euromines

The European Magnesite / Magnesia Industry:

enabler in the transition to a low-carbon economy

January
2020

Contents

Climate change is an undeniable and critical global challenge and its causes must be addressed by everybody as inaction is no longer an option. Transitioning to a low-carbon economy and achieving the EU climate targets will require large amounts of resources and efforts. The European magnesia sector recognizes the need to respond to this challenge and is committed to take the necessary measures to ensure that it is part of the solution.

Provider of main primary raw materials for several value chains such as steel, agriculture, paper, cement, ceramics, rubber and plastics, glass, pharmaceuticals, the European magnesia industry is a strategic supplier generating value added through employment, economic growth, development, innovation and trade. Hence, our sector is committed to engage along the value chain to ensure that climate change risks are adequately taken into consideration, decarbonisation actions are adopted and implemented and emissions are mitigated and reduced.

1

57%

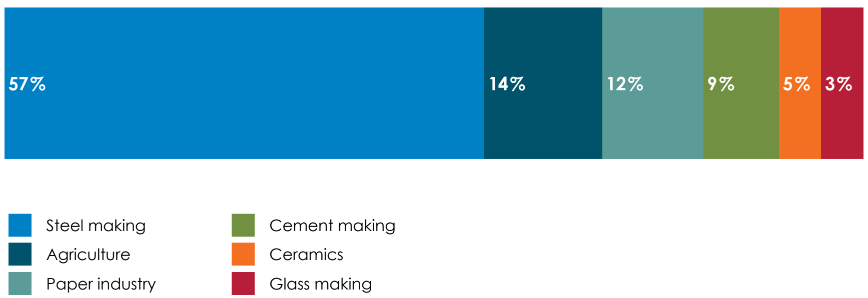
of magnesia is used in the steel making sector.

Overview of the European magnesia industry

In Europe, more than 98% of magnesite ($MgCO_3$ + heat ⇨ MgO + CO_2) is used for magnesia processing and refined in three commercial types of products: caustic calcined magnesia (CCM), dead burned magnesia (DBM) and fused magnesia (FM). DBM and FM are mostly used in the refractory industry for cement, glass, iron and steel making but it is also an important raw material in some advanced electrical application, leather tanning and other similar applications. CCM is mostly used in chemical-based applications such as fertilisers and livestock feed, pulp and paper, rubber and plastics, pharmaceuticals, hydrometallurgy as well as waste or water treatment.

In addition to being produced from magnesite (produced material is called natural magnesia), magnesia can be processed from other sources such as magnesium hydroxide, magnesium chloride together with dolomite or lime. The obtained material is called synthetic magnesia.

Main uses of magnesia over 2012 – 2016



Source: Industrial Minerals Forum and Research (IMFORMED), 2017, https://imformed.com/magnesia-maelstrom-in-china/

The end-uses of magnesia/magnesia include:

— Steel industry (also applies to cement, glass and ceramics): DBM and FM are used as the main raw material for basic refractories.

— The magnesia refractories can be classified in shaped and non-shaped. The shaped magnesia refractory bricks are often impregnated with carbon (tar, pitch, graphite) to give optimum properties for corrosion resistance in environments of basic slags, particularly in BOF (basic oxygen furnaces) or slag lines of treatment ladles. Magnesia bricks often in combination with spinel or chrome are also used in ferroalloy and non-ferrous industries (AZoM, 2001). Magnesia is also used in hot metal transport and machinery (JRC, 2013). The unshaped magnesia products are also used in special repair mixes. In this context, the optimization and improvement of the refractories based on magnesia represent key points for increasing the energy efficiency in other European industrial sectors.

— Agriculture: The magnesium element contained in magnesium oxide is required for plant photosynthesis and as a nutrient contributing to animal health. CCM is the most commonly used source of magnesium for ruminant nutrition, but is also used for sheep and poultry. In addition, CCM is used in various fertiliser applications, especially for crops such as citrus, potatoes, vegetables, fruit and grass pastures (Baymag, 2016). The use of magnesia in agriculture is important in several aspects like crop improvement and improvements in animal production, ultimately in the food chain.

