INDUSTRIAL MINERALS SECTOR CONTRIBUTION TO CIRCULAR ECONOMY

Industrial Minerals

Together for Sustainable Future

IMA Europe

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Executive summary

The concept of Circular Economy although not new, within a policy context is aiming to transform the economy from a linear into a circular model, by promoting and putting into practice the recycling, recovery and the re-use of end applications. The mining sector has embraced the concept of circular economy in its own processes, minimising the negative impacts on the environment, the society and maximizing its favourable impact on the overall economy. New innovative projects have been developed to reach more sustainable business models, which go from the extraction and processing of the minerals, through the delivering of products to the value chains, to the recovering of the land after the use.

Following the commitments undertaken in the sector roadmap 'Imagine the Future with Industrial Minerals, this report presents projects from industrial minerals companies contributing to the circular economy, throughout the different life cycle stages of the minerals: extraction, manufacturing, transport, use phase and end of life. Myths and facts regarding the industries are exposed in the light of case studies coming from different countries, companies and related to different minerals, with both qualitative and quantitative data.

The chapters of the report correspond to different life phases of minerals, throughout the value chain: Optimisation of the use of resources at quarry level; improvement of processing to minimize environmental implication and mitigate carbon footprint; minimization of transport and facilitation of usage at customer's premises.

Quarries are managed as to minimize footprint and optimize the use of natural resources, operations are constantly improved to reduce carbon emissions and reduce wastes, transport is permanently challenged to implement the best techniques.

The sustainable use of the land is a concept now embedded in the industry business model. The post-mining restoration is part of the permitting process and many companies adapt their plans to the need of the specific site and the local communities. As the last stage of the life cycle, the report focuses on the mineral optimization during the use phase along the entire value chain and at their end of life. Projects show that the mining industry brings added value to circular economy along the value chain improving for instance the performances of their applications and increasing their recyclability.

Case studies are very diverse, in terms of geographical coverage and methods to achieve the same objective, therefore offering a large catalogue of good practices.

Our sector is strongly committed to contributing to economic growth and societal wealth in the EU through sustainable extraction, production, management and use of the invaluable resources they produce or use to contribute to the overall policy objectives of the Circular Economy.

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List of abbreviations

CRM's – Critical Raw Materials

IM – Industrial Minerals

LREE – Light Rare Earth Elements

LCI – Life Cycle Inventory

LCA – Life Cycle Assessment

IMA-Europe – Industrial Minerals Association Europe

IMA-NA – Industrial Minerals Association North America

PCC – Precipitated Calcium Carbonate

GCC – Ground Calcium Carbonate

FGT – Flue Gas Treatment

Legend of symbols used in the case studies

Resource optimization & By-product valorization
(at quarry)

Water efficiency
(at quarry)

Fuel/Energy efficiency & Mitigate process emissions
(at processing stage)

Energy generation (wind, solar, hydropower)
(at quarry & processing stage)

Co-existence & Land restoration
(at quarry & post-closure stage)

Digitalization
(at processing stage & use phase)

Sustainable transport
(at quarry & transport to end users - module transport change)

Use light materials
(at use phase)

Waste to product & Synergies in supply chain recycling
(end of life)

Cost savings

1. Introduction

Industrial minerals are geological materials which are mined for their commercial value. They are **not fuel (fuel minerals or mineral fuels)** and are **not sources of metals (metallic minerals)**.

They are used in their natural state or after beneficiation either as raw materials or as additives in a wide range of applications.

The most known industrial minerals are:
Calcium Carbonate, Limestone, Clays, Kaolin, Silica sand, Diatomite, Bentonite, Borate, Feldspar, Talc, Andalusite, Mica, Vermiculite, Sepiolite.

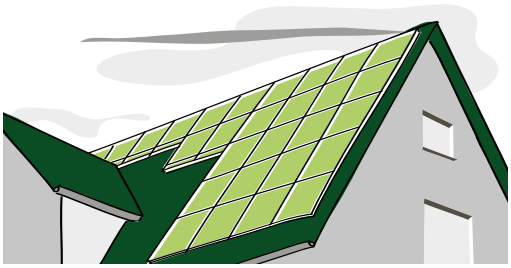
Did you know that?

GLASS: 100% minerals
Silica sand, Dolomite, Calcium carbonate, Lime, Feldspar, Borate

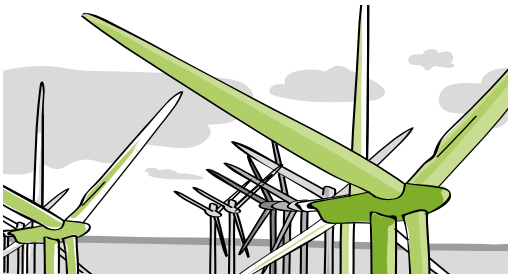
PAINT: 50% of minerals
Calcium carbonates, Quartz, Cristobalite, Plastic clay, Talc, Bentonite, Diatomite, Mica, Perlite

CERAMICS: 100% minerals
Feldspar, Clay & Kaolin, Lime, Talc, Silica

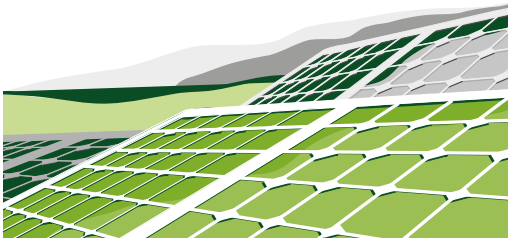
PAPER: up to 50% minerals
Calcium Carbonate, Talc, Kaolin, Bentonite



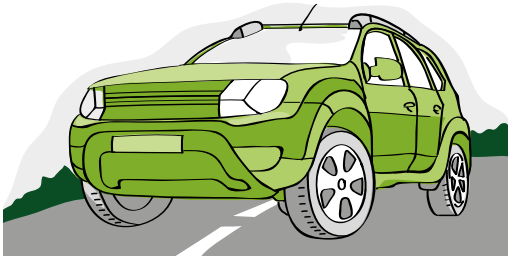
HOUSE: up to 150 tonnes of minerals
Cement (Clay, Lime, Silica sand), Plaster & Plasterboard (Gypsum, Hydrated lime, Calcium carbonate), Insulation (Perlite), Ceramics, Bricks & Tiles, Glass, Paint, etc.



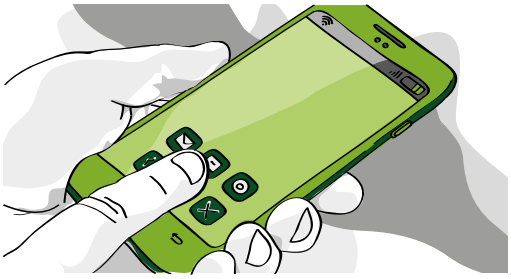
WIND BLADES: up to 95% of minerals
Advanced plastic & Fiberglass (Silica sand, Limestone, Soda ash, Borax, Feldspar, Nepheline Syenite, Magnesite, Kaolin, Clay), Steel (Limestone, Bentonite, Silica sand), Concrete (up to 85% of minerals, Lime(stone), Aggregates)



SOLAR CELLS: up to 95% of minerals
Quartzite, Boron



CAR: up to 100-150 kg of minerals
Rubber (Talc, Calcium carbonate, Baryte), Plastics (Talc, Calcium carbonate, Kaolin, Silica sand, Wollastonite), Glass (Silica sand, Dolomite, Calcium carbonate, Lime, Feldspar, Borate), Casting (Bentonite, Silica sand, Wollastonite)

