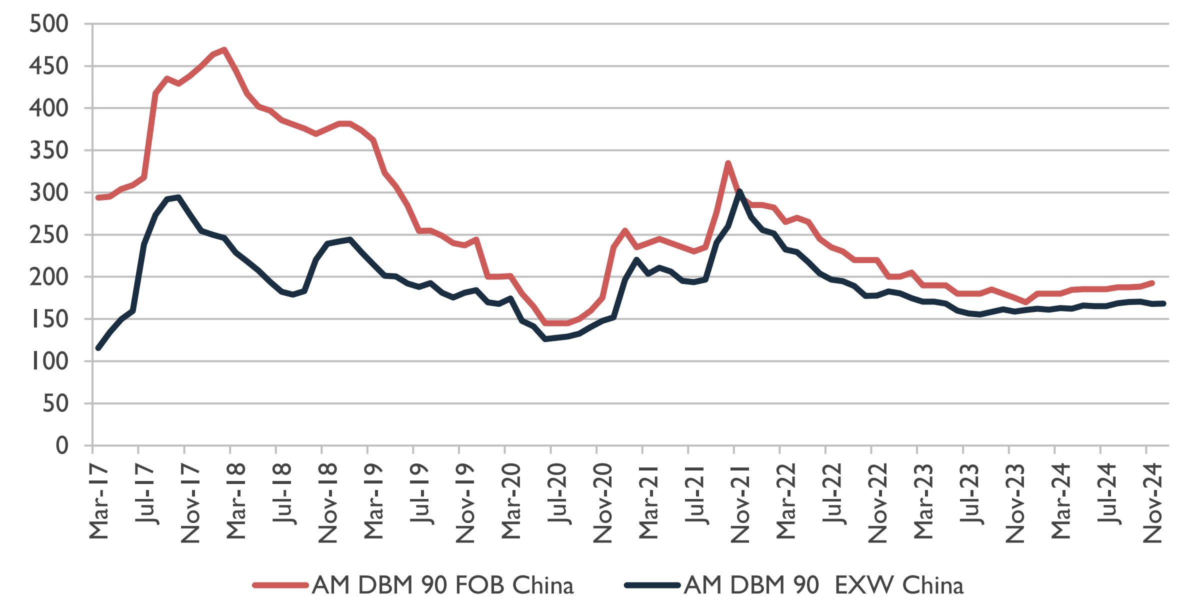
Sources: Asian Metal (AM), Global Trade Tracker (GTT)
*Note: *, no prior data*

5.2. DBM Prices

Like other magnesia products, the Chinese export price is used as a global benchmark for DBM, as China accounts for most of the international trade into the market. Given this, changes in Chinese policy can affect the whole market such as the government's pollution and environmental measures, which resulted in closures and a loss of capacity in 2017 and 2018, with prices soaring from US$325/t to US$1,150/t over one year for 97.5% MgO ( ).

This then stimulated capacity expansions, particularly of high grade DBM and FM and prices fell by the end of 2020. Efforts by the authorities to regulate the industry with consolidation and closures caused price hikes in 2021/2022, but since then, prices have been less volatile and have been gradually improving over the last year ( ).

Figure 31: Chinese DBM prices (US$/t)

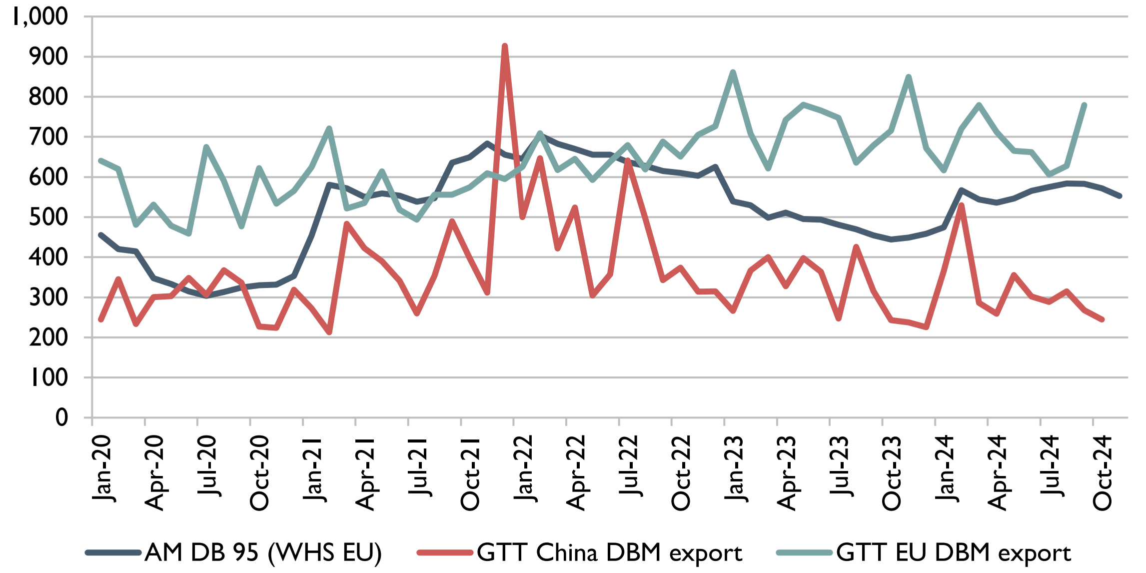


Source: Asian Metal (AM)
Notes: Average 90% MgO lump DBM grade

shows European prices, including Chinese spot prices in warehouse and averaged export prices from China to Europe (FOB China) for an average 90% MgO grade . Excluding a period in mid-2021 to mid-2022 when there were shortages in supply from China, the average European export prices are consistently higher compared to ex-warehouse prices, even though they are FOB prices.

Since mid-2022, Chinese prices have declined, reflecting the excess capacity and supply from China that was overhanging the export market. FOB pricing is once again shown to be subject to fluctuations linked to new regulations over environmental inspections, causing temporary closures and supply disruption.

Figure 32: European DBM prices (US$/t)

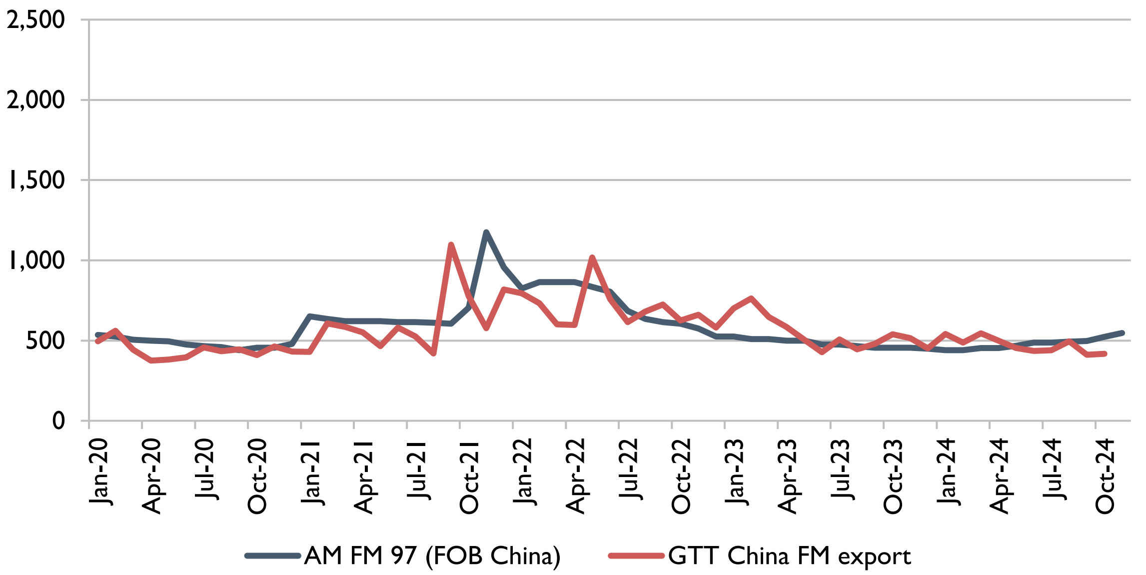


Source: Asian Metal (AM); Global Trade Tracker (GTT)
Notes: AM price is lump 95% MgO in Warehouse Europe; GTT is an average of DBM grades exported

5.3. FM prices

Given that both DBM and FM are mainly consumed in the refractories industry, Chinese FM prices effectively track DBM prices. Like DBM, the industry has seen some price swings over the last five years linked to export demand, oversupply, and measures undertaken by the Chinese to regulate the magnesia industry.

Figure 33: Chinese FM prices US$/t 2020-2024



Source: Asian Metal, Global Trade Tracker

6. Overview of global magnesia consumption

6.1. DBM & FM consumption

Refractories is by far the major market for DBM and FM accounting for approximately 10Mtpy of magnesia in 2023, largely following trends in the steel industry, and to a lesser extent, the cement industry and non-ferrous metals. A small percentage of DBM, around 4-5% in Europe, is used as an electrical insulating material and in welding rod fluxes.