— Paper industry: CCM is used in the chemical process of wood pulping as raw material for magnesium sulphite production, subsequently used for pulping as a cellulose protector and peroxide stabiliser (after pulp bleaching). The sulphite processes represent 10% of global wood pulp production (Grecian Magnesite, 2013). In addition, magnesia may be used in wastewater treatment that paper and pulping mills operate for the disposal of their water (Van Mannekus & Co, 2016).

— Construction industry: Sorel cement is a strong binder based on magnesia and a magnesium oxychloride formulation. It is fast-hardening and has a number of specific (e.g. industrial floors) and general repair applications. Magnesia is also used as a room temperature curing agent for phosphate cements (AZoM, 2001).

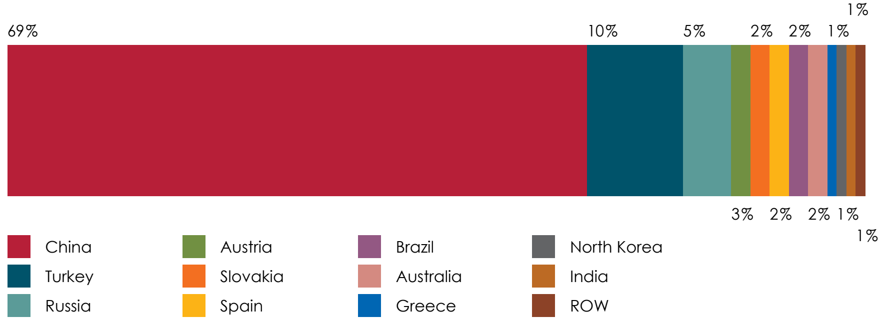
— Ceramics: Magnesia ceramics have high thermal stability, as well as good corrosion resistance, good insulating properties and thermal conductivity. They are mainly used for manufacturing high temperature crucibles, thermocouple tubes, heating elements, and foam ceramic filters for molten metal or in kiln furniture (SubsTech, 2015).

— Glass making: Magnesia is used by the glass industry for its thermal and pyrochemical resistance in melting furnaces and regenerator chambers as refractory lining (JRC, 2013). As constituent in the glass formulation leads to increased mechanical properties that are required in glass used in modern constructions and other technological applications.

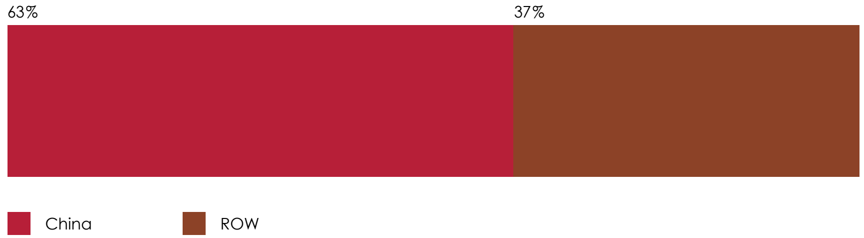
— Other applications of magnesia/magnesia include electrical insulation components (DBM), pharmaceuticals and cosmetics (CCM), sugar refining (CCM), fillers in plastics, rubber, paints and adhesives (CCM), etc. (Euromines, 2017).

In 2016, China made up over 69% of the global magnesia production and 63% of global magnesia production.

Magnesite world production 2016



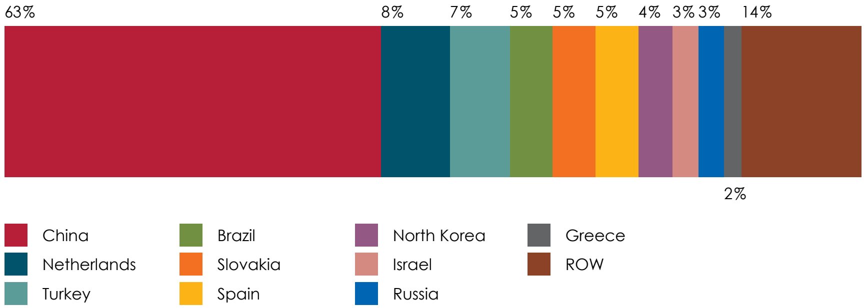
Magnesia production



Source: Industrial Minerals Forum and Research (IMFORMED), 2017, https://imformed.com/magnesia-maelstrom-in-china/

China is not only the main producer but it also dominates the export market as the largest exporter of magnesia in the world with just under half of the export market share, thus having a dominant power in setting the prices, prices with which the European producers have to compete against, leading to low profit margins for the sector.