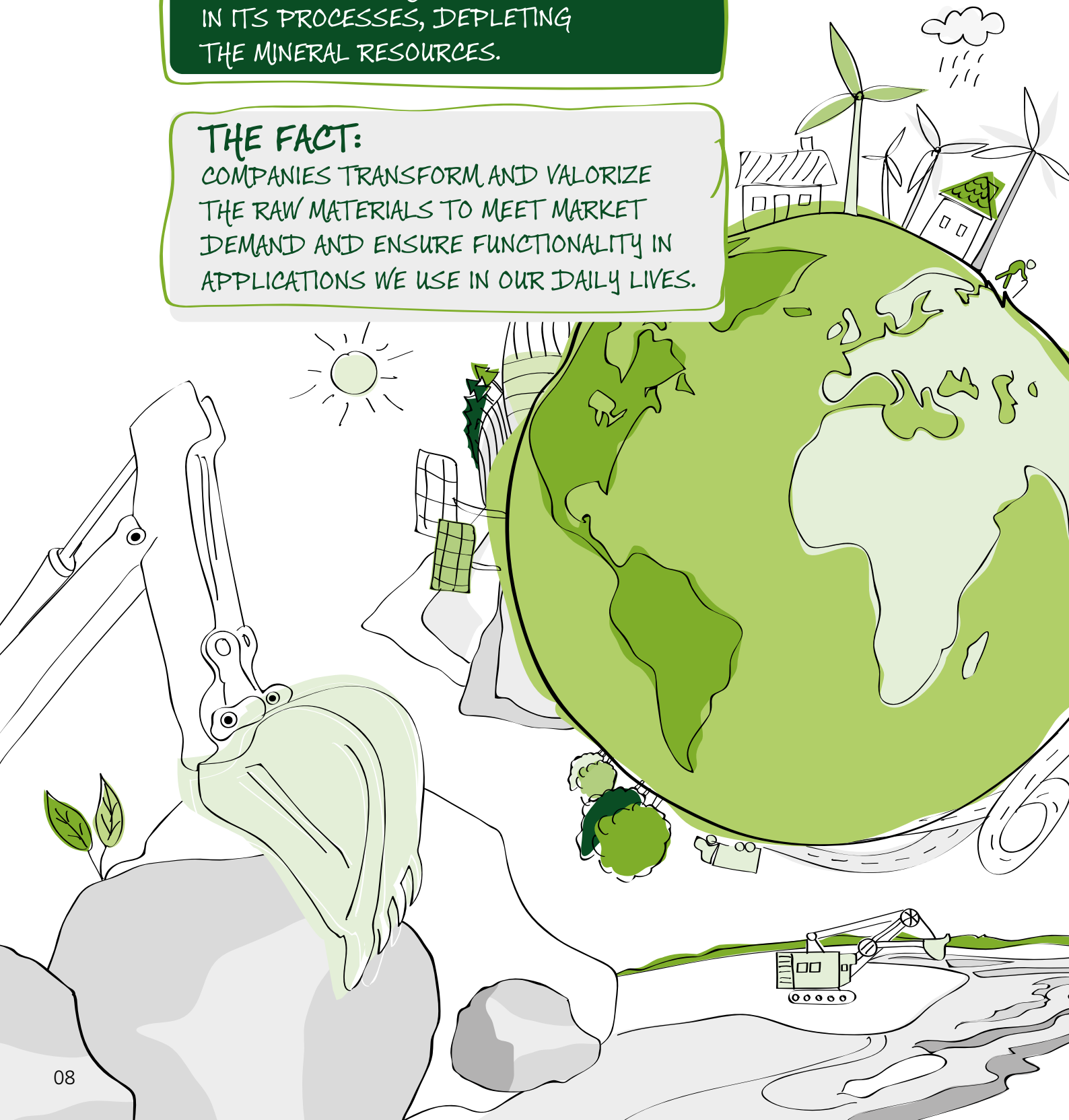


SMARTPHONE: up to 60% of minerals
Cover (resistant, lightweight, fire-proofed and recyclable Carbonates, Mica, Talc), Battery (Calcium carbonate, Silica sand, Clays), Reinforced Steel (Silica sand, Andalusite, Lime), Glass (47 g Silica sand)

2. Resource Optimization of Minerals at quarry

THE MYTH:
THE MINING INDUSTRY USES ONLY HIGH QUALITY RAW MATERIALS IN ITS PROCESSES, DEPLETING THE MINERAL RESOURCES.

THE FACT:
COMPANIES TRANSFORM AND VALORIZE THE RAW MATERIALS TO MEET MARKET DEMAND AND ENSURE FUNCTIONALITY IN APPLICATIONS WE USE IN OUR DAILY LIVES.



THE MYTH:

THE MINING INDUSTRY HAS NO SOLUTION TO DECREASE THE WASTE GENERATION.

THE FACT:

THANKS TO DEMAND, AS WELL AS THE DEPLOYMENT OF INNOVATION AND NEW TECHNOLOGIES, THE INDUSTRY MANAGED TO DECREASE THE WASTE VOLUMES, AS WELL AS LOWER THE WATER FOOTPRINT.

Gravel Mining in Bentonite Quarries

The project developed in Bavarian Bentonite operations at Clariant. From the bentonite extraction & processing operations, also sand and gravel for the building industry could be valorized thanks to the high demand and the practice put in place on-site. To achieve this resource optimization, the bentonite overburden is processed, separated and classified to get sand and especially gravel for the concrete industry.

Raw materials:	Bentonite (primary), Sand & Gravel (by-products)
Country:	Germany
Replicated:	Yes
Innovation:	Quarry Develop best practice of sorting and classifying by-products for use in the concrete building sector (6 million tons overburden, 180 000 tons gravel)

Sector commitment towards sustainability at quarry and value chain sustainable resource management

As part of its effort to assess the impacts of the different minerals in the extraction and processing stage, IMA Europe has conducted Life Cycle Inventory (LCI) projects. These projects are part of a strategic sector commitment towards sustainable management resources at the quarry as well as along the value chain. The LCI data are qualitative, based on industry data from operations and the studies are verified by external experts and are freely available to interested stakeholders and LCA experts[1]. Apart responding to requests down the value chain, members use these studies to develop plans to mitigate and lower their overall environmental footprint.

IMA Europe's minerals	Bentonite[2]	Calcium carbonate[3]	Silica[3]	Feldspar[3]	Kaolin, Clay[3]	Hydrated lime, Quicklime[4] [5]
LCI	√	√	√	√	√	√
Geographical coverage	EU + Turkey + Morocco	EU + Turkey + Norway	EU + Turkey	EU + Turkey	EU + Turkey	EU-28

[1] http://eplca.jrc.ec.europa.eu/ELCD3/ [2] Shtiza A. Doome R. and M. Wyart. 2014. Sustainability is not about measuring, is about driving actions: Use of life cycle analysis within industrial minerals sector and beyond. 8th International Conference of Society & Materials, 20-21 May, Belgium. [3] Shtiza A. R. Doome and M. Wyart. 2013. Assessing the environmental footprint of selected industrial minerals by means of life cycle inventory analysis: A sectoral study. 6th International SDIMI, Greece. [4] Schlegel T., Naffin B., Gregoire D., Shtiza A., Despotou E. 2012. Life cycle inventory of quicklime and hydrated lime: A study from the European Lime Association (EuLA). SETAC Europe 18th LCA Symposium, 25-27 November, Denmark. [5] Shtiza A., Verhelst F., 2014. The value of EuLA life cycle inventory (LCI) data to conduct LCA studies & their applicability. Science-Industry Roundtable: The use of lime in mortars. 10 July, Portugal.

Raw materials: Bentonite, Calcium carbonate, Silica, Feldspar, Kaolin, Clay, Quicklime, Hydrated lime
Country: Europe
Replicated: Industrial Minerals Association North America (IMA-NA)
Innovation: Quarry
Identification of hot spots for improvement

Talc waste valorized in landscaping and safety embankments

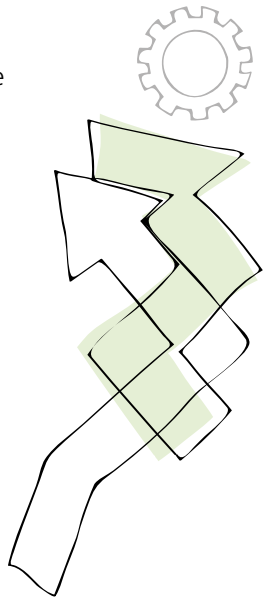
Waste or sterile rock generated from the extraction stages are used on-site for screening, landscaping, haul road surfacing, safety embankments along haul roads or river embankments and edging for settlement ponds. All these measures result in lowering the volume of waste to be disposed and also create new eco-systems for the flora and fauna to thrive in the ongoing operations.

Raw materials: Talc
Country: France
Replicated: Austria
Innovation: Quarry

Boron's overburden wins Solid Waste Reduction Awards

Rio Tinto Borates has established procedures around the world to reduce, reuse, and recycle waste produced at its operations and offices. As an example of this, the Boron mine in California has developed an innovative approach to dispose the overburden, which will lead to a significant reduction in its diesel use. Extensive geological engineering analysis were integrated into cost-environment--benefit analysis. Boron's analysis suggests that in-pit dumping will reduce diesel use by an average of **4 million litres per year** over the life of the mine, due to reduction in distance and travel time required to complete a cycle. The Boron site has been honoured with the Solid Waste Reduction Awards from the California Integrated Waste Management Board[6].

[6] http://www.riotinto.com/energyandminerals/boron-4638.aspx



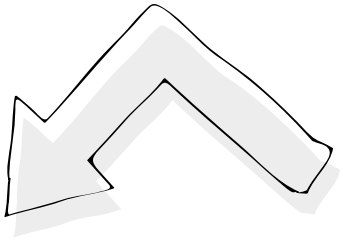
Raw materials: Boron
Country: USA
Replicated: Not reported
Innovation: Quarry
Overburden in-pit disposal results in average fuel savings 4 Mill litres/year over the lifetime of the mine due to reduction in distance and travel time required to complete a cycle. Boron operations have lowered energy use and greenhouse gas emissions by >5% per tonne of product through improvements in plant design and maintenance practices

Kaolin waste as source of Light Rare Earth Elements (LREE)

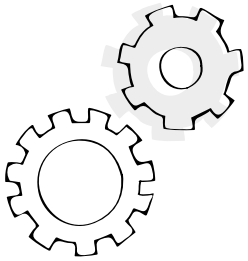
The high demand for critical raw materials in EU, has driven some innovation towards the historical waste and their potential to deliver some of these CRM's for the EU economy. The kaolin processing waste from Cornwall operations of Imerys were assessed for their viability to process and to supply critical raw materials to the EU needs and mitigate the supply risks from global suppliers[7].
Light Rare Earth Elements (LREE), hosted in monazite and rare-metals (Sn, Nb, W), hosted in cassiterite, rutile and wolframite, respectively, are pre-concentrated in the micaceous residue of a kaolin plant. An enhanced gravity concentration flowsheet was developed and tested, to assess feasibility of extracting the LREE's and metals.