6.1.1. Refractories

DBM has the highest melting point of all common refractory oxides, high resistance to basic slags and high strength to withstand wear and abrasion in hot environments. FM grains are added to refractories such as mag-carbon bricks to enhance their performance and durability due to FM's high specific gravity and large crystal size.

It is therefore a critical input for industrial processes that require thermal insulation and structural integrity where standard materials would fail due to high heat, chemical reactions or mechanical wear.

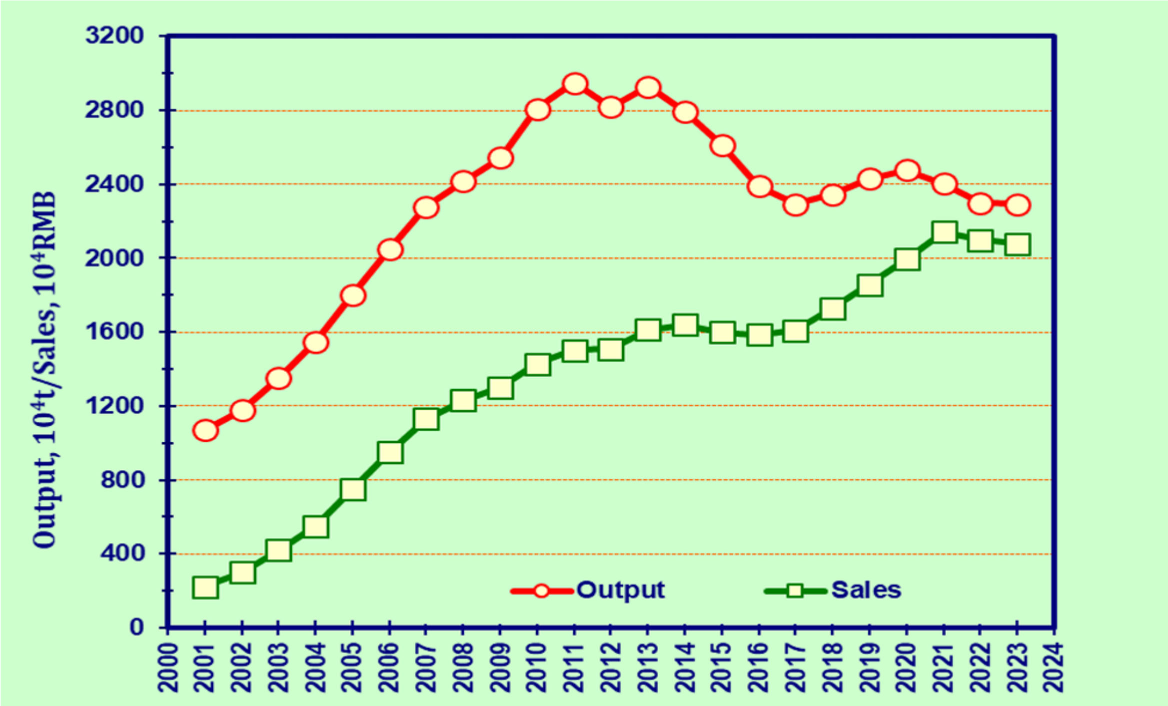
Around 68% of refractory magnesia is consumed in the steel industry, with cement representing a further 9%. Demand for refractories and refractory magnesia therefore tracks the fortunes of the steel industry, and particularly that of the Chinese industry.

Global demand for refractory magnesia is estimated to have dropped to 10Mt in 2023, mirroring the fall in refractory production. Over the same period, the fall in magnesia consumption was less, reflecting higher demand for mag-carbon and other specialised magnesia-containing refractory products in the production of high-grade steels that are processed under extreme operating conditions, and strengthening of non-steel applications.

Overall, the European market for DBM and FM was estimated at roughly 1030kt with other applications estimated at 40kt.

China dominates the world market, accounting for up to 70% of magnesia demand in this sector, owing to the country's high refractory output and abundant availability of magnesite raw materials. Figure 34 shows the growth in the Chinese industry over the last twenty years. In 2023 Chinese refractory production was 22.93Mt, slightly down from 2022 levels. China is also a leading exporter of refractory products.

Figure 34: Production and estimated sales of Chinese refractories



Source: ACRI, Baowu Refractories

6.1.2. Electrical insulation

Magnesia is used as an electrical insulating material in the form of electrical-grade magnesia (EGM) or electrical-grade fused magnesia (EFM) powder. EGM powder for low-temperature heating elements is based on DBM. EFM powder for high-temperature products is based on FM produced from CCM. The main uses for EGM/EFM are in industrial appliances such as boilers and in heating elements for domestic appliances such as cookers, washing machines, and dishwashers.

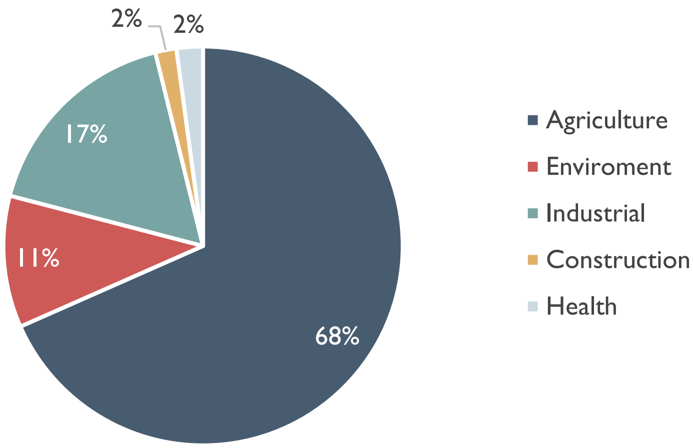
6.2. CCM consumption

Global CCM end markets are estimated at 4.7-5Mtpy, excluding some 2.5Mtpy for the production of other magnesium chemicals, including feedstock for FM manufacture and Mg(OH)2 production. As a result, total CCM consumption could be counted as closer to 7.5Mtpy.

CCM is consumed in a varied number of applications, from commodity applications with few constraints in terms of grade or impurities to USP-grade material added to pharmaceuticals. Sectors where CCM is widely used include environmental, agriculture and other industrial uses.

The European market split is shown in Figure 35, with nearly 70% used in the agriculture industry mainly in dairy and animal feed applications. The total market size was estimated at 470-490kt in 2023.

Figure 35: EU market for CCM (%) by application 2023



Source: Project Blue, Project Blue confidential questionnaire sent to sample of EU CCM suppliers

Magnesium is an essential element in agriculture for both **animal health and fertilisers** and CCM finds application as an available form of magnesium in animal feedstuffs and fertilisers. Use of CCM has historically been concentrated in North America and Europe, but growing populations, industrialisation of farming and changing dietary patterns have driven growth in consumption in the Asia-Pacific region. In Europe, CCM is mainly used in animal feed and the dairy industry, with a smaller percentage used as a fertiliser. It is vital for the health of livestock including sheep and cattle as a magnesium deficiency can supress appetite and reduce the feed intake of the animals.

In the **environmental** sector, CCM is consumed in water treatment and soil remediation. As a basic reagent, the compound can neutralise or capture acidic liquids or gaseous pollutants. In aqueous environments, it provides the ideal pH range for heavy metal precipitation. This sector is a more important market for magnesium hydroxide, however, which is widely used in FGD systems and, increasingly, in exhaust gas cleaning and sulphur abatement.

CCM is used in several important **industrial applications** including bisulfite pulp mills, rubber compounds, brake linings, catalysts, ceramics, electrical steels, fuel additives, glass and leather tanning. The main application in the rubber industry is in the production of polychloroprene (CR) marketed under the tradename neoprene which finds application in automotive components, construction and foam mattresses.

Health, dental applications, food and personal care items are another important sector which is low in volume but high in value. Magnesium carbonate is used in all four sectors, as again magnesium is vital for human health. CCM is used in both sugar beet and sugar cane production, and additionally in olive oil production.

Construction provides the global leading market for non-refractory magnesia, where CCM is a constituent of magnesium oxide cements and magboard. Both are environmentally friendly building materials. No toxic materials are consumed in production, while the production process consumes 30% less energy than Portland cement production and absorbs up to 10% more CO2 than it emits. China is estimated to account for up to 60% of world CCM demand in this market, with the USA accounting for a further 20%. In other regions, widespread use of magnesium-oxide-based building materials has been much more limited including the EU where total demand in construction is less than 2% of CCM demand.