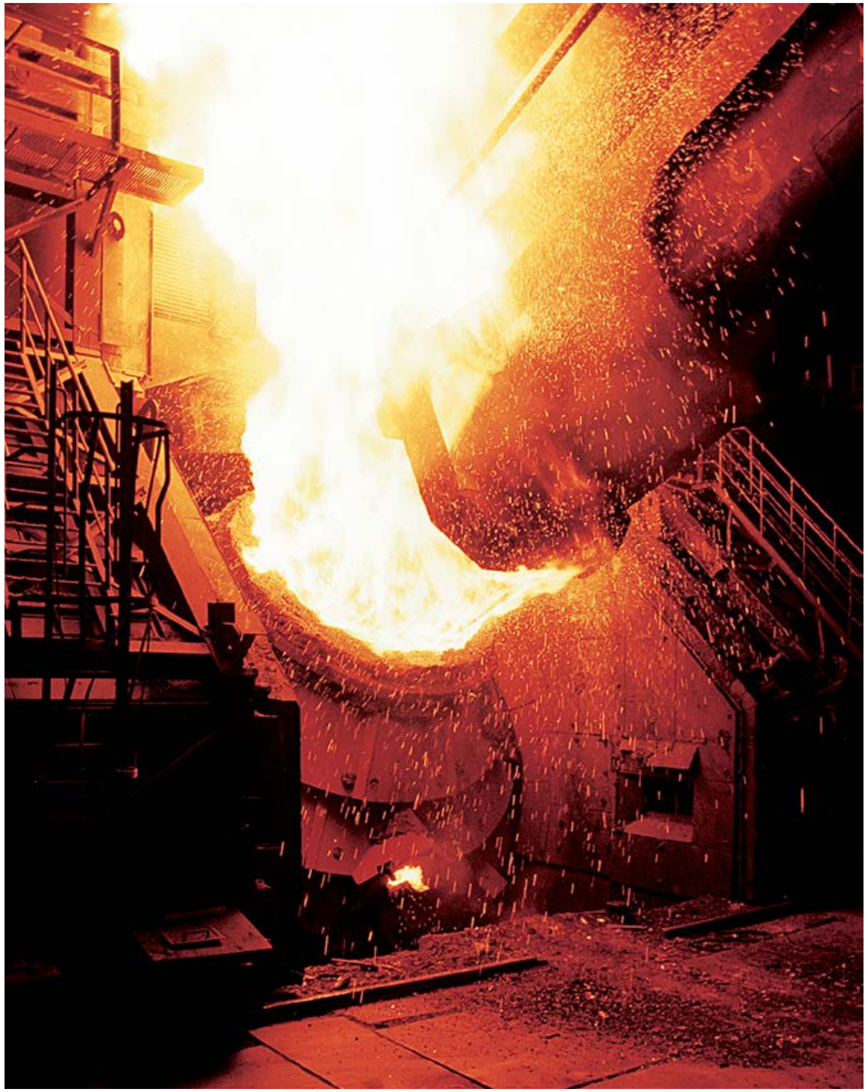
Global exports of magnesia by main country



Source: Industrial Minerals Forum and Research (IMFORMED), 2017, https://imformed.com/magnesia-maelstrom-in-china/

The main driver for demand for the magnesia sector globally and in Europe is the growth in refractory demand especially from the steel industry but also includes the demands from glass and cement sectors. Dead burned magnesia (DBM) currently makes up the largest portion of produced magnesia intermediate products. However, due to fused magnesia's (FM) superior stability and strength, demand and market share for FM is expected to grow in the future.

In the upcoming period, the global magnesium oxide market was projected to grow from 2016-2026 at over 4% CAGR, due to steady demand from iron and steel refractories and a resurgence of the construction industry which result in additional demand for cement and construction steel.




2
50%
In 30 years
50% less energy

chapter 2

The European magnesia industry and its contribution to a low-carbon economy

Process emissions are generated through chemical reactions among the raw materials used in the production process including their thermal decomposition. These emissions, strictly correlated to the production level by a multiplication factor, the so called stoichiometric factor (deriving from the CO_2 content of the used raw materials - geogenic emissions) are unavoidable. The magnesia production processes deal directly with this particular type "geogenic process emission" which are unavoidable and impossible to reduce without reducing the production level. The EU magnesia sector has different energy consumption the most important one is the thermal consumption in the burners for the transformation of magnesite in magnesia. The Temperature can achieve 2.000ºC. The thermal energy consumption can represent the 80-95% of the total energy consumption. Electricity is needed for all industrial equipment, offices and auxiliary departments: maintenance, laboratories. Also diesel is used for mobile machinery in mining and manufacturing activities.