[7] Dehaine Q., Filippov L.O., 2015. Rare earth (La, Ce, Nd) and rare metals (Sn, Nb, W) as by-product of kaolin production, Cornwall: Part 1: Selection and characterisation of the valuable stream. Minerals Engineering 76, Pp. 141-153. http://dx.doi.org/10.1016/j.mineng.2014.10.006

Raw materials: Kaolin (primary), Sand & Gravel (by-products), Critical raw materials (CRM's)
Country: UK
Replicated: Ongoing
Innovation: Quarry
Kaolin waste assessed for CRM's



Limestone, integrated approach for Resource Optimization from the extraction and processing stages



Nordkalk strives to optimize the use of all the extracted /processed raw materials, aiming for 100% material efficiency, which is sound from both financial and environmental point of view. The raw material optimization efforts include using all by-products: wall rock that is extracted in addition to regular limestone, fine sand produced in the flotation process, filter dust, which builds up in all lime kilns and at grinding plants, and residues created in lime burning and slaking. Nordkalk also assists its customers by handling their process by-products in a sustainable way. In 2016, Nordkalk was able to raise the material efficiency rate **from 94.3% to 96.6%**, thanks to the integrated approach developed that focuses on valorization of lime kiln dust and especially of wall rock to ensure the same functionality during the use phase[8].

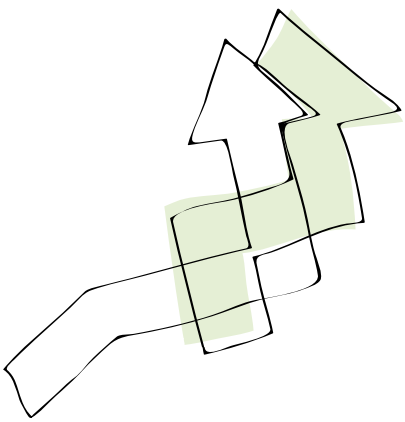
[8] Nordkalk Sustainability Report 2016. Pp. 10.

Raw materials: Limestone
Country: Finland
Replicated: Estonia, Sweden
Innovation: Quarry
Rock wall and dust kiln by-products use improved the resource efficiency of the site from 94.3% to 96.6%

Today's the backfill, tomorrow's the raw material

In the 80's, with the development of the paper industry, the kaolin was exclusively used for paper application. With the 90's crisis, due to changes in the paper market, Cavisa valorized the former waste flows into new markets. So, the kaolin that was not good for paper due to abrasion, were recovered to supply the ceramic glaze or in the paint market. Current tailings formed by Kaolin, Mica and Silica sand, were in proper proportion and granulometry for new formulations in new strategic industrial sectors. There was a small problem: consumption rate was smaller than the production rate. Thus, the mining company used the by-products to restore old mines, to valorize them in the future.

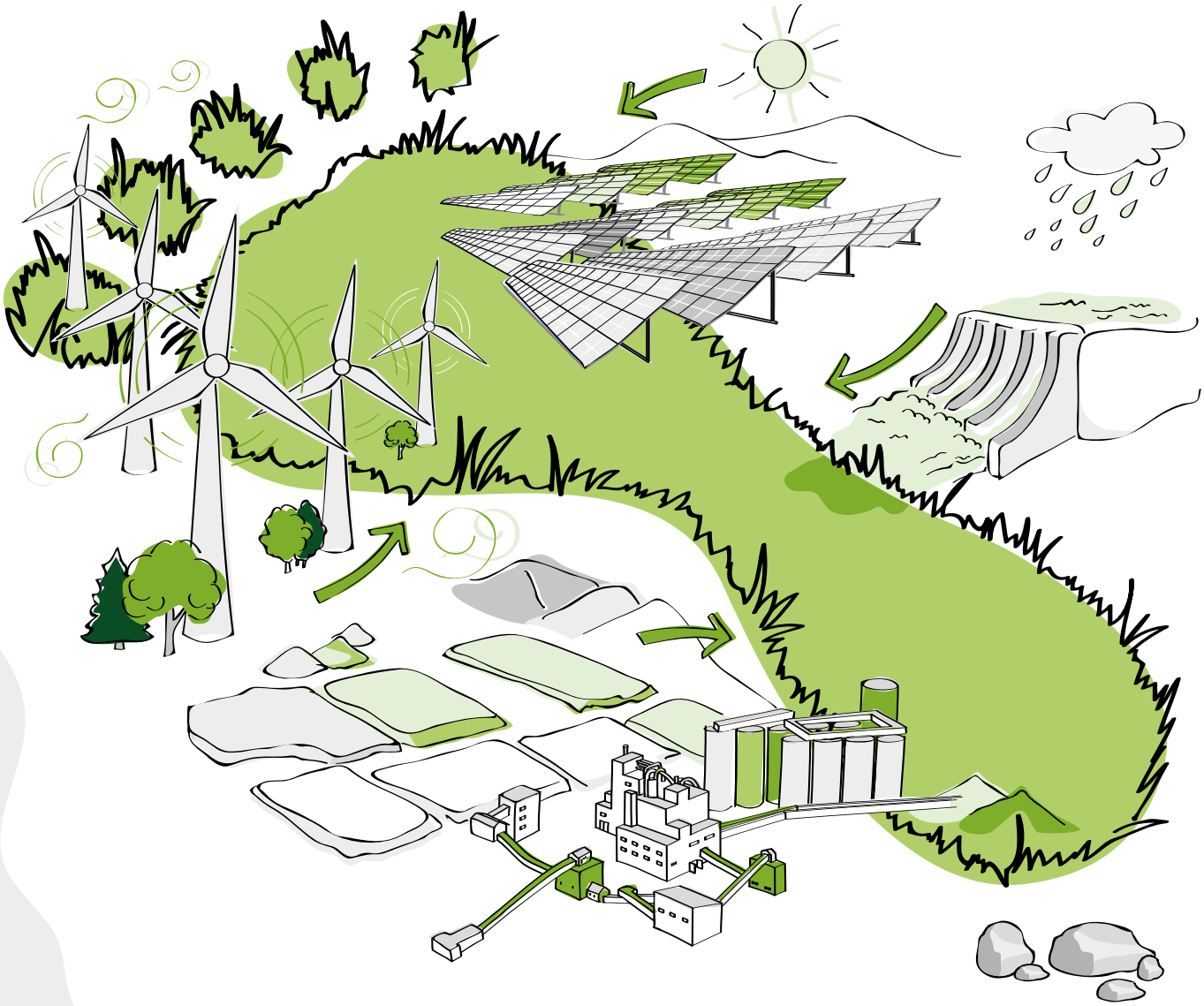
Raw materials: Kaolin, Mica, Silica sand
Country: Spain
Replicated: Not reported
Innovation: Quarry



3. Optimization of Minerals/Energy at processing

THE MYTH:
THE MINING INDUSTRY IS NOT SUSTAINABLE.

THE FACT:
COMPANIES HAVE DEVELOPED PROJECTS TO ASSESS PROCESS HOT SPOTS AND HAVE ADOPTED STRATEGY TO MITIGATE FUEL DEPENDENCY AND LOWER THE CARBON FOOTPRINT.



Processing efficiency in the drying stage of talc manufacturing

The project includes a production line for a new generation of highly lamellar talc with a process more efficient in water, energy and gas for the final drying of the product[9] Imerys talc is progressively converting its plants from fuel oil to natural gas which produces less sulfur and lower CO_2.

[9] Ademe publication (MAG N°34).

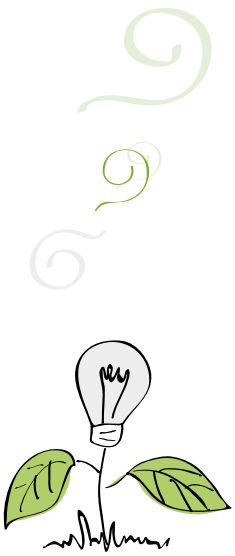
Raw materials: Talc
Country: France
Replicated: Not reported
Innovation: Processing stage
Green Energy generation (solar)
Energy efficiency (60% of site energy needs)
Water efficiency

Energy Efficient Calcination at silica site

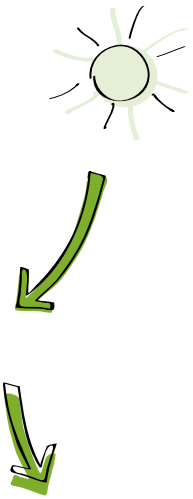
To meet growing demand from customers worldwide, in October 2017 Sibelco officially opened its third cristobalite kiln. Located in Belgium, the new kiln utilises the latest technology to synthesise cristobalite. The new kiln operates to advanced levels of energy efficiency with lower emissions. A multinational team worked collaboratively to deliver the project on promise, with construction completed on time and budget with zero accidents, and in close cooperation with the local community and authorities throughout. Sibelco was privileged to welcome a wide range of stakeholders to the official opening ceremony, providing customers with a close-up look at the new facility which will enable to increase cristobalite production by around 70,000 tonnes per year[10].

[10] Sibelco Annual Report 2017.

Raw materials: Silica, Cristobalite
Country: Belgium
Replicated: Not reported
Innovation: Processing stage
Energy efficiency



ADIREN4LIME Anaerobic Digestion as a Renewable Energy for the Lime Industry



Lime processing needs large amount of energy (kiln, hydrator, crusher, mill). The project of Singleton Birch aimed at reducing energy costs and reliance on grid electricity and gas. Anaerobic Digestion is a process where micro-organisms break down some organic biomass in anaerobic conditions to produce biogas. The methane can be used to produce electricity or upgraded to Biomethane for injection into the gas grid and can be used as a fuel for lime kilns. The combined output of the 3 Anaerobic Digestion plants is 110% of Singleton Birch's electricity demand. The grid connection has a capacity to export 100% of electricity to grid and generates 15 GWh of electricity per annum.