CCM is also used to produce **magnesium hydroxide** which plays an important role in several sectors including marine and industrial flue gas treatment to neutralise acidic components, especially sulphur oxides (SOX) in exhaust gases. Magnesium hydroxide is also commonly used as a flame retardant in plastics, thermoplastics and cables, which are finding increasing demand in electric vehicle cabling where a higher thermal resistance is required. In other areas, magnesium hydroxide is used as an anti-fungal agent in plant protection and sprayed on a variety of crops to prevent attacks, and it is also used in sustainable water treatment to remove heavy metals, pH adjustment and phosphorus removal, to enhance the quality of treated water.

7. Barriers to entry for the supply and processing of magnesia

To get a broad understanding of the state of the European magnesia industry, Project Blue conducted a survey targeting active European magnesia producers. Responses to the survey results are compiled in this section to address the barriers to competitive magnesia production within the European Union.

When responding to the barriers to competitive magnesia production in Europe, all participants ranked competitive international pricing as the highest risk to the European magnesia industry, while high capital investment and regulatory/permitting obstacles were also highlighted. The following main themes were evident from the responses:

7.1. Decarbonisation

Production of magnesia and refractories is an energy-intensive process with a high carbon dioxide intensity. Great efforts have been made by producing companies to reduce emissions. For example, one of the major producers surveyed has decreased overall global emissions by 26% in 2022 alone. At the current time, there is limited availability and underdevelopment of CO2 Capture, Utilisation and Storage (CCUS) associated with the magnesia industry, which has created a technology gap between the aspirations of managing CO2 emissions and the creation of economically feasible methods for storage or capture. Without these in place, decarbonisation is a major barrier to entry or expansion for EU magnesia production.

Going forward decarbonisation is being driven by novel technologies such as Carbon Capture and Utilisation (CCU) and alternative fuel sources. To apply this to magnesia, means that regulations will have to be changed, such as in Austria where Carbon Capture and Storage is currently forbidden by law. This surmounts to a significant if not impossible barrier to the industry.

Other EU carbon regulations that do not recognise the carbon captured into chemically stable industrial compounds suitable for use in cement, concrete, ceramics and other end uses as carbon free. This will dramatically affect the business case for such CCU schemes. The other serious challenge facing the industry in Europe is the lack of carbon dioxide transport and infrastructure in the EU which will be essential to the development and use of technical solutions in the future.

7.2. High energy costs

Given the high calcining and sintering temperatures during furnace operations, magnesia is a highly energy-intensive product, especially DBM and FM which require higher temperatures. Rising energy costs in Europe directly affect the price structure of magnesia. In line with European energy transition goals, EU producers face additional challenges and pressures to adopt renewable energy into their production process, which combined with the high energy costs represent a considerable barrier to both entry and expansion in the business. This again raises costs when compared to non-EU competitors that are not operating under the same regulatory framework, making it more challenging to compete on price.

Energy price fluctuations add further complexity and make financial forecasting and strategic decisions in the magnesia industry very challenging and is another barrier to new entrants. Producers try to mitigate the effects by dynamically altering production schedules to lower energy load during periods of peak energy prices to reduce costs. These adjustments lead to reduced output which can disrupt the supply chain and customer deliveries.

7.3. Alternative energy sources

There is considerable pressure for European magnesia producers to adopt renewable energy sources, which are technically challenging given the high temperature requirements of magnesia production. DBM requires temperatures often exceeding 1,800 °C, and currently, this restricts the use of renewables as the sole input since they are not able to consistently achieve the required temperatures. With the absence of renewable alternatives, European producers must rely on fossil fuels such as LNG, pet coke, and heavy oil, which increases carbon emissions. Natural gas is the main fuel solution going forward. However, for any new plant investment the high costs associated with alternative energy sources will make the business case uneconomic. Moreover, there is also concern about energy security in Europe, especially sources such as LNG or biomass given the fluctuations in supply over the last three years.

7.4. Competitive international pricing

There is intensive competition for magnesia markets, largely driven by the excess capacity and supply from Chinese producers, which puts tremendous downward pressure on pricing in Europe. The overcapacity in China coupled with cheaper production costs, has meant material exported is aggressively priced to take market share. However, owing to state and federal measures from environmental inspections to quotas, Chinese export pricing can be highly volatile, rising when there are short-term disruptions to supply, but falling rapidly when supplies are restored.

In addition, European producers face both financial and administrative obstacles as they work to meet EU environmental standards, which increase production and overhead costs. The regulatory environment requires substantial investment in sustainable technology, which adds pressure when competing with non-EU sources. It also impacts the ability of EU producers to compete in markets outside of Europe as other regions do not have the same environmental and reporting standards.

7.5. Imports of magnesia and finished products

Magnesia imports from countries with lower production costs such as China, Brazil, Turkey and Saudi Arabia are challenging EU producers in terms of pricing and markets.

However, it is not only magnesia imports that should be considered. There has been a rise in the import of finished products such as refractory bricks, monolithics, prepared animal feeds, and fertilisers as well as ready-to-use products such as brake pads and linings, and heating elements which were previously produced in the EU and are now imported.

Imports of steel and other critical metals into the EU also place further pressure on the end use of magnesia as the European supply chain is circumvented. This shift has increased competition and decreased market demand for locally produced magnesia in the EU, further challenging the EU producers' financial viability.

7.6. Regulatory challenges

One of the challenges European producers faces is lengthy timelines in Environmental Impact Assessments and Mining permits when trying to bring a new operation on stream, whether a new site or expansion. As such, this adds to the cost structure as producers navigate strict permitting specifications and enquiries which remain long and complex.

European producers also have to comply with sustainable practices, which are essential to meet EU environmental standards but are not applied to non-EU imported material, which creates a strategic disadvantage as the EU producers have to balance their costs and competitive pricing to the requirement for environmentally responsible operations.

8. The European magnesia supply risk

The magnesia industry faces several critical supply risks that could significantly impact production and global supply chains. Currently, the high energy cost and associated carbon emissions of magnesia production pose significant challenges to the competitiveness of the EU magnesia industry.

As a result, of the headwinds described in the Barriers to entry, capacity utilisation has dropped below 50% in some cases, which impacts plant economics and increases unit costs significantly. Many producers are raising funds towards technological advancements to reduce carbon emissions, while others are exploring disinvestments of high-energy-cost products. Other strategies are a focus on recycling and alternative sources of magnesia.

These supply risks highlight key target areas where strategic support could be implemented to ensure the competitiveness of European producers. To understand what types of interventions and support would be beneficial, survey participants were asked to rank supportive measures to emphasise the needs of the magnesia industry. Survey participants consistently ranked the following in order as the most important.

- Support towards energy-efficient and low-emissions technology adoption
- Regulatory support in the form of subsidies and tariffs
- Streamlined permitting processes

In essence, the implementation of regulatory support in the form of subsidies and tariffs will strengthen supply chain security while the streamlining of permitting processes could improve long-term industry resilience by removing unnecessary lengthy and complex procedures. Although these three above-mentioned measures were ranked as the most significant, all support measures were highlighted as important initiatives (other measures not mentioned above include: R&D funding for alternative raw materials or improved processing; and Investment incentives).

Energy-efficient technology and related carbon reduction technology (including carbon storage) measures and support would allow for a tangible reduction in costs and enable compliance with strict environmental standards. These measures will ensure that companies maintain modern facilities with continuous process optimisation and in turn, a reduction in carbon emissions.

8.1. Dependency on single sources

Many end use industries are heavily dependent on a single source for their magnesia supply, which can be a risky strategy, especially when that source can be subject to price fluctuations and supply shortages. The European supply risk is its high dependency on one Province in China, Liaoning, for a significant proportion of its magnesia requirements in all forms.

8.2. Geopolitical tensions

Geopolitical tensions, especially involving the major magnesia-producing country, China, could disrupt the supply chains with the overreliance on a single source. Production or export quotas, trade disputes or sanctions can lead to restrictions on the export of magnesia, causing shortages in the EU dependent on imports. The vulnerability has been highlighted by recent events such as the Covid-19 pandemic and the Russia-Ukraine war, where supply chains for raw materials and finished goods have been disrupted resulting in a structurally higher inflation and energy price environment. The China-Taiwan dispute, if escalated, could be particularly disruptive for Chinese magnesia exports, as this would block a major shipping route for the material to Europe.

8.3. Limited primary supply and resource depletion

In the magnesia industry, there is a shortage of commercially developed mineral resources and processing plants. There is an over-reliance on supply and trade on limited overseas sources, which can also be stressed by logistical challenges.

The depletion of natural resources used in magnesia production, such as magnesite, can pose a long-term supply risk. This is evident in China, where over the last five years, additional processing has been installed to improve grade recoveries from lower quality magnesite deposits, increasing the cost of processing and extraction for magnesia production. These high grade DBM and EFM products are aimed at the Chinese domestic markets, reducing the capacity available for export.

8.4. Environmental regulations

Stricter environmental regulations worldwide especially in China, are affecting magnesia capacity and causing temporary and permanent closures and supply disruption. For example, increased regulations aimed at reducing pollution and carbon emissions mean the closure of magnesia plants that do not meet new standards, which can result in supply shortages.