The direct emissions of CO_2 from the magnesia production come from process emission up to 70% of the total and from thermal energy consumption from the burners. Residual emissions come from the use of diesel in heavy loaders and trucks. The sector also has indirect emissions due to magnesia sector is intensive consumer of electricity; grinding and sieving equipment among others.

The European Commission has already acknowledged the difficulty in reducing process emissions (Phase 3 of ETS): where the fall-back approach for process emissions is used, the number of free allowances provided is equivalent to 97% of the process emissions.

Despite its high share of process emissions from the chemical reaction of turning magnesium carbonate ($MgCO_3$) into magnesium oxide (MgO) and carbon dioxide (CO_2), a large proportion of emission from the sector being unavoidable, the magnesia sector has greatly improved its productivity and energy efficiency, to the extent that plants today are using as much as 50% less energy than they did back in the 1980s. The sector is still implementing new solutions aiming at further reducing the energy consumption and CO_2 emissions, these measures including exploring waste heat/waste gas recovery and alternative fuels for the firing process. As the world shifts to a low-CO_2 future, companies explore its future contribution to reducing CO_2 and to leveraging "decarbonisation" in other sectors in particular by supporting the circular economy and saving resources and by providing products for the energy transition. The magnesia sector is already exploring innovative ways to reduce emissions such as the use of biogas from animal waste in place of fossil fuels in the firing process and recovering heat from the firing process.

Data from industry indicates that the combined emission intensity has been improving from 16.8 $KgCO_2e$/ EUR in 2014 to 15.4 $KgCO_2e$/ EUR in 2016. Facilities have also introduced process optimisation measures that aim to improve energy efficiency and reduce CO_2 emissions, including:

— Fuel switching

— Improved insulation

— Improved systems using recycling of heat, cooling and compressed air

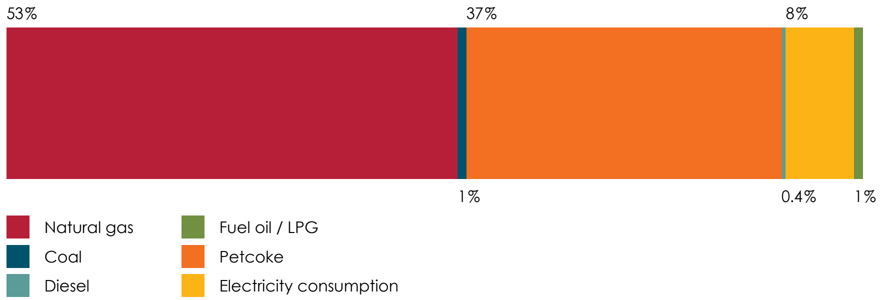
These measures integrated in the production processes combined with energy and emission savings have been a key factor in maintaining a competitive cost structure for the sector. Even more, electrification including the development of electric kilns capable of generating the high temperatures needed for the calcination process represents a distinct possibility and is being explored as a potential future decarbonisation method. As the sector grows and technological innovations will make new kiln types available, the European magnesia sector will consume increasing amounts of electricity and become highly dependent on the CO_2 neutrality of its electricity supply as a pathway to abatement emissions. Therefore, as the magnesia sector looks to reduce its emissions, electrification will increasingly become an area that is to be explored.

2.1 Access to clean power and current fuel mix

The European magnesia sector recognises the need to reduce emissions from the use of coal and supports collaborative approaches to accelerate the use of low-emission technologies as part of the transition to a lower carbon energy mix.

The current fossil fuel use by the magnesia sector is high but is in the process of transitioning to the lowest emitting fuel available. Natural gas accounts for almost 60% fossil fuel consumption.

2014 – 2016 average fuel mix by magnesia companies



Source: Data provided by Euromines member companies

2.2 Energy efficiency

The European magnesia sector has already implemented energy efficiency measures in the production processes aiming at reducing costs but also remaining competitive. Further abatement is heavily dependent on future technological developments in electric kilns and upon the emission intensity of the electricity grid.