Raw materials: Lime
Country: UK
Replicated: No
Innovation: Processing stage
Green energy generation (abiotic depletion: 15 GWh/year)

Commitment to renewable at Kaolin and Ball clay site

Imerys Kaolin (UKP) has a strong commitment to a greener future and has recently made significant investments in renewable energy installations across its restored clay pits, mica dams and in surrounding land in the UK: 34 MW capacity of installed renewable energy; 10 renewable energy installations (4 wind turbines, 5 solar parks). Using renewable electrical energy from three sites, Imerys Kaolin has reduced carbon emissions by -3000 t/CO_2. This is a 5% reduction[11].

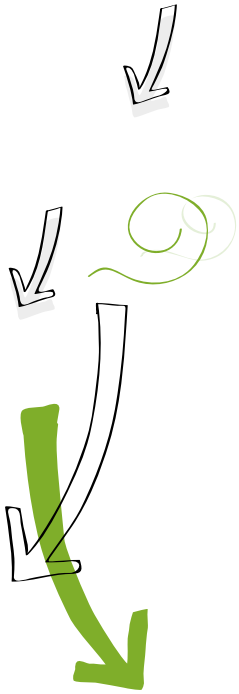
[11] https://imerys-kaolin.com/europe-middle-east/wp-content/uploads/sites/3/2017/02/UKP_SD001-Imerys-Kaolin-SD-brochure_A4.pdf

Raw materials: Kaolin, Clay, Mica
Country: UK
Replicated: Ukraine, France
Innovation: Processing stage
Green Energy generation (solar/wind)
Total: 5% carbon emission reduction
CO_2 footprint (-3000 t/year)

Natural drying of bentonite in air drying fields and optimization of bentonite use for the end applications

Imerys (formerly S&B) uses low purity bentonite raw material to mix with high purity one to avoid sacrificing high purity when not required in the end application. Air drying of mined bentonite deposited in layers, lowers fuel consumption in subsequent processing steps, resulting in also reduction of fuel dependency and reduction of the carbon footprint.

Raw materials: Bentonite
Country: Greece
Replicated: Italy by Clariant
Innovation: Processing stage
Energy efficiency (-35% less energy consumption)
CO_2 footprint (-24,000 t/year)
Optimized use of raw materials for the end application
Valorize low quality Bentonite

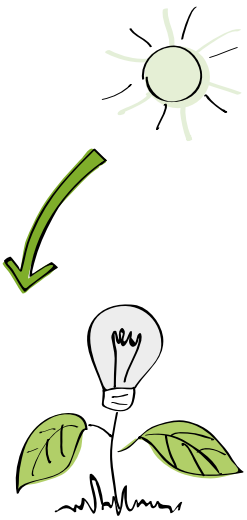


Green wind energy in silica sand site

A trio of new wind turbines are now fully operational at Sibelco's Mol/Dessel site in Belgium. The turbines will generate more than 21,000 MWh of clean energy per year will contribute to the Belgian green energy grid production as well as to the company processing stages. The project was developed in association with energy specialists, and will significantly reduce the carbon footprint of Sibelco's local operations. A second project, incorporating seven turbines at Sibelco's site in Lommel, Belgium, is in the final stages of permitting[12].

[12] Sibelco Annual Report 2017.

Raw materials: Silica sand
Country: Belgium
Replicated: Taiwan & Australia operational, Belgium ongoing
Innovation: Processing stage
Green Energy generation (wind: 21,000 MWh/year)
Energy efficiency



STOICISM an example of integrated assessment for energy and resource efficiency

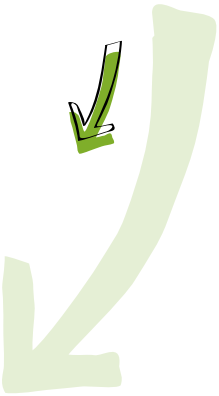
Sustainable Technologies for Calcined Industrial Minerals (STOICISM) objective is to provide technology solutions to reduce impact on the environment, contribute to the sustainability of European mineral resources and exploiting new, high value-added mineral products. The new technologies were tested for the calcination of minerals, notably diatomaceous earth (DE), perlite and kaolinitic clay[13]. Multiple innovations delivered on digitalization of the processing and on-line monitoring towards energy and resource efficiency. The link of the deposit with the end uses was extensively explored to optimise resource use and better market requirements.

[13] https://www.stoicism.eu/stoicism-fp7-research-innovation-project

Raw materials: Diatomaceous earth (DE), Perlite, Kaolinitic clay
Country: UK, Greece, Turkey, Spain
Replicated: Not reported
Innovation: Processing stage
Thanks to the use of digitalization, processing stage improvements the following can be reported:
– for Kaolin (greenhouse gas impact could be reduced by 80% if the dry mining, renewables and fluidized bed projects are combined)
– for DE (greenhouse gas impact could be reduced by 65%, if the advanced electrostatic separation, renewables and waste recycling are combined)
– for Perlite (if renewables and waste recycling projects are combined, the greenhouse gas impact could be reduced by 42%)

Zero waste water – wet grinding has closed flow of water circulation

Thanks to the new wet grinding, Calcit achieved a closed flow of water circulation, in this way avoiding producing any waste water.

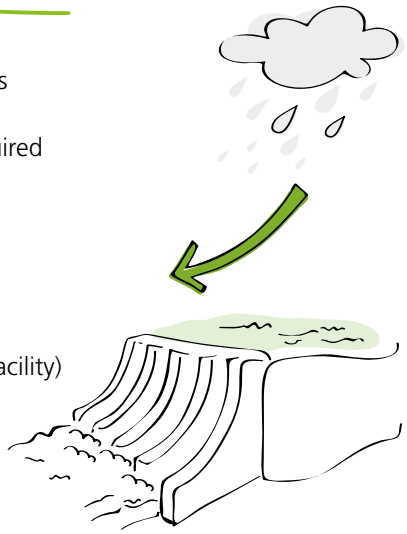


Raw materials: Calcium carbonate
Country: Slovenia
Replicated: Croatia by Calcit Lika (mid 2016)
Innovation: Processing stage
Energy efficiency, Water footprint
Raw material, Waste valorization

Talc operations use hydropower to cover part of the energy needs

Renewable energies such as hydroelectricity are used to cover part of the energy requirements. Imerys talc operation in southwest France owns and runs three hydroelectric power stations which combine 8 million kWh of GHG-free, totally renewable energy each year, enough to supply 12% of the energy required to power our nearby milling facility.

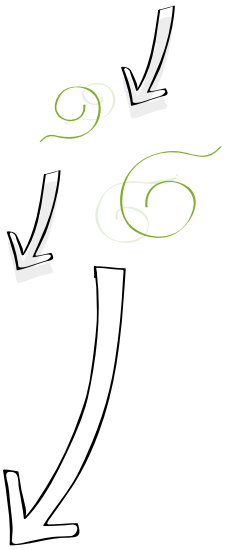
Raw materials: Talc
Country: France
Replicated: Not reported
Innovation: Processing stage
Green Energy generation (hydropower: 12% of total milling facility)
CO_2 footprint (8 million kWh of GHG-free/year)



CO_2 neutral manufacturing sites and product at bentonite site

Sivomatic is a fully integrated extractive mining, processing and cat litter producing company. Since 2014 the production sites in Holland and Austria are CO_2 neutral and certified by Climate Neutral Group. As a part of this carbon neutral certification process, a solar panel project is operational since 2013 in the Dutch processing facility. It is about 1,300 panels with a power of 330,000 kWh. This is one of the larger projects in the Netherlands. To compensate for the remaining CO_2 emissions Sivomatic participates in a biogas project and a wind energy project in Turkey. Furthermore, Sivomatic supplies a CO_2 neutral product since 2015.

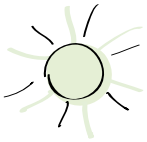
Raw materials: Bentonite
Country: Netherlands
Replicated: Austria, Turkey
Innovation: Processing stage
– Holland (solar panel project 1,300 panels with a power of 330,000 kWh to compensate the rest of the Dutch emissions, Sivomatic contributes to a biogass project in Turkey)
– Austria (to compensate for the CO_2 emission Sivomatic participates in a wind energy project in Turkey)

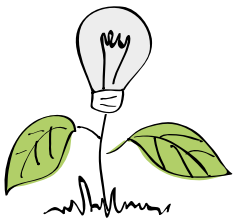


Renewables & Energy efficiency as drivers towards sustainability

IMI Fabi is currently supporting the development of renewable energy in Italy with contribution to multiple projects: Thermoelectric energy – in 2014 a 2 MW cogeneration plant started up at IMI Fabi's site in Postalesio, thereby giving partial electric independence and at the same time the opportunity to reuse the heat generated in the talc production cycle thus contributing to the energy efficiency of the operations; Solar energy – thanks to the realization of a 1 MW photovoltaic park located in northern Italy from 2011; Hydroelectric Energy – through the participation of 30% of the hydroelectric project along Mallero stream whose entry into service is planned within the next two years; Wind energy – through a feasibility study for testing the possibility to build a wind farm near the Sa Matta mine near Nuoro and eventually include it in a broader environmental restoration plan.