8.5. Separation of calcining and processing capacity

If mining becomes more restricted or costly in the EU, then one option is the increased import of ore, which already happens from Turkey. Imports of magnesite into the EU for processing into magnesia from third parties rather than in-house production would introduce some key risks for the magnesia industry. Transporting raw materials to off-site facilities or from further offshore can induce supply chain delays, additional transport and logistic costs, and a greater dependency on third parties to maintain a quality product. Together this would increase the costs and reduce operational efficiency which would impact the industry's competitiveness.

8.6. Market demand fluctuations

Fluctuations in market demand for magnesia can create supply risks. For example, an increase in demand from industries such as refractories can strain existing supply chains for particular grades leading to shortages. This has been seen in recent years in demand for high grade DBM and EFM and led to additional processing capacity being installed in China to address the problem.

8.7. Technological changes

Advancements in technology can lead to changes in production processes and the introduction of alternative materials, however, this is highly unlikely in the next decade for magnesia in its main applications. The main technology change will be that recycling will become more economic and established and move from a relatively small part of the supply chain to the mainstream processing line. Advances in processing and sorting technology will be key. This includes primary mineral miners increasing mine waste recycling efforts.

9. The importance of magnesia to EU Industry

This section discusses some of the major industries where magnesia is a critical input for the production process – that is to say, without magnesia, there would be no production and a total reliance by the EU on imports of magnesia products or finished refractory products for applications in steel, cement and several metals needed for the energy transition.

Some forms of magnesia are also used in animal feedstuffs and fertilisers, essential for the agricultural sector in Europe and particularly the dairy industry, of which Europe is one of the largest producers in the world.

Therefore, while the value of the magnesia sector itself is relatively small within the EU, its necessity (with the lack of substitution discussed later in this document) within larger strategic industries must be considered.

9.1. Iron and steel

Magnesium compounds, specifically dead-burned and fused magnesia, are used as refractory materials in the steel industry, and this is one of the largest uses for these compounds. Magnesia is utilised to produce refractory shapes, bricks and castables also known as monolithics, which are materials used to line furnaces, kilns, and other high-temperature equipment.

Shaped refractories are produced in a very wide range of sizes and shapes from simple bricks to highly complex shapes such as nozzles. Bricks are bonded together with refractory cement to line furnaces and kilns. Magnesia-carbon bricks are commonly used in high temperature corrosive environments, such as iron blast furnaces, ladles and steel furnaces. Magnesia-carbon bricks also make up most of the lining of furnaces used in continuous steel operations.

Castable/monolithic refractories typically have a deformable or flexible quality which enables quicker installation of the furnace lining as it can be made continuously.

In the EU, steel production and consumption in the EU are expected to grow in line with GDP over the next five years. This is a positive inflection from the decline in both production and consumption over the last five years. This translates into a positive continual demand for magnesia-based refractories.

Table 4: EU steel production and consumption forecasts

(million tonnes)	2018	2023	2028e	5-yr CAGR
EU Crude Steel Production	160	126	141	2.2%
EU Finished Steel Production	149	118	130	2.0%
EU Steel Consumption	151	130	143	1.8%

The risks to these forecasts depend on the overall inflationary and interest rate environment within the EU, as the end-use sectors are highly sensitive to these factors. The housing/construction sector accounts for 33% of steel consumption in the EU, whereas the automotive industry accounts for 17%

of steel consumption, resulting in half of the European steel demand from these two large sectors alone.

The remaining industries, such as machinery and equipment, are facing an increasingly squeezed position over the long term, especially if Europe gets caught between a protectionist U.S. and a more competitive China. The EU steel industry itself has been dealing with overcapacity with energy and raw material prices at uncompetitive levels for many years now.

From a sustainability perspective, which is largely driven by the EU Green Deal, it is possible to identify 35Mtpa of new steel capacity in the EU using the EAF route on a 2030 horizon. There is another 10Mtpa that could come onstream in the early 2030s, replacing blast furnaces and mostly dedicated to steel long products.

This again is evidence of the continued utilisation of magnesia refractories which have a higher usage in EAF and are used to recycle scrap steel as part of the drive to sustainability. In EAFs, magnesia-carbon bricks are used in steel ladle slag zones, where refining and trimming of steel are carried out, and have replaced alumina and zircon refractory linings. The magnesia-carbon bricks can cope more easily with higher temperatures and longer dwelling times. Unit consumption of refractories in EAFs may continue to fall slightly but overall consumption of mag-carbon bricks in EAFs should increase as the amount of steel produced in these furnaces rises.

Table 5: New EAF steel capacity in the EU that could come online by 2030

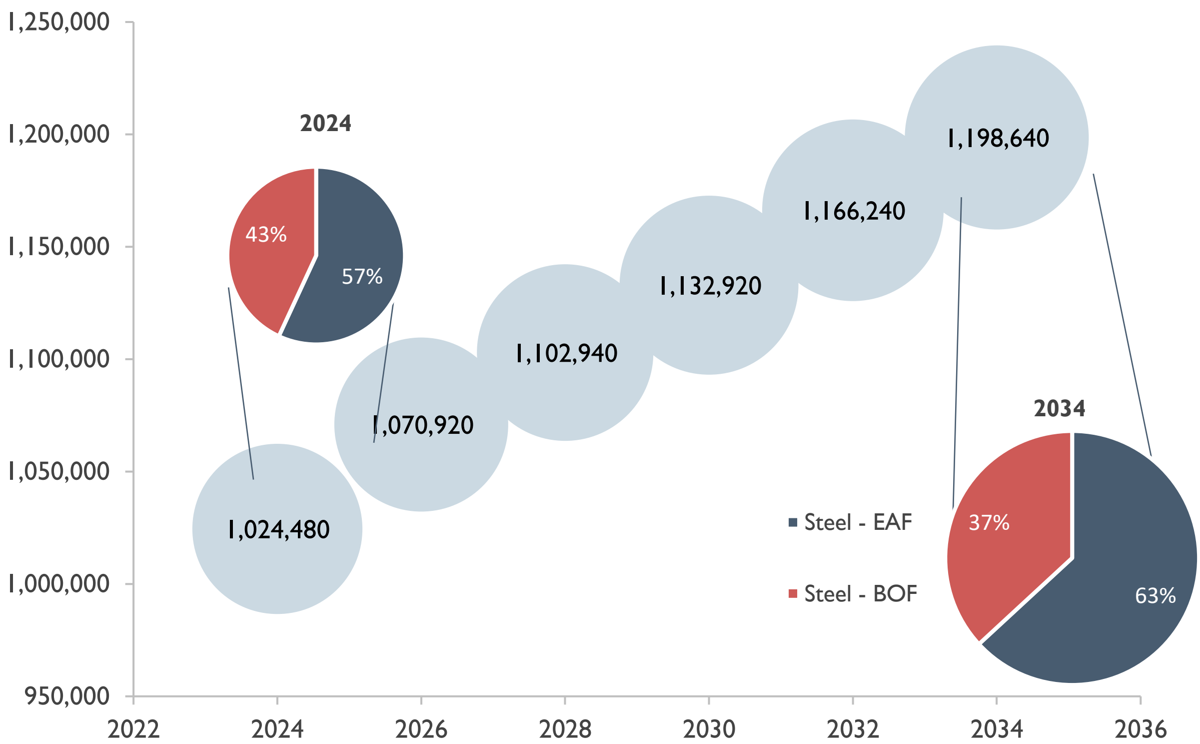
Company	New EAF Capacity (Mtpy)
Voestalpine	2.5
Liberty Steel (Ostrava and Galati)	6.4
ThyssenKrupp	2.2
ArcelorMittal (incl. Dunkirk, Gijon, Bremen, Gent)	10.0
SAAB	2.5
Tata (UK)	3.2
Blastr Green Steel	2.5
H2 Green Steel	2.5
ADI (Italy)	2.0
Saarstahl	1.9
Total	**35.7**

Source: Project Blue

However, a number of these projects will rely on DRI (direct reduced iron) supply becoming available as well, which will bring additional capital requirements and needs coordination with the upstream iron ore players outside of Europe. Furthermore, for these projects to be financially competitive, the implementation of CBAM will need to be simplified and enforced, and free carbon allowances need to be structured over a long enough period for the industry to adjust its production to the new environmental standards.

It is also not yet clear how CBAM will be accounted for in steel exports. Higher costs within the EU will not translate to globally competitive products until carbon costs are applied globally.