Another very important aspect that needs to be taken into consideration when aiming at increasing energy efficiency is that the EU magnesia sector has different points of energy consumption; the most important one being the thermal consumption in the burners turning magnesite into magnesia, when the temperatures may reach 2.000ºC. The thermal energy consumption can represent the 80-95% of the total energy consumption and therefore electricity is essential for all industrial equipment, offices and auxiliary departments: maintenance, laboratories.

So far, the measures taken by the sector to improve energy efficiency included:

- Decrease of the thermal energy consumption supported either by the installation of heat exchangers or through the use of pure O_2, which had allowed to use a lower amount of natural gas
- Reduction in specific fuel consumption:
  - Shaft kilns by at least 20% since 1995, 10 % since 2001
  - Rotary kilns by at least 15% since 1995, 5 % since 2001
  - Calcination unit and shaft kiln by at least 40% since 2001
- Reduction of electric energy intensity with at least 20% since 2001 (in kW/t production)
- Reduction of specific fuel consumption in rotary kilns
- Optimization of the raw material pre-heater in rotary kilns;
- Implementation of a predictive control system for rotary kilns.
- Recovering at least 10% of the thermal energy waste

The future actions include a minimum 5% energy efficiency increase by 2025 through:

— New generation transformers
— Replacement of electrical motors with new generation low consumption motors (class IE3 and IE2 with converters)
— Progressive replacement of all lights with LED
— Recovery of thermal energy
— Improvement the quality of the kiln feed

2.3 Renewables energy use

The magnesia industry recognises the importance of using clean energy resources and it is already taking several measures aiming for a 100% renewable energy supply, amongst which are:

— the use of photovoltaic systems, and
— the use of 10-30% of the thermal energy from biomass.

However, unless the necessary energy is produced through a self- owned power generation plant, the access to renewable, carbon-neutral energy depends on the energy mix determined at national level.

Magnesia production no matter which type, has a calcination step that requires heating the magnesia up minimum 1,000 °C. In addition, electricity consumption is also present in mining and processing of the raw magnesia. Magnesia production therefore is very energy and electricity intensive. In this context and also given the fact that Directive 2018/2001 on the promotion of the use of energy from renewable sources states at paragraph (9) that "[…]a target defined at Union level would leave greater flexibility for Member States to meet their greenhouse gas reduction targets in the most cost-effective manner in accordance with their specific circumstances, energy mix and capacity to produce renewable energy," might not be enough to ensure the increasing electricity demand of the magnesia.

Last, but not least, the sector has to develop this technology for the rotary kilns, avoiding the corrosion that can be produced in the use of biomass at high temperatures.

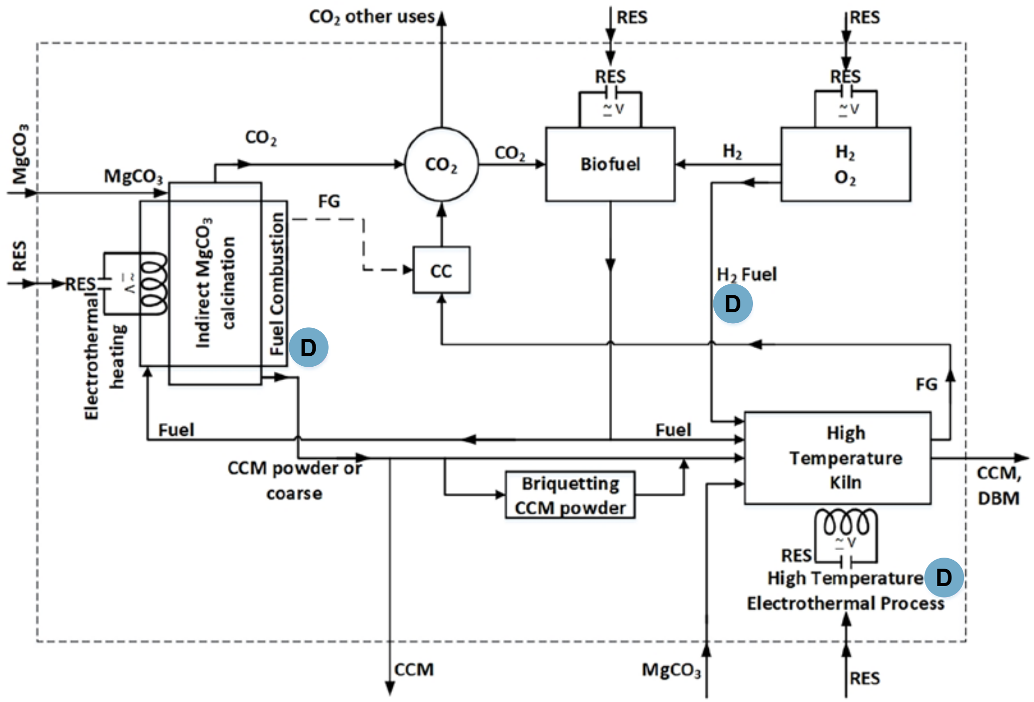
2.4 Low-carbon research, development and innovations for carbon neutral MgO production