Raw materials: Talc
Country: Italy
Replicated: Not reported
Innovation: Processing stage
Green energy generation (solar, hydroelectric)
Energy efficiency





Moha Solar park at lime facility

In view of integrating the most recent sustainable practices, Carmeuse has integrated a solar park in the restored area of an operating quarry. The project developed in Moha, is extended on 6 ha field and is composed of 13.200 solar panels providing 3.6 GWh/year accounting for 19% of the total electricity consumption for the lime plant operations located nearby). The project is fully integrated in the environment with multiple other ecosystem services (beehives and bird conservation program).

Raw materials: Limestone, Quicklime, Hydrated lime
Country: Belgium (Wallonia)
Replicated: Not reported
Innovation: Processing stage
Green Energy generation (solar: 19% of the electricity needs for the processing facility)
CO_2 footprint (-1259 t/year)

EPOS (Enhanced energy and resource efficiency and Performance in process industry Operations via onsite and cross-sectorial Symbiosis)

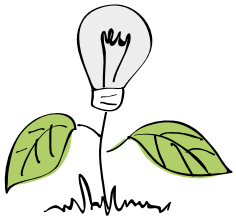
EPOS project brings together 5 global process industries from 5 key relevant sectors: steel, cement, chemicals, minerals (calcium carbonate) and engineering. The symbiosis approach of EPOS offers great opportunities for sustainability in industry as cross-sectorial collaboration has often not been endeavored before. The use of by-products from one sector as input to another sector can greatly improve energy and resource efficiency and contribute to the circular economy objectives. Such generic industrial symbiosis solutions can be replicated in many other sites, further improving sustainability. The project delivers a tool that can be embraced by the industrial minerals sector as such and be used in Business to Business relations and create business opportunities within the value chain. This project also illustrates that digitalization can deliver in circularity hubs which can be enhanced especially in industrialized regions where the multi-sector facilities are in the vicinity. For example, the EPOS toolbox led to the identification of a high calorific byproduct stream from a chemical process that could be used in the kiln of a nearby cement plant, hence reduce primary fuel consumption by 20%.

Raw materials: Calcium carbonate
Country: UK
Replicated: France, Germany
Innovation: Processing stage & Value chain cooperation
Reduce primary energy consumption by 20%
Resource efficiency

Pit water in closed loops and cleaned before discharge

At Imerys talc mines and plants, pit water used to clean equipment is degreased in separation tanks, water containing solids such as talc particles is channeled into sedimentation ponds to remove suspended particles prior to discharge.

Raw materials: Talc
Country: France
Replicated: Not reported
Innovation: Processing stage
Water efficiency (decantation before discharge to water body)

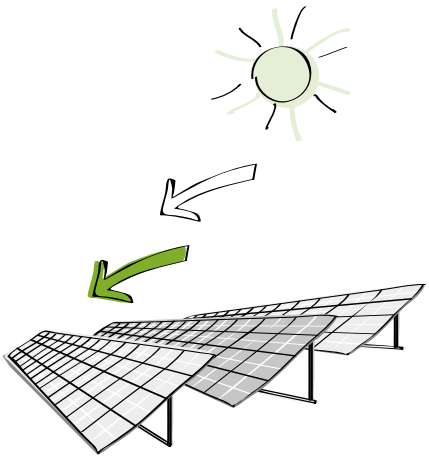


Green (solar) energy to improve energy footprint and lower CO_2 at silica site

Besides wind energy, Sibelco also makes use of solar energy generated on-site. At its Lommel and Maasmechelen sites, a total of 2 hectares of land is covered by solar panels. The solar panels in Maasmechelen provide up to 1034 MWh/year and CO_2 savings up to 471 t/year of the site's electricity needs[14].

[14] https://www.izen.eu/nl/epc/grondopstelling

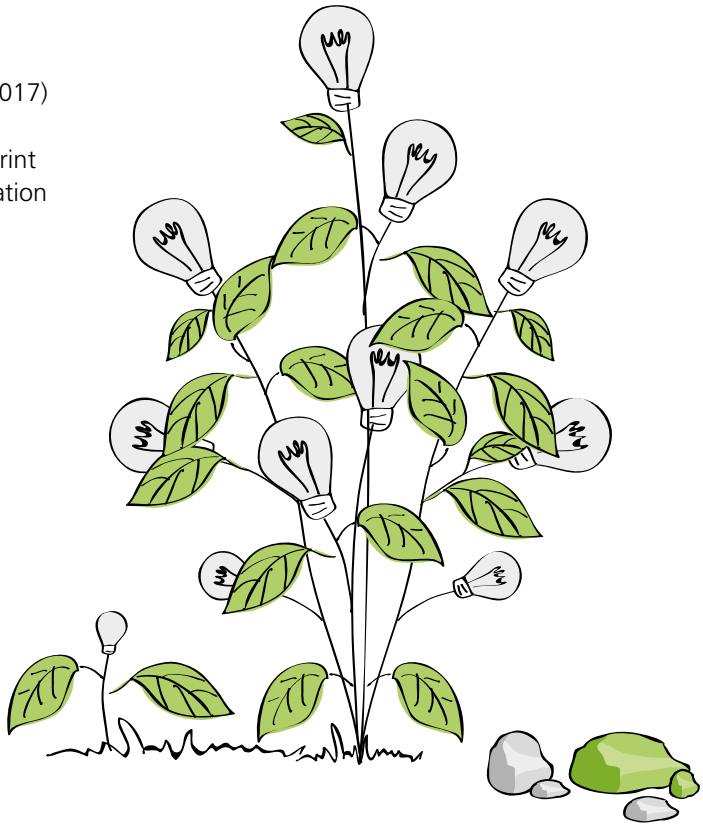
Raw materials: Silica sand
Country: Belgium
Replicated: Not reported
Innovation: Processing stage
Green Energy generation (solar: 1034 MWh/year)
Lower the CO_2 footprint by up to 471 t/year



Lower emissions of CO_2 – production optimization to reduce CO_2 emissions

In order to reduce CO_2 emission, Calcit started a process to optimize its production managing for example to increase the quantity production with the same energy consumption, eliminate free running of the machines and to dry their products with gas and not electricity.

Raw materials: Calcium carbonate
Country: Slovenia
Replicated: Croatia by Calcit Lika (mid 2017)
Innovation: Processing stage
Energy efficiency, CO_2 footprint
Raw material, Waste valorization



4. Sustainable transport processing facilities/customers

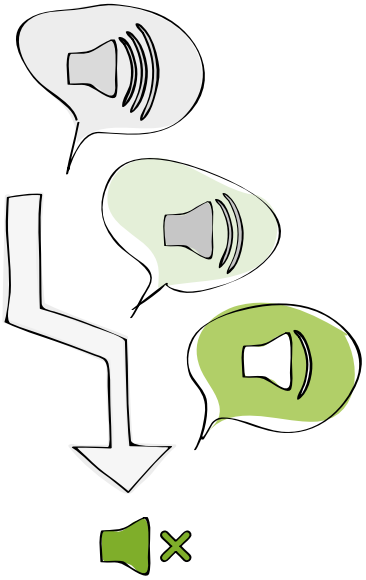
THE MYTH:
THE MINING INDUSTRY IS NOISY,
AND THE TRANSPORT IS NOT SUSTAINABLE.

THE FACT:
ACCESS TO DIFFERENT TRANSPORT MODULES
IS CONDITIONED BY AVAILABLE INFRASTRUCTURE.

Underground mine as a way to minimize nuisance and minimize truck transport within the quarry

In Austria Omya developed a crusher in the upper part of the quarry, to minimize the impact (noise, dust, and nuisance for the local community and local infrastructure). The development of an underground mine in Italy in a touristic area also ensures a co-habitation of different activities in within the same area by minimizing the impacts being visual or acoustic.

Raw materials: Calcium carbonate
Country: Austria
Replicated: Italy
Innovation: Underground transport to minimize dust, nuisance and truck transport module from Road to Rail
Energy generation (200 kW generative operation/year)

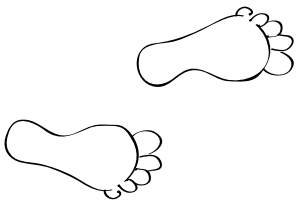


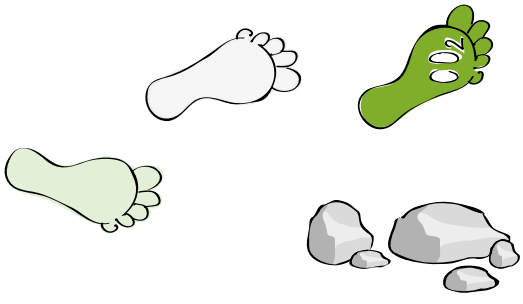
Precipitated Calcium Carbonate as a new model of integrated business

The production of the PCC (Precipitated calcium carbonate) in the paper mills is part of the satellite plants (mid 80's). Due to the site integration and no transport, the CO_2 footprint is lower. This site integration supports the PCC resource optimization in paper making process[15] [16].

[15] Roskill report.
[16] http://www.co2reuse.eu/images/stories/pdf-files/5-Schyvinck_CO2reuse_and_Minerals_Oct2012.pdf

Raw materials: Precipitated Calcium carbonate (PCC)
Country: USA (1986)
Replicated: EU (1988)
Innovation: Processing stage
Total absorption of the CO_2 in EU PCC production is 880 kt/year





Conveyor Belt produces clean energy

The conveyor belt starts at 1.300 meters above sea level where the quarry is located and transports the pre-grinded material down to the valley were the Sibelco plant is located (700 m above sea level). This conveyor belt has a length of 2,500 m (of which 1,500 m in tunnel), an average gradient of 28% and is capable of transporting, recovering 1,000 kW of electricity (the energy is developed by the belt brakes)[17].