Figure 36: Forecast growth of magnesia-based refractories in steel (t)



Source: Project Blue *Note: Basic Oxygen Furnace (BOF), Electric Arc Furnace (EAF)*

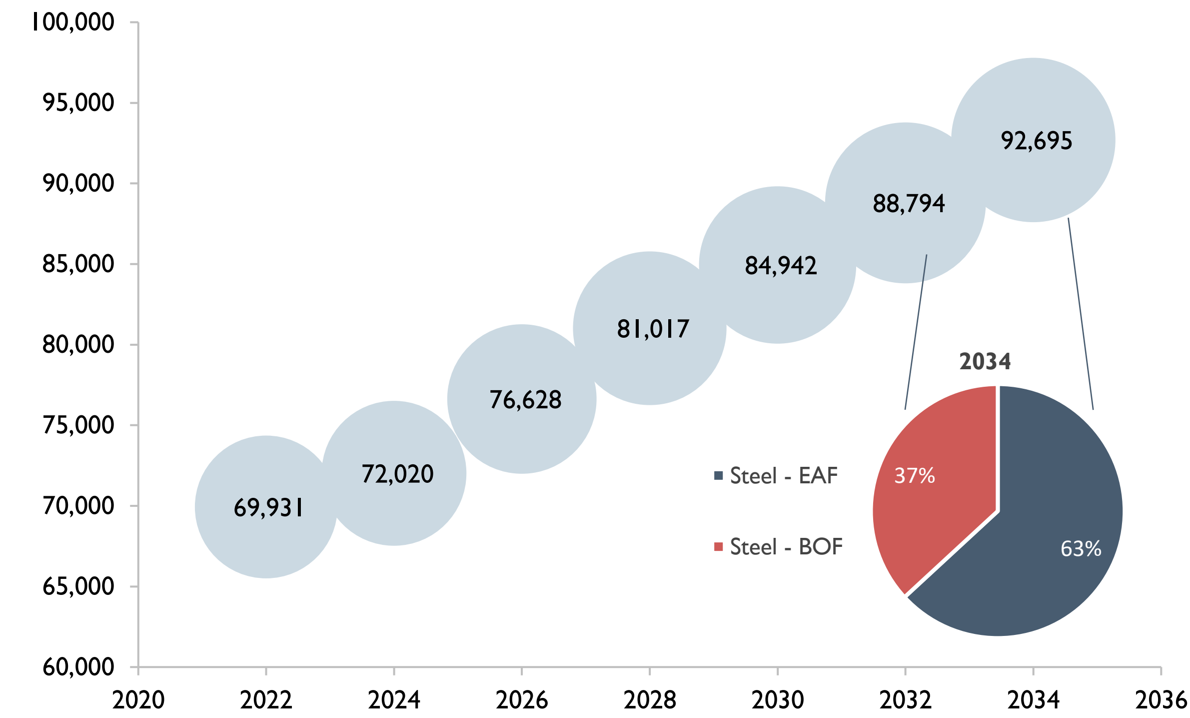
9.2. Cement

The second largest market for magnesia refractories is the cement industry, which has growth rates reflecting levels of construction activity, moderated by the slow or declining economic conditions in Europe. Magnesia alumina spinel refractories are typically used in the industry. Longer campaigns and higher use of alternative fuels, which raises thermal stress levels in kilns, have resulted in increased demand for high-grade magnesia refractories.

European cement markets faced numerous challenges in 2023, including financial instability, high costs, inflation, and fluctuating demand in both residential and non-residential construction. Countries such as Austria, Czechia, Denmark, Finland, France, and Germany saw declines in cement production and consumption due to high interest rates and reduced purchasing power. However, Bulgaria and Portugal experienced growth driven by real estate activity and infrastructure investments. Unique factors also influenced markets, with the Russian-Ukraine conflict impacting Luxembourg's industry (rising energy costs) and Greece's economic growth supporting construction. Overall, 2023 highlighted varied growth patterns and significant economic challenges across European cement markets.

In Europe, the average annual consumption of DBM for cement production is stable at just over 72ktpy. In 2023, this figure rose to 76ktpy, with projections for 2024 suggesting further growth to as much as 92kt by 2043 ( ). Employment in the cement industry also increased, with just over 39,000 individuals employed in 2023 compared to 34,974 in 2022, showing a crucial role in national development and economic growth.

Figure 37: Forecast growth of magnesia-based refractories in cement for Europe (t)



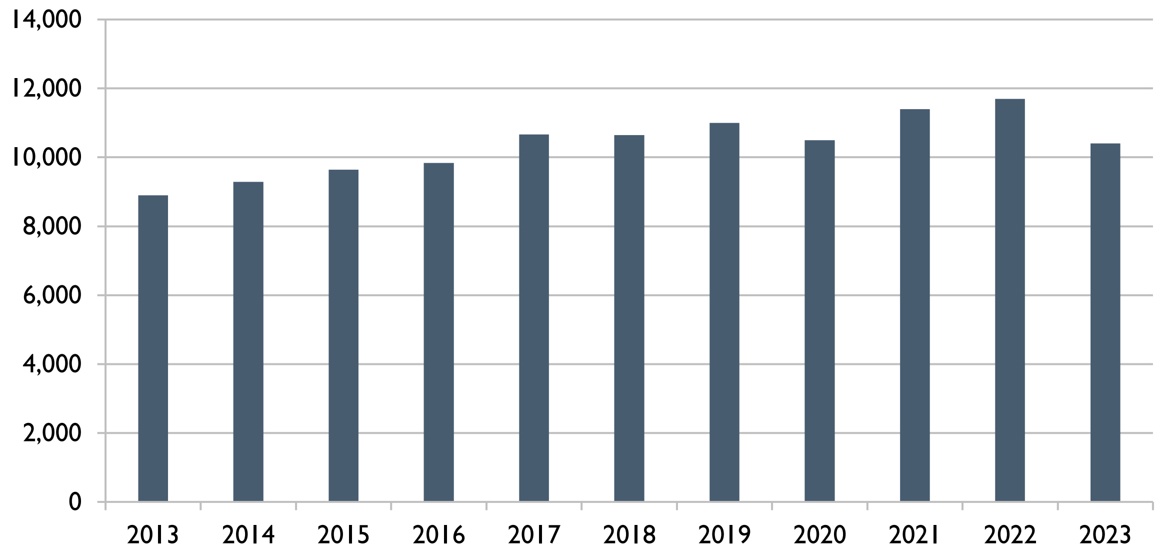
Source: Project Blue, World Steel Association

9.3. Glass industry

Magnesia refractories are also critical for the production of glass, from automotive windscreens to window glass in all types of construction, as well as container glass widely used for beverage and food packaging. This is because of the magnesia refractories high mechanical strength and good resistance to thermal shock, erosion and spalling.

European glass production levels continue to rank among the world's largest glass producers alongside China and North America. Germany is the leading producer in the EU, closely followed by Italy, France, Spain, and Poland. The UK is also a significant producer. In terms of glass production, Container glass accounted for 64.1% of production, flat glass (cast, sheet and float) (28.9%), domestic glass (2.5%), continuous filament glass fibres (2.2%) and special glass (2.3%). The sector took a drop in production in 2023, following years of growth from 31.6Mt in 2013 to 40.2Mt in 2022, owing to rising energy prices and competition from investments outside the region. Glass is playing a very important role in Europe for energy efficiency, safety and comfort in many applications, contributing towards EU sustainable living goals as well delivering on the EU Circular Economy Plan.

Figure 38: Ggrowth of all glass production in the EU 2013-2023 (kt)



Source: Glass Alliance Europe
Note: Figures for 2014 to 2023 refer to the EU-28 that was in formation at the time including the UK

9.4. Nickel-cobalt processing

High-grade CCM is used in the hydrometallurgical processing of nickel-cobalt laterite ores using high-pressure acid leaching (HPAL) technology. This technology is increasingly being adopted as a cost-effective and lower carbon extraction process as shown in Figure 39, and will be going forward as demand for nickel increases. CCM is used to achieve the highest possible metal content in the precipitate and low precipitate concentrations of undesirable ore-originating metals, and improve the efficiency of the process. Magnesia is a non-corrosive and non-hazardous product, and does not cause scaling.