Whilst as mentioned before, the magnesia sector has been and will continue to reduce its CO_2 emissions from energy use; the complete removal of carbon dioxide from its processing emissions has to include both the process emissions (decomposition of raw materials) and CO_2 from the thermal treatment process.

1. In both state-of-the-art magnesia production processes, described in paragraph 1 (magnesite and synthetic route), the unavoidable geogenic CO_2 emissions amount for 1,09 tn CO_2 / tn MgO. The only sustainable perspective for this type of emissions seems to be the CCU. The process CO_2 can be captured either as separate high purity CO_2 stream in an indirect calcination step or together with the other CO_2 emissions (Flue gasses) from the thermal treatment process.
2. The required very high temperatures (≈ 2000 °C) to produce DBM also generate thermal process CO_2 emissions. According to the existing technologies, these high temperatures can be generated only by fuels combustion. The future perspectives to replace the fossil fuels are the followings:
   - The use of biofuels and biogas that will be produced by the CO_2 captured from the magnesia production and H_2 produced using RES. It is expected that most of the CO_2 generated in the MgO production will be used back to the process as fuel – close CO_2 loop.
   - High temperature kilns powered by RES, either as traditional kilns and burners technology using H_2 fuel or new generation of kilns based on the development of high temperature electro thermal processes.

The figure below depicts a future vision of the carbon neutral Magnesia production from Magnesite.

Zero CO_2 emissions MgO production scheme



Having that in mind the CCU for process emissions and CC and conversion to fuels of the thermal process emissions as key enablers to reach carbon neutrality, several companies in this sector already participate in projects aiming at designing and testing of innovative processes for CO_2 capture and its use in industrial production.

However a common cross-sectoral effort to develop breakthrough technologies such as the following is required.

- CC technologies at affordable cost.
- Electricity from RES.
- Conversion of CO_2 to biofuels.
- Technologies to use H_2 fuel.
- High temperature electrothermal processes.

2.5 Circular economy in magnesia production

The current goal of the magnesia/magnesia industry in Europe is to assure a sustainable process of magnesia raw material mining with a net zero waste generation, and therefore our minimum waste technology of magnesia mining is in operation approximately 94% days a year. The fine mineral particles accumulation in the tailing pond is currently around 5-7 thousand tons per year and waste aggregates are reduced by approximately 250 thousand tons of material per year.

The future projects to be developed by our industry include:

- Recovery magnesia from old tailings
- Valorise low grade magnesia deposits
- Recycling and use of mining waste sand by-products
- Used refractories are recycled

2.6 Quality improvements in the sector leading to reduced material consumption along the value chain

Reducing emissions also contribute to a performance increase in the characteristics of the magnesia products used in the steel production. For example, an increase of the economic lifetime of the installed refractory linings – magnesia products result in a reduced consumption of refractory products per unit in the production of steel. Specific consumption of refractory materials in the steel industry reduced in the last 35 years from the value of 30kg/t of produced steel to the current value of 10-15 kg/t produced steel (INFORMED 2017).


3
8%
of world magnesia
produced in Europe.

chapter 3

Challenges:

The magnesia industry supports efforts to mitigate CO_2 emissions by investing in and/or implementing solutions enabling and leading to a low-carbon economy. However, in spite of our commitments the sector finds itself several times increasingly squeezed between high electricity, fuel and CO_2 costs in Europe and competition from China and other major exporters. Continued cost and competition pressure on European producers is likely to lead to issues such as disruption of supply for the value chains such as European producers of steel and cement, which rely on the various magnesia intermediate products.