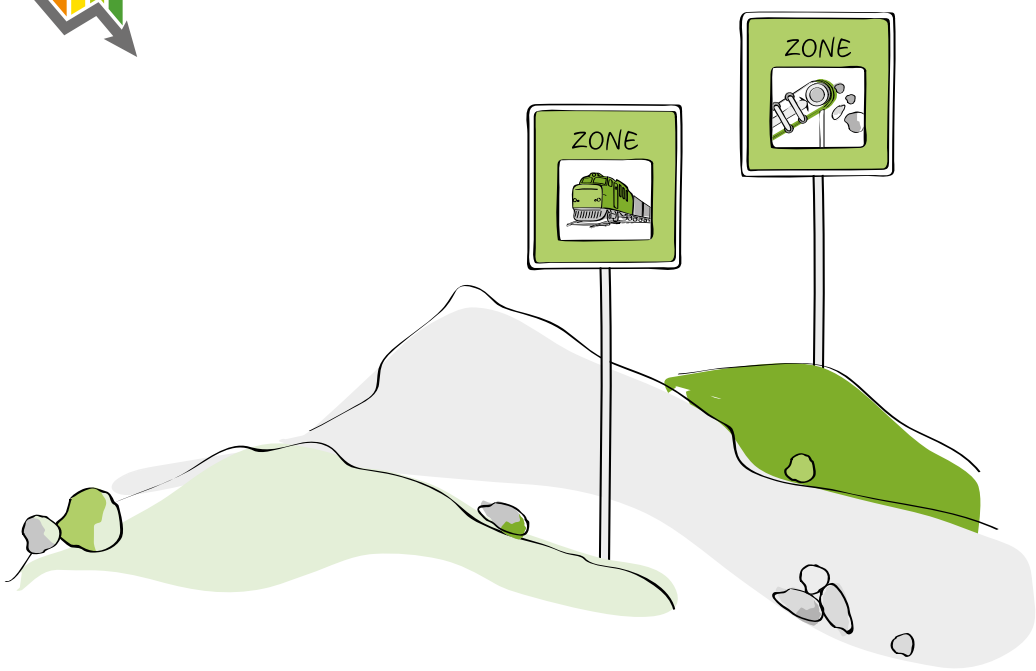
[17] http://www.sibelco-italia.com/it/locations/robilante-cn

Raw materials: Silica sand
Country: Italy
Replicated: Not reported
Innovation: Change transport module from Road to conveyer belt
Energy generation (1000 kW generative operation/year)
Other benefits (less trucks, reduce noise, dust and other nuisances for the local community)

Lower emissions of CO_2 – transformed truck deliveries to rail deliveries

To reduce CO_2 emissions, Calcit d.o.o. started dispatching a great number of shipment over railways, reducing in this way the trucks deliveries.

Raw materials: Calcium carbonate
Country: Slovenia (2009)
Replicated: Croatia (2016)
Innovation: Change transport module from Road to Rail



Silo monitoring and stock product management in distance

Ordering product or organizing delivery is settled via an on-line tool developed by Singleton Birch in their lime facility in UK. Via the secure web portal from everywhere, the experts can make the silo monitoring and stock management services in distance for the multiple suppliers and arrange time delivery based on customer needs. This low-cost solution can meet costumer level indicator outputs to the installation of new measurement devices, suitable for any silo system or product. This digital tool results in raw material efficiency and fuel savings thanks to fleet optimization as well as cost savings and efficiency for the administration[18].

[18] https://www.singletonbirch.co.uk/services/silo-monitoring-and-stock-management

Raw materials: Limestone, Quicklime, Hydrated lime
Country: UK
Replicated: Global
Innovation: Digitalization
Fuel savings fleet optimization trips
Other benefits (cost savings in administration)

Resizing bags for sustainable transport and plastic package avoidance

Tolsa decided to resizing the format of polypropylene big-bag to better fit volumes in transport. Unitary weight is reduced by more than 10% for the Bentonite and Sepiolite operations[19].

[19] Ecoembes(*) webpage. Quality improvement initiatives 2012-2014.

Raw materials: Bentonite, Sepiolite
Country: Spain (2009)
Replicated: Not reported
Innovation: Change packaging size and minimise plastic waste by 10% and move it up

Gravity Underground Conveyer Belt to minimise transport by track

In view of improving the performance of the lime manufacturing site in Austria Baumit invested in a multiple retrofit project which consisted of: two new crushers, two shafts, and an underground tunnel for a gravity conveyer belt. A new conveyor gravity belt (distance between axis 1020 m, width of belt 1000 mm can generate about 200 MWh per year of electricity. More than 150 tons of CO_2 can be saved per year. It was a company initiative to improve the environment footprint and energy savings to produce limestone. With this project conveying of limestone by gravity, noise, dust emissions and other nuisances for the local community nearby. [20].

[20] EuLA 2018. Innovation in the lime sector 2.0. EuLA, 2018. Pp. 22.

Raw materials:	Limestone
Country:	Austria
Replicated:	Not reported
Innovation:	Conveying of limestone by gravity within quarry/processing facilities Energy generation (by gravity: 200 MW/year) CO_2 footprint (-150 t/year) Other benefits (less trucks, reduce noise, dust and other nuisances for the local community)

5. Life during and after mining

THE MYTH:
MINING HAS A LARGE LAND FOOTPRINT.

THE FACT:
MINING IS A TEMPORARY USE OF LAND.
THE SURFACE OF ALL QUARRY AND MINING OPERATIONS IS 0.1% OF THE EU SURFACE AREA.

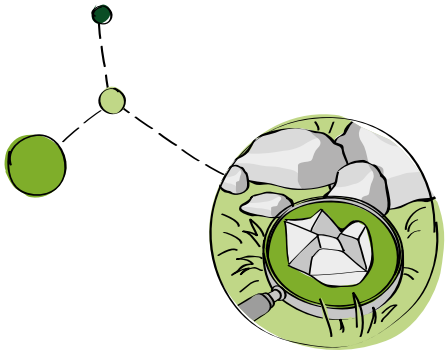
THE MYTH:
MINING RESULTS IN DEGRADATION OF LAND.

THE FACT:
- AS PART OF THE PERMITTING PROCESS, DURING- AND POST-MINING RESTORATION ARE PLANNED WELL AHEAD AND EXECUTED ACCORDINGLY;
- MINING IS COMPATIBLE WITH OTHER LAND USES. EVIDENCE SHOWS, THAT DURING MINING AND POST-CLOSURE, THE BIODIVERSITY IS ENHANCED;
- THE RESTORATION PRACTICES ARE DIFFERENT, AND THEY VARY FROM SITE TO SITE AND LOCATION IN CLOSE COOPERATION WITH MULTIPLE STAKEHOLDERS (AUTHORITIES, NGO'S AND LOCAL COMMUNITIES).

NaSa explorers (Nature and Sand Explorers)

At their Frechensite, Quarzwerke launched in 2014 a successful environmental education project for pupils, including refugee and mentally handicapped children. As "Nature and Sand explorers" (NaSa), the children enjoy exploring local nature habitats, and learning about biodiversity conservation compatible with silica sand extraction. Equipped with an exploration bag and tools, the children go out into the woods & fields, to pools and ponds, and into the laboratory and the quarry. They are guided by Quarzwerke's biologist and a teacher specialized in providing environmental education for children.

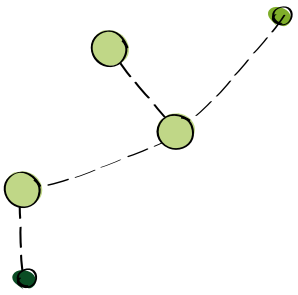
Raw materials: Silica sand
Country: Germany
Replicated: Germany
Innovation: Co-existence mining & Education



Former Kaolin quarry, now a lake that supports community needs during dry summers

Galicia is near Atlantic region without too much problems with water supplies because is raining 10 months a year. This situation is changing due to global warming, so the community around the mine has water restrictions during very hot summers. The former kaolin mines, which now are lakes store more than 5 millions cubic meters of water. Then, three years ago the Council Major and Cavisa the kaolin mining company signed a pact to supply water from the lakes of the restored kaolin mines which were previously analyzed and meet the appropriate quality standards. The company owned lands are uses to plant native seeds (e.g. wheat), or raising cows of autochthonous Galician breed, of highly priced meat, according to small farmers and local traders. Vimianzo council has pumping stations with water treatment in several lakes. These former kaolin quarries also provide water supply to the firefighting equipment and helicopters to fight the forest fires that plague Galicia every summer.

Raw materials: Kaolin
Country: Spain
Replicated: Not reported
Innovation: 5 millions cubic meters of water in former kaolin quarry operations
The former kaolin quarry is used to plant less productive native seeds but with more added value such as wheat, or raising cows of autochthonous Galician breed, of highly priced meat, according to small farmers and local traders
Co-existence mining & agriculture



Preserving wildlife habitat and enhance biodiversity

An important component of Sibelco's resource management program is the commitment to preserve and enhance biodiversity on the lands owned. Working with community and national organizations, Sibelco has transformed more than 100,000 acres into healthy and diverse ecosystems for wildlife, including wood ducks, whitetail deer, wild turkey, bluebirds, screech owls and an abundance of fish species. Sibelco is recognized by the Wildlife Habitat Council (WHC) for its preservation efforts and has certified 37 of the sites through WHC's Wildlife at Work program. They have received the Wildlife Habitat Council's most coveted Corporate Habitat of the Year Award, recognizing the conservatory projects designed to reintroduce and protect displaced species[21].