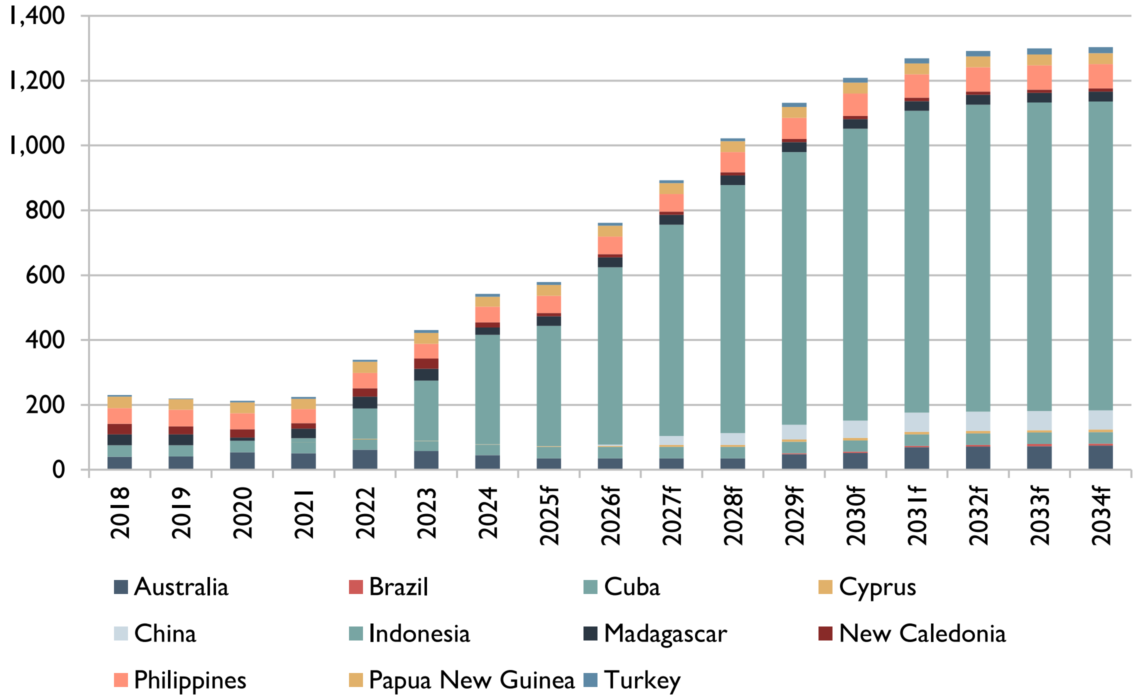
Lower grade natural CCM is also used for acid neutralisation/pH adjustment in preliminary and secondary recovery units as well as wastewater streams. CCM (and/or magnesium hydroxide) is used in wastewater treatment for heavy metal precipitation, pH adjustment, and phosphorus removal, effectively enhancing the overall quality of treated water.

Compared to other neutralisation agents, CCM and/or magnesium hydroxide have the advantages of lower sludge volumes and a higher neutralisation capacity per unit weight.

Primary nickel consumption increased at a rate of 6.1%py between 2014 and 2023, reaching 3.2Mt. Growth has been driven mostly by nickel's use within stainless steel but also increasingly in its use in batteries. Consumption is dominated by stainless steel which accounts for two thirds of total primary demand.

However, nickel consumption in the battery sector has grown more quickly in recent years. Demand here is underpinned by the electrification of the automotive industry. International climate policy and regulations stipulating the end of internal combustion engine (ICE) sales have pressured automotive companies to switch their fleets to electric vehicles. Given that nickel increases the energy density of lithium-ion batteries and thus the range of an EV on a single charge, cell manufacturers are developing batteries with increasingly nickel-rich chemistries, particularly in higher-end EV models.

Figure 39: Nickel HPAL supply 2018 to 2024 by country, including forecast to 2034 (contained Ni kt)



Source: Project Blue

9.5. Food value chain

Magnesium is an essential element for crop nutrition and animal health. CCM and magnesium sulphate, in natural and synthetic form, and as a component of potash-magnesium blends, are widely used as forms of magnesium in animal feedstuffs and fertilisers. CCM is used more widely in dairy and animal feed, with a smaller proportion used in fertilisers. Dairy and animal feed play a significant role for the agricultural economy, rural development and food security in Europe.

Europe is one of the world's largest producers of milk and dairy products, and output continues to rise. In 2023, the dairy sector produced 161Mt of milk products, up 0.8Mt on the previous year, of which 96% was cows' milk, followed by ewe, goat or buffalo milk. Just over 22% of the EU's raw milk was produced in Germany, and with France, Poland, the Netherlands, and Italy, provided 66% of collected cow's milk in the EU. Approximately 70% of all the milk produced in the EU is processed into cheese and butter, alongside the production of 22Mt of drinking milk and 3Mt of dairy powder products.

In terms of animal feed, at the end of 2023, there were 133M pigs, 74M bovine animals, and 68M sheep and goats, with the majority held in just a few countries (Spain, France, Germany and Italy). Spain accounts for 25% of the EU pig population and 24% of the sheep population. There is an overall downward trend in livestock populations in the EU, but an increased focus on animal welfare and health, linked to food quality and safety, which is key for magnesia consumption as it is essential for animal health.

Further. magnesium is just as important in the human food chain, being vital to human health and is a co-factor in more than 300 essential enzyme systems that regulate many diverse biochemical reactions in the human body such as muscle and nerve function, bone development, and blood glucose control amongst others. A deficiency of magnesium ions may contribute to heart disease, hypertension, metabolic syndrome and diabetes. The recommended daily dietary intake for magnesium in adults is 310-420mg. Magnesium is found naturally in foods such as green leafy vegetables, fish, milk products, nuts, and legumes. However, magnesium supplements are available in a variety of forms, one of the top-selling mineral nutrients overall, with an average multi-mineral supplement in the UK will contain 250-750mg of magnesium, for example.

9.6. The energy transition

The energy transition is heavily dependent on critical raw materials (CRMs) to build out renewable energy technologies and electric vehicles. These materials' high intensity of use reflects the shift toward low-carbon technologies, but securing them presents challenges, given their uneven global distribution and supply chain vulnerabilities. Recycling, domestic sourcing, and reducing material usage are strategies being explored to address these issues.

The European Union recently introduced the Critical Raw Materials Act and the Net-Zero Industry Act to bolster its green transition. These policies target mining 10% and processing 40% of annual CRM needs within the EU by 2030, reducing dependency on imports, particularly from China. The EU also aims to produce 40% of its clean technology domestically by 2030 and is investing in accelerating permitting and funding for strategic projects to meet its decarbonization and climate neutrality goals.

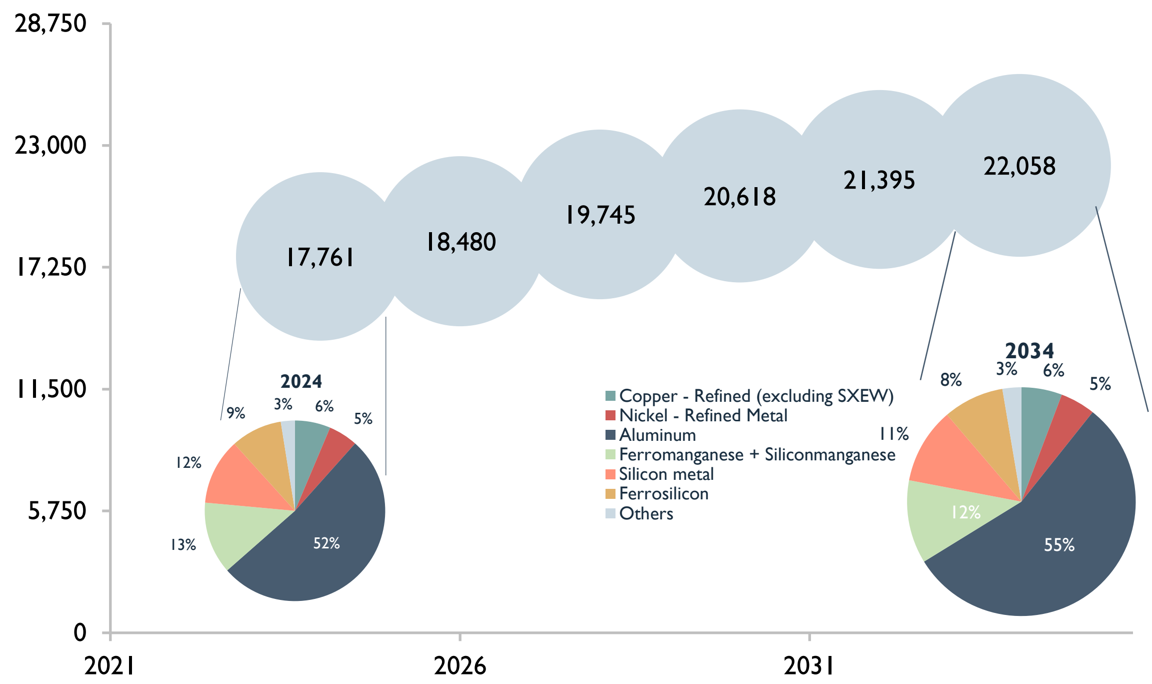
In addition to the iron and steel, and cement sectors noted above, magnesia is critical to produce many of these critical and strategic metals. Its use in refractory bricks is prevalent in pyrometallurgical processes, which is the main process for smelting or refining most critical metals around the world such as copper and aluminium. This suggests that magnesia consumption will increase in these energy transition sectors as it is used as a refractory in metal refining (Figure 40).

Copper demand is forecast to grow by a CAGR of 3.3% over the next decade, driven by the growth in green energy infrastructure, while building and construction will remain one of the largest end-use sectors. The growth rate in excess of overall GDP is driven by the structural shift in the world's energy system from being powered by carbon to powered by electrons. Upgrading and expanding electrical grids and deploying charging stations for EVs are two of the biggest drivers for copper demand – and whether primary or recycled copper, nearly all processes require refractory bricks for metal production.