3.1 Trade competition

If the European magnesia sector will not be able to compete, Europe will find itself dependent on Chinese and other non-EU magnesia materials. China already dominates the export market as the largest exporter of magnesia in the world with just under half of the export market share. China's dominance of the market at nearly 70% of the global production means that the Chinese magnesia sector can often set prices and, while there are some quality differences between magnesia products, product price remains a key factor in the competitiveness of the producers.

3.2 The price setting

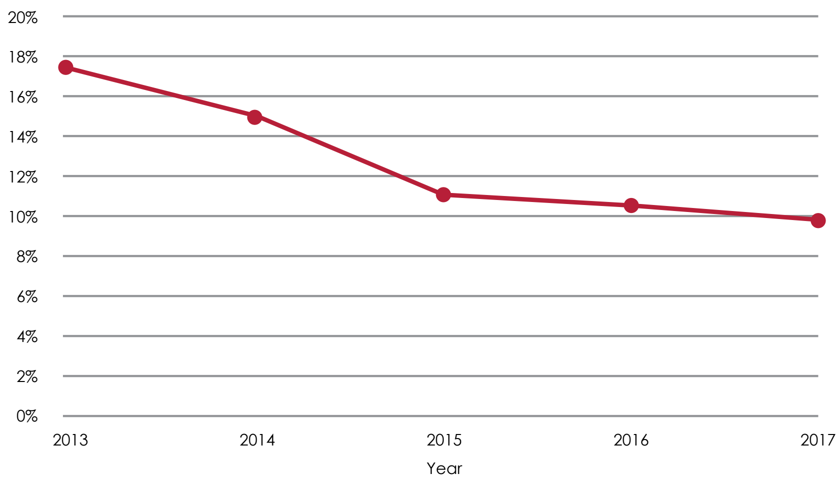
The European magnesia sector is considerably exposed to world markets and global price setting. The largest share of its production is sold to sectors characterized by high concentration and strong bargaining power. Price differentiation based on quality is only possible to limited extent, especially in light of the sheer dominance of China in the export market, and hence European producers can be seen as price takers for this product segment. Trade ratios in the sector are high and European companies have to compete increasingly with low-cost manufacturing countries.

For magnesia, the main customer segment is the steel sector. The steel sector works with global purchasing organizations that compare prices across suppliers worldwide and buy in large quantities, as such the steel sector also has significant bargaining power with suppliers. Price differentiations as a result of quality or specific product characteristics and service is only possible to a limited extend and price is more and more seen as the determining factor.

3.3 Ongoing increasing costs and expenses

Due to the high trade intensity, nature of the market and presence of low-priced Chinese competitors, profit margins are low. Furthermore, as the cost of electricity in EU countries are tied with the price of EUAs (since power generators covered by the EU ETS pass their carbon costs to customers), the recent increases in EUA prices have led to additional cost concerns amongst magnesia producers. Data collected from European magnesia producers shown below indicate that due to a rise in costs, the average profit margin in the sector has fallen by over 6% since 2013.

Average profit margin for magnesia producers



Source: Data provided by Euromines member companies

chapter 3

On average the earnings before tax (EBITA) of European magnesia and magnesia producers has dropped by over 40% from 2013 to 2016.