[21] unimin.com/community-environment

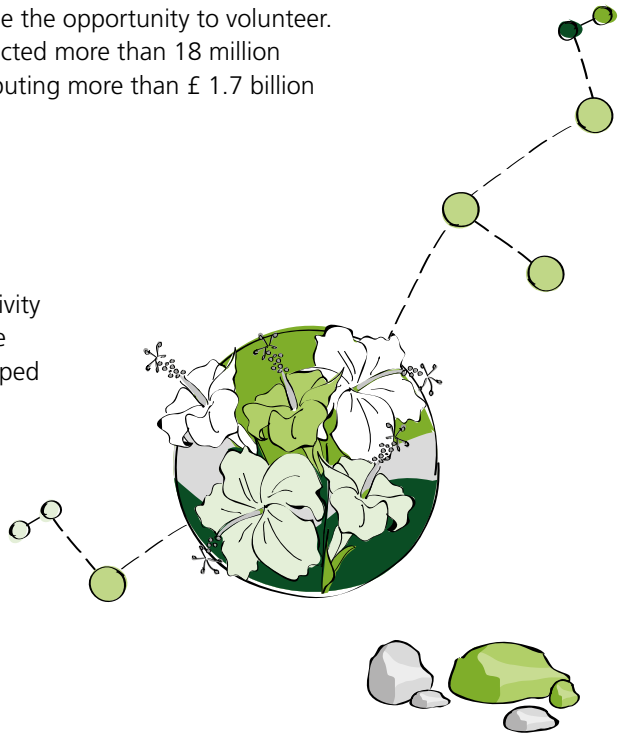
Raw materials: Silica
Country: Europe
Replicated: USA, Latin America
Innovation: Post-closure mine as new ecosystem
Properly managed restored areas ensure other ecosystems can be developed

The Eden Project in Cornwall

The Goonvean former Kaolin Quarry became the Eden park after a close consultation and engagement of the local and scientific community. The Eden Project in Cornwall is a spectacular example of a re purposed mine. Until 1995, the land was mined for kaolin and clay. Today, the old pit has been transformed into an ecotourism destination and educational charity with beautiful gardens showcasing some of the world's rarest plants, sustainability training programmes for educators and students, and on-site modules for a Master of Science programme in sustainability. The Eden project in Cornwall employs some 400 people and gives another 300 people the opportunity to volunteer. Since opening to the public in 2001, the place has attracted more than 18 million visitors and inspired an economic renaissance by contributing more than £ 1.7 billion to the local economy[22].

[22] edenproject.com

Raw materials: Kaolin
Country: UK
Replicated: Not reported
Innovation: Post-closure mine as new economic activity
Properly managed restored areas ensure other economic activities can be developed and sustained



Cornish Imerys Trial Marathon at Kaolin & China clay operations

The Cornish Imerys Trail Marathon offers a unique experience to runners. For one day only, the land of Cornwall's China clay Industry is open to the public. The operational working sites along with land which has been restored from the industrial past provides a challenging and spectacular trail course. Both half/trail marathon routes takes the participants on a discovery and adventure through Cornwall's mining industry, past and present. There is also organized a Children's fun run after the main races have started. There will also be activities running throughout the day for all the family organized by the Cornwall College who also provides food and drinks. Annually from 200 to 500 people attend this marathon.

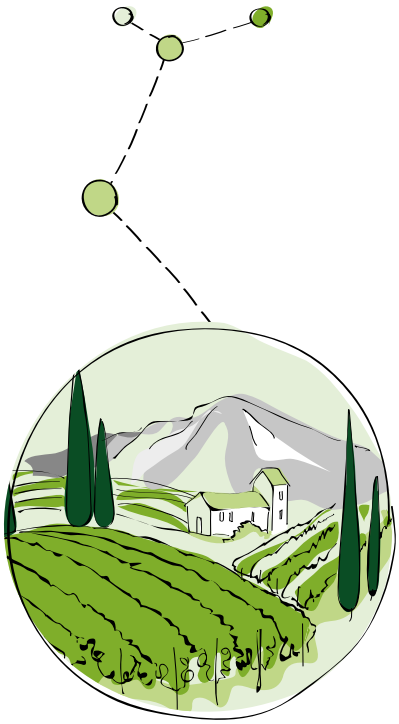
Raw materials: Kaolin, China clay
Country: UK
Replicated: Not reported
Innovation: Co-existence mining & Sport/tourism

From Perlite Quarry to Organic Vineyard

In 2014, Imerys (formerly S&B) decided to "transform" a usual reclamation practice into an innovative economic, environmentally friendly activity at the rehabilitated part or of Trachilas active perlite mine in Milos island, (Greece). A feasibility study and a business plan were initially carried out to assess the initiative's sustainability. Then, in February 2014 the planting of 17,500 vines of a Cyclades variety (Assyrtiko) in the first 5 hectares of Imerys's "vineyard" was concluded. The Milos Vineyard project is fully compliant with the company's environmental strategy on the fundamental principle of the minimization of its environmental impact at the same time adhering to Biodiversity management principles for the use of local plant species in reclamation works[23].

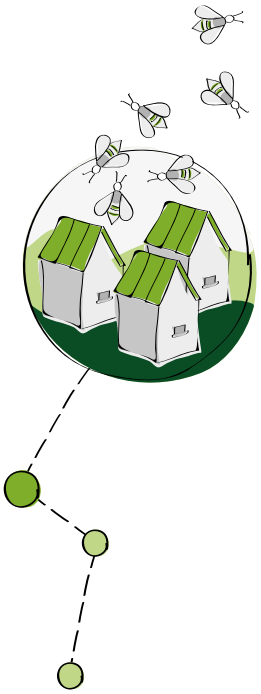
[23] http://imerys-additivesformetallurgy.com/sustainability-case-studies/bravo-sustainability-awards-ceremony-2017

Raw materials: Perlite
Country: Greece
Replicated: Not reported
Innovation: Post-closure mine as new economic activity
Properly managed restored areas ensure other economic activities can be developed



A dynamic & diverse ecosystem is an integral part of an active limestone mine

This Carmeuse project is an illustration how an active mine is a place for the biodiversity to thrive thanks to the company action and the management plan that allow the development of multiple ecosystems (Pioneer grassland, Perch raptors, Bee-hives, Wildflower meadow, Rocky cliffs, Soft cliffs, Linear stockpiles, Water bodies, Nesting decks, Calcareous grazing grassland, Forest areas).
This case study in Belgium illustrates how a single site can create conditions for multiple species & ecosystems to develop.



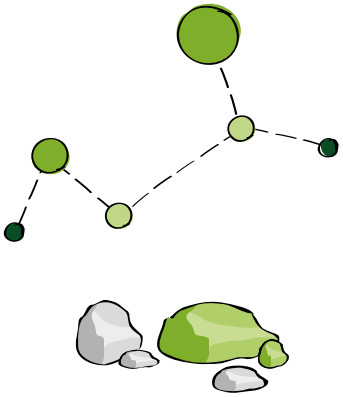
Raw materials: Limestone, Lime
Country: Belgium
Replicated: Belgium
Innovation: Co-existence (active mine as a thriving ecosystem)
Properly managed restored areas ensure biodiversity of ecosystems and species at the same site as extraction, processing operations and solar power energy generation are ongoing

Exploitation Plan and Restoration activities in an active mine

Tolsa's mining is carried out opencast by the sterile transfer method. This method combines the work of mining with that of filling and restoring the mined areas, without the need to install permanent dumps[24]. Closing mining cycle in the minimum time, by integrated mining and reclamation process. Transport management and impact reduction are critical parameters for return of land premises to farmers and landowners with improved crop performance and natural oxygenated soils. The restoration activities and agricultural cultivation were followed up by means of drone technology.

[24] Restauration Plan for the Natural Area C.E. V. (Madrid). Tolsa, S.A. and CRS. August 2015.