Similarly, aluminium demand will also see moderate, but stable growth over the next decade, driven by its use in lightweighting vehicles, particularly EVs with heavier batteries, and use in overhead, long-distance electrical transmission cables. Notably, aluminium is an easily recycled material, particularly from cans and packaging industries. Like copper, the aluminium smelting process, whether from primary alumina or recycled products, requires refractory bricks.

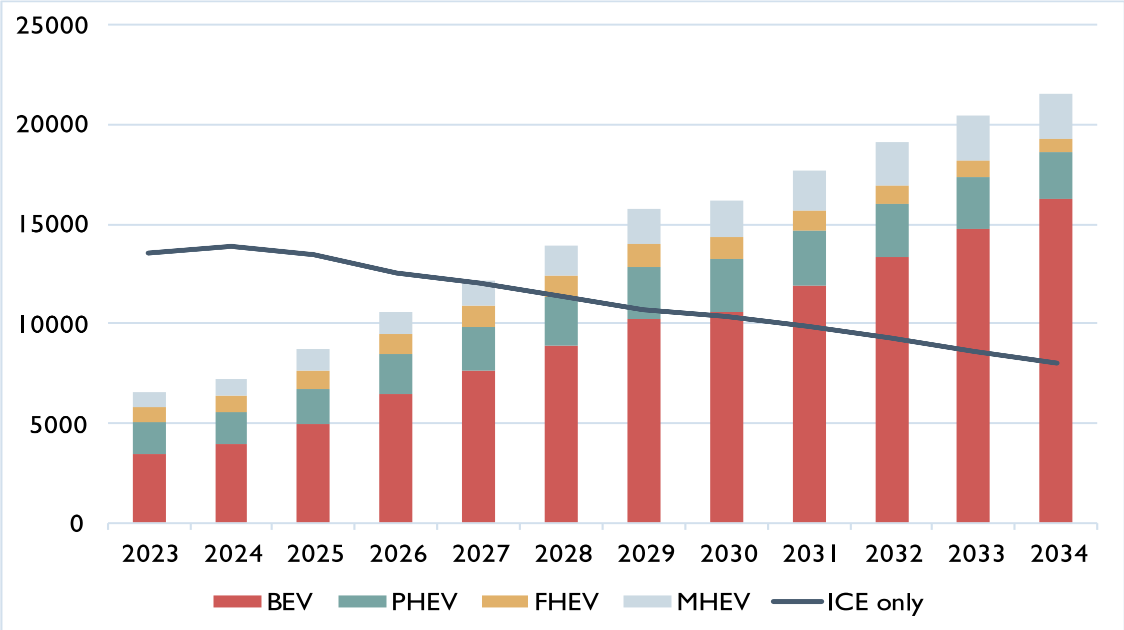
Figure 40 shows the expected growth in refractory consumption across several critical metal markets including nickel, copper and aluminium which are all necessary to build the products and infrastructure required for the energy transition.

Figure 40: Forecast growth of magnesia-based refractories in non-ferrous metals (t)



Source: Project Blue

Figure 41: Aluminium consumption in the automotive industry related to EVs (kt)



Source: Project Blue

CCM is used in hydrometallurgical processing, which is used to process oxides, an increasing portion of mined raw materials (especially copper and nickel). Although there are no active operations in the EU at the moment, there are several projects in the pipeline for the refining of metals such as nickel and cobalt for chemical applications such as batteries, as well as projects to recycle batteries themselves as part of the EU's battery directive.

9.7. Magnesium metal

Despite Europe's long history with magnesium metal production, the EU currently has no refining capacity for primary magnesium metal. Following the scaling-up of the Chinese magnesium metal supply into the global market, operations in Europe and North America were placed under extreme pressure with many operations unable to compete in the international market and closed.

In 2002, Norsk Hydro closed its Porsgrunn production facility in Norway, which was soon followed by the closure of French producer SOFREM in July of 2002. Since 2002, Europe has not produced primary magnesium, although some smaller recycling operations are situated in Austria, Belgium, Germany, Italy, and the Netherlands. For this reason, Europe has become reliant on magnesium metal imports from China to meet its domestic demand.

In recent years, the high supply risk of magnesium metal has come under focus. This supply risk is based on the localised Chinese production that accounts for 90% of global primary magnesium metal, with much of this output coming from a single county in China, Fugu County in the Shaanxi province.

To address this supply risk, several European projects are under development, including Verde Magnesium, Magnesium for Europe, and Mures Magnesium.

Romania-based Verde Magnesium has made good progress towards project implementation after the company was granted its mining licence by the National Agency for Mineral Resources of Romania. The company plans to utilise renewable energy sources along with recycled aluminium in its production process and will develop the project over the next 4 to 5 years. The plant will have an initial capacity of 30ktpy.

Magnesium for Europe plans to use high magnesium-grade dolomite deposits as a feedstock for its magnesium metal operations which will be sourced in Bosnia-Herzegovina. The company also plans to employ an aluminothermic reduction technique that is more energy efficient. Additionally, Magnesium for Europe is also investigating the use of green energy to power operations. The project will have an initial capacity of 15ktpy that will be ramped up over a 3-year period from 2026. Following its successful commission, the aim is to expand the production capacity to 50ktpy of magnesium metal.

Mures Magnesium is developing a project based on an electrolytic production method and plans to use high-grade magnesium waste feedstocks to produce magnesium metal. It is aiming at an initial 20ktpy magnesium metal production plant.

9.7.1. Magnesium metal production from magnesia

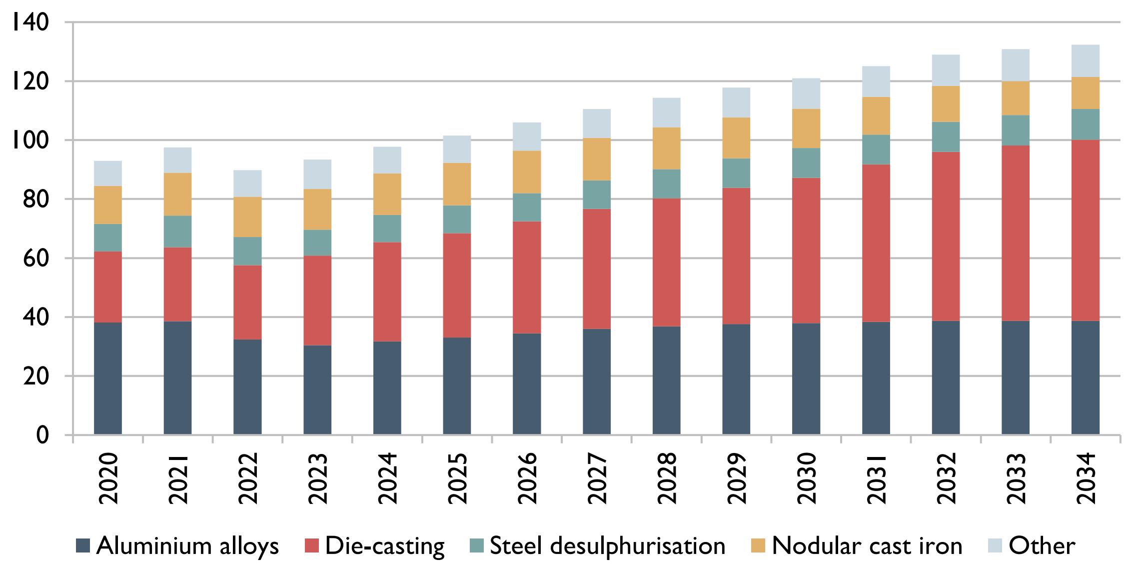
Magnesium metal is generally produced in two ways, a thermal reduction process called the Pidgeon process (among others), and less commonly an electrolytic process associated with brine or seawater sources.

The electrolytic processing method requires that magnesium chloride be produced as a first step from brine and seawater sources as a feedstock for magnesium metal. To this end, Europe's magnesia production could be converted to magnesium chloride, or its own brine source could be used, to go through various routes as a feedstock for electrolytic magnesium metal production. This technique has been successfully employed at a commercial scale by both US Magnesium and Dead Sea Minerals.

9.7.2. European magnesium metal demand

Magnesium metal demand in Europe is set to increase moderately over the next decade from 93.8kt in 2023 to 132.4kt by 2034, representing a CAGR of 1.02%. This will initially be driven by the aluminium industry, where magnesium metal is used as an alloying element, while the largest growth rate will be seen in the die-casting industry where magnesium metal is used for lightweighting (Figure 42). Growth in die-casting demand will specifically reflect the development and growth in the EV automotive industry in Europe. Magnesium alloys in die-casting are forecast to grow from 30kt in 2023 to more than 60kt by 2034, doubling this demand over the next 10 years.