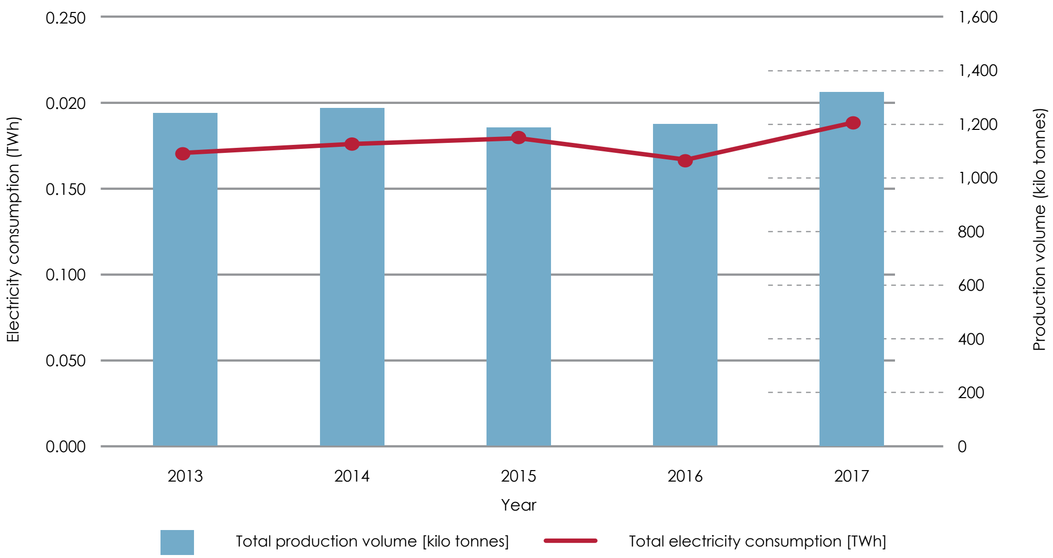
3.4 Increasing electricity prices

The electro-intensity of the companies is based upon only electricity consumption for the production magnesia and values on average (unweighted) are around 0.15MWh/t reflecting the high proportion of DBM produced (which has comparably lower electricity intensity) compared to FM which can be over 3.5 MWh/t. However, it is important to note that electricity intensity is likely to increase as the production of FM is projected to increase and as the magnesia sector looks to decrease emissions through electrification (a potential major development pathway for future technologies. The electricity intensity of the magnesia sector is thus already higher than some of the sectors considered to be eligible for indirect emissions compensation, providing an indication of how vulnerable the sector is to carbon cost pass through from European power generators, especially if the electricity consumption within the sector is to grow.

3.5 Increasing EUA prices

In the previous section, it has been demonstrated that the indirect carbon costs passed on to the sector by electricity suppliers are difficult to pass on to customers given the global market and high trade intensity. This implies that such costs would have to be absorbed by the companies in the sector itself, at the expense of profit margins. Given the low profit margins of the sector, the sector has limited capacity to absorb the cost pass through as carbon costs would eat up a significant percentage of already decreasing profits.

Annual electricity consumption and production of the European magnesia sector



Source: Data provided by Euromines member companies

EUA prices [EUR/tCO_2] 2014 to 2018

Source: European energy exchange, https://www.eex.com/en/market-data/environmental-markets/spot-market/european-emission-allowances#!/2019/03/04

Compared to other regions of the world, that are part of the same global market, this would imply a loss of competitiveness for EU magnesia and magnesia producers, which may lead to decrease in profit and market share vis-a-vis non-EU producers not facing such additional costs. As a result of this there is a risk to carbon leakage given that major competitors in other regions of the world do not have similar cost issues when producing the same products. This problem is likely to be further exacerbated by the rising price of EUAs which in turn is likely to result in rising electricity prices.

4

100%

taking measures aiming for a 100% renewable energy supply

chapter 4

Conclusion and recommendations

Ensuring a carbon neutral society and reaching the climate change targets requires multiple actors along the entire value chain to act simultaneously towards the same objective. Therefore, a shift is needed towards a systemic approach. When determining the contribution brought by a specific economic activity, three strategic segments should be addressed simultaneously: the sustainable supply of the raw materials needed to support the deployment of low carbon technologies; the contribution of production processes of upstream and downstream industries and the closure of the material loops (the shift from linear to circular thinking). Only through an integrated value chain approach can real advances in low carbon technologies be understood, achieved and evaluated on a long term.

Using a value chain approach would make it easier to boost the contribution of existing economic activities, but also to create and develop new more efficient low-carbon activities, through the introduction of new materials and investments.

At the same time it is essential to ensure that objectives and related measures are proportionate, practical and implementable, in line with EU competition rules and business confidentiality requirements.

European Magnesite Producers:

— Grecian Magnesite S.A.

— Magnesitas De Rubián S.A.

— Magnesitas Navarras

— Nedmag B.V.

— RHI Magnesita

— SLOVMAG

— SMZ, a. s. Jelšava

— Terna Mag S.A.

European Association of Mining Industries,
Metal Ores & Industrial Minerals

Avenue de Tervueren 168, box 15,
1150 Brussels, Belgium

www.euromines.org

Tel.: +32 2 205 08 40