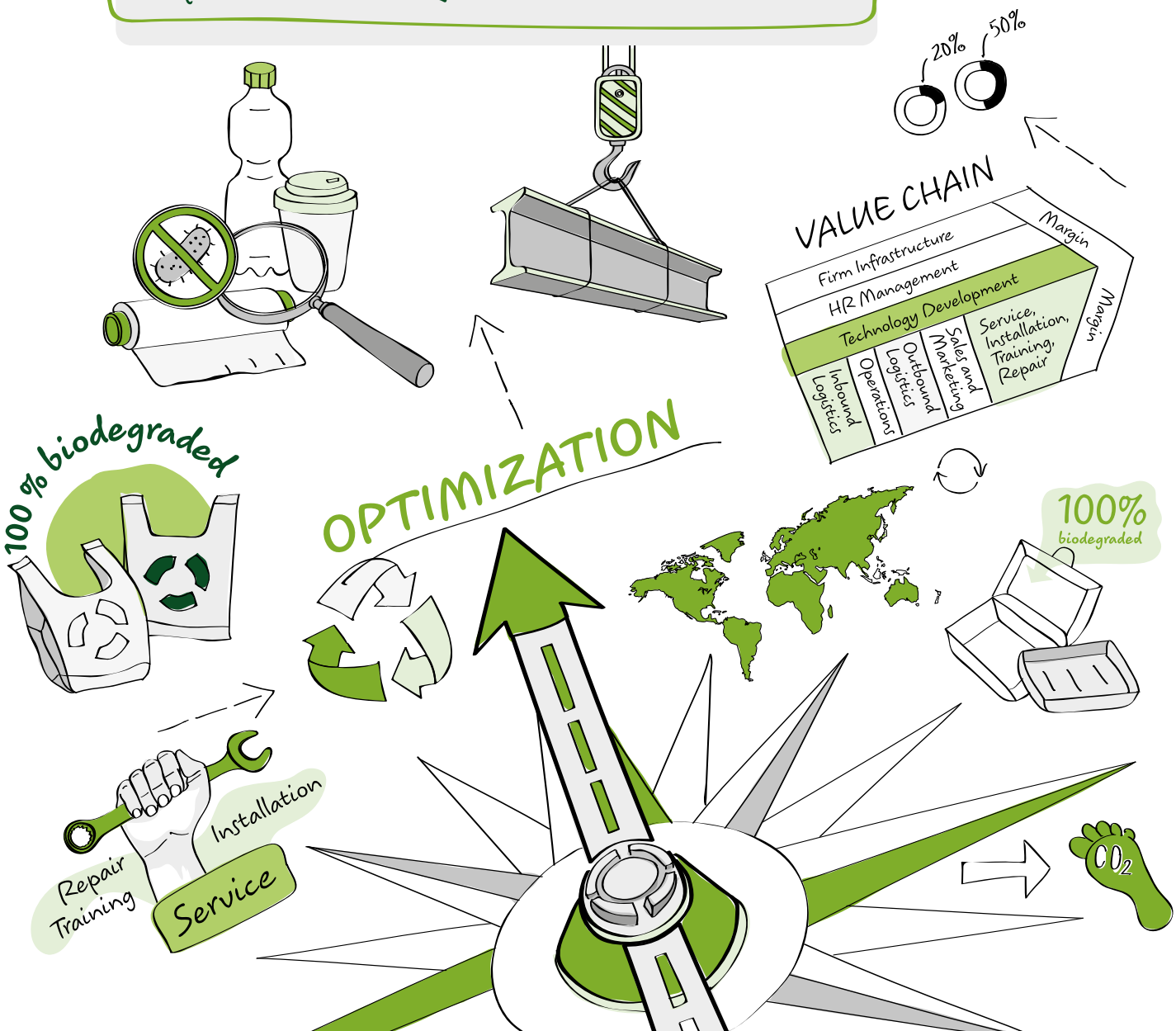
Raw materials: Sepiolite
Country: Spain
Replicated: Not reported
Innovation: Co-existence (restoration in active mine and return to agriculture land)
Lower CO_2 footprint of 156 t/year
Use of digital technology to assess the quality of restoration
Other benefits (return of the land for agricultural use)



6. Mineral optimization during the use phase along the value chain

THE MYTH:
THE MINING INDUSTRY DOES NOT BRING ANY ADDED VALUE TO CIRCULAR ECONOMY ALONG THE VALUE CHAIN.

THE FACT:
MINING CONTRIBUTES TO THE CIRCULAR ECONOMY THROUGH THE VALUE CHAIN AND SUPPORT THE OVERALL POLICY OBJECTIVES.

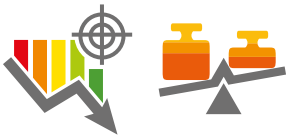


Talc use on car composites results in lighter and more fuel-efficient cars

Imerys' use of talc in plastic composite for cars results in 10% lighter car and fuel savings in the range of 7 L for the lifetime of the car[25].

[25] 2018. World Materials Forum. Materials Efficiency: Use smarter, less and longer.

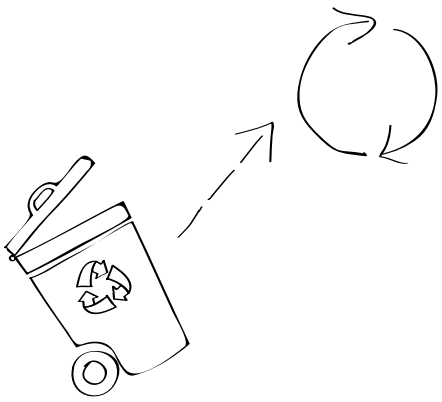
Raw materials: Kaolin, China clay
Country: Europe
Replicated: Not reported
Innovation: Fuel savings in the range of 7 L for the lifetime of the car
Lighter cars by 10%



PLA4FOOD

PLA4FOOD dealt with the development of innovative active and biodegradable packaging for fresh-cut food products based on renewable resources thermoplastic materials (PLA-polylactic acid) functionalised with the synergic addition of additives from natural sources (antioxidants, antibacterial and antifungal) in order to increase the shelf-life of packed products. A suitable method to incorporate sepiolite clay in a plasticized PLA is to produce a sepiolite masterbatch (15 wt.-% sepiolite) and to dilute it to the required amount. Two batches of plasticized PLA with sepiolites grades from Tolsa were provided to for film and sheet manufacturing. PLA4FOOD produced two different packaging products: a rigid tray, and a flexible bag or covering material. The products were tested with the aim to have a minimum time of preservation of 7 days. The plastic materials were 100% biodegraded after six months in normal composting conditions.

Raw materials: Sepiolite
Country: Spain
Replicated: Not reported
Innovation: 100% biodegadable, Plastic waste avoidance



Limeflow in Steel

Steel is one of the main markets where lime is used. The challenge of the market is to improve the flowability of the lime injection during the steelmaking. Project objectives were to improve the flowability of lime as well as the handling system delivering better performance and efficiency during the steel making[26]. Carmeuse project was finalized in 2008 and addressed the technology development and innovation aspects: since 100% of lime is managed by pneumatic injection, the lime flow management is easier. Due to automatization, the control of lime additions compared to other methods of lime additions is easier. Reduced cost related to maintenance compared to mechanical handling systems. 10% reduced lime loss, due to baghouse and lower disposal. Cleaner environment and improved safety for workers is also achieved. This technology developed in the USA is also being used extensively in the EU steel making sector.

[26] EuLA 2018. Innovation in the lime sector 2.0. EuLA, 2018. Pp. 49.

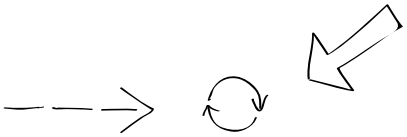
Raw materials: Lime
Country: USA
Replicated: Europe
Innovation: Resource optimization (10% lime resource savings)
Other benefits (lower disposal costs)

Harbour sludge

In southern Ireland a harbour required dredging for the safe passage of commercial and tourist fleets. The location is in one of Irelands busiest tourist locations, known for its natural surroundings and picturesque amenities. Dredged material could not be moved directly inland due to its liquidity making it unsafe to transport. Because of the location, this material could not be treated on land prior to transport as it would have caused too great a visual impact. Lime company and dredging specialist company developed a harbour sediment treatment technique that the material could be stabilized while still on the extraction barges. The deep injection of quicklime served to stabilize the material prior to transport. Dust, noise and visual impacts were kept to a minimum. Low dust solution to the problem of drying/stabilizing harbour sludge so that the material can be transported safely off-site. The concepts of this project were expanded to include larger, commercial ports in Ireland. Similar project was also developed in Norway harbour[27].

[27] 2018. EuLA Innovation report. Pp. 57-58.

Raw materials: Quicklime
Country: Ireland
Replicated: Norway (Franzefoss Minerals)
Innovation: From waste sludge to agriculture land
Other benefits (reduce the dust noise and visual impact)

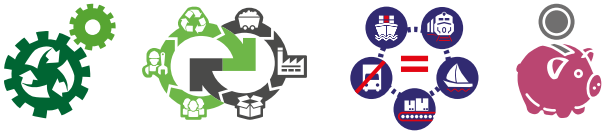


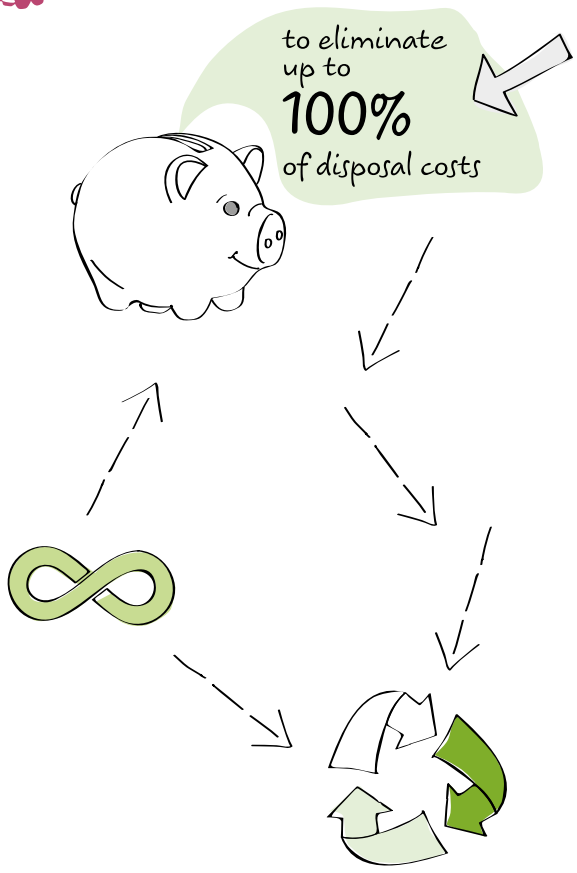
Mineral solution for Sediment Management

A new Clariant