Figure 42: European magnesium metal demand by application (kt)



Source: Project Blue

Current EU magnesium metal demand is being met by large-scale Chinese imports. However, should European projects currently under development successfully be commissioned, domestic magnesium metal production will be able to support about one-third to half of the domestic demand (depending on the year of commissioning). Active involvement of the European magnesia industry may therefore play an important role in meeting additional EU magnesium demand. Given the chemistry of the thermal reduction process, the excess magnesium metal requirement (60ktpy and more) could amount to about 100 to 150kt of magnesia per year.

10. Substitution and recycling of magnesia

10.1. Substitution risk

In the refractories space, any widespread substitution of magnesia-based refractories by other basic products is unlikely over the next ten years. It is more likely that magnesia-alumina spinel and magnesia-alumina-graphite blocks and monolithics will replace both alumina refractories in steel-making ladles and mag-chrome refractories in cement kilns. Both trends are underway and enhancing demand for magnesia.

A factor that appears more likely to restrain some growth in refractory magnesia consumption over the next decade is the recovery and re-use of spent refractories. Recycled materials were estimated to account for just 5-7% of refractory raw material consumption in 2022. Refractory and magnesia producers are all focusing on the re-use of refractory materials, developing technologies, such as automatic sorting, cleaning and stabilisation processes, to meet the target of raising utilisation rates for recycled materials.

There is little threat of direct substitution for magnesia-based refractories, at previous times of high magnesia prices, some very limited substitution by dolomite and olivine basic refractories has occurred. In another measure, Chinese sources have reported a rising demand for olivine to replace magnesia, because pollution control measures have had less impact on olivine mining and processing operations.

There is some competition between CCM and magnesium sulphate in fertiliser applications. While growing populations and the industrialisation of farming are driving growth in the use of fertilisers, CCM can face substitution from magnesium sulphate. However, magnesium sulphate is mainly used in granulated NPK fertilisers due to its solubility, whereas CCM is used in chemical route NPK fertilisers where it turns into soluble derivatives during the production process. CCM can also be used as a feedstock to produce magnesium sulphate, where magnesium sulphate isn't locally available.

While CCM has a higher product cost than natural magnesium sulphate and has lower solubility, it does have a much higher availability of magnesium at roughly 40%, than the 10% availability of the commonly available commercial variant of MgSO4.7H2O. The market share for CCM held by fertiliser uses is therefore expected to decline very slightly over the next decade, with some erosion of markets in NPK fertiliser blends but will not be replaced.

10.2. Recycling

It has been estimated that some 7.6-12.6Mtpy of refractory waste is generated worldwide, and approximately 50% of this volume is reused in the iron and steel industry. However, much of this is not recycled into new refractory products but as a low-grade magnesia source into slags. Typical examples include MgO-C bricks, which are widely recycled in low-grade re-manufactured MgO-C bricks and ramming masses, while MgO-Cr bricks are being recycled as gunning mixes for steel furnaces and permanent lining bricks.

However, refractory recycling is far from consistent throughout the world, and many recyclers are in different stages of this journey. The European refractories recycling industry is among the most developed and is driven by 15-20 established companies which have a culture of EU-wide research and collaboration including end-users and mineral processors. The established recyclers tend to partner with refractory or steel producers and target certain refractory types to suit their business model. However, the total volumes of used refractory recycling are still comparatively small.

The European Union has implemented specific rules to enhance the recycling of critical raw materials (CRMs) under the Critical Raw Materials Act (CRMA), which became effective in May 2024. These rules aim to reduce dependency on imports and bolster sustainability by integrating circular economy practices into raw material management. A study by Mountan Universität Leden details the importance of magnesia as an indispensable input material to a significant number of critical and strategic raw materials, not only in the production lines but also in the recycling of these materials.

The key recycling-related targets set by the CRMA for 2030 include obtaining at least 15% of the EU's annual CRM consumption from recycling. This initiative focuses on both recovery from waste streams as well as end-of-life circular economy goals.

In metal processing, scrap metal and materials can often be introduced at some point in the flowsheet before producing refined materials. Therefore, recycling end-of-life products is not necessarily additive to magnesia demand, but to the extent recycling becomes increasingly mandated within the EU and more economic than using primary feedstock, it should support the overall growth and development of these sectors in general.

11. Background

Magnesia (magnesium oxide) is the most important magnesium compound in terms of the global volumes produced worldwide, which include chlorides, sulphates, and carbonates which are used in a wide range of different applications. The compounds are mainly sourced from mines, but also from seawater, brines or deep salt beds.

Most magnesia output, around 93%, is based on magnesite (natural magnesium carbonate). Brines and seawater typically provide feedstock to produce magnesium chemicals such as magnesium chloride and magnesium sulphate and are also important raw materials for magnesia production often termed "synthetic magnesia". Synthetic magnesia is generally higher in purity, but production costs are higher due to increased energy consumption.

Three main magnesia grades are produced, and the type depends on the temperature and time of calcination along with the requirements for application-specific magnesia properties. These are:

- Caustic calcined magnesia (CCM)
- Dead burned magnesia (DBM)
- Fused magnesia (FM)

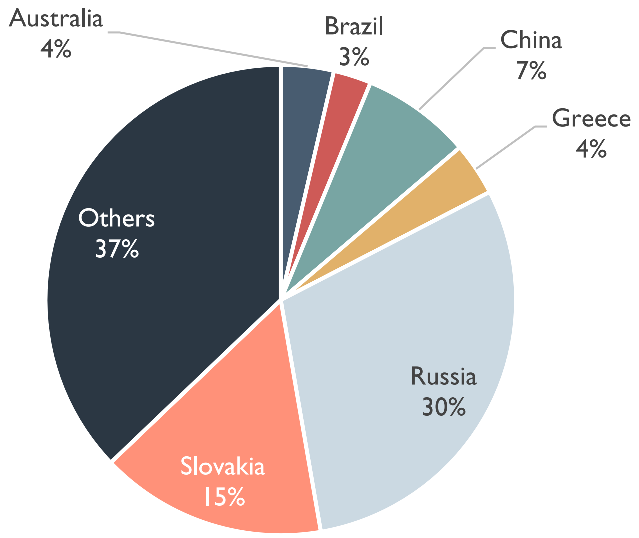
Overall, refractory magnesia manufacturing is a highly energy-intensive process, and therefore, energy costs will ultimately drive the cost structure (13-34% of DBM production costs and 30-46% of EFM costs). Other commercially mined magnesium minerals include olivine, a magnesium-iron silicate mineral; dunite (an olivine-rich rock); brucite, a natural magnesium hydroxide mineral; huntite (magnesium-calcium carbonate); and hydromagnesite (hydrated magnesium carbonate). There are also various sulphates and chlorides associated with potassium minerals.

11.1. Reserves

Global magnesite deposits are geographically widespread, with two countries, Russia, and Slovakia together accounting for 45% of the world's total reserves. Chinese reserves represent around 7%, whereas reserves in North Korea, previously thought to be very significant are included in "other" due to the lack of delineation.

Magnesite resources are in Russia (30%), Slovakia (15%), China (7%), Greece (4%), Australia (4%), and Brazil (3%), with the rest of the world volumes representing roughly 37%. Despite only accounting for a relatively small share of global magnesite reserves, China dominates the global supply chain of magnesite. Most Chinese reserves are in Liaoning province, which is the largest producer, although there are regulations in place to curb any future increases in production from the province. In terms of resources, Liaoning Province has magnesite resources of 2.975 Bn tonnes, which if proven as reserves would account for 90% of Chinese reserves and 20% of the global reserve base.

Figure 43: Global Magnesite Reserves 2024 (%)



Source: USGS

12. Glossary

M	Million
t	Tonne
Mt	Million tonnes
tpy	Metric tonne per year
kg	Kilogramme
CCM	Caustic Calcined Magnesia
DBM	Dead Burned Magnesia
FM	Fused Magnesia
MgO	Magnesia
EAF	Electric Arc Furnace in steelmaking
BOF	Basic Oxygen Furnace in steelmaking
CBAM	Carbon Border Adjustment Mechanism
HHI	Herfindahl–Hirschman Index, a measure of industry concentration
USGS	US Geological Survey
BGS	British Geological Survey
DNPM	Departamento Nacional de Produção Mineral
GTT	Global Trade Tracker
FOB	Free on Board (Inco term)
EXW	Ex-works
WHS	In-Warehouse
CIF	Cost Insurance Freight (INCO term)
LNG	Liquid Natural Gas
AM	Asian Metal (Price Reporting Agency)
CRM	Critical Raw Materials
CAGR	Compound Average Growth Rate
ICE	Internal Combustion Engine
EV	Electric Vehicles
DRI	Direct Reduced Iron
NPK	Nitrogen- Phosphorus- Potassium (fertiliser)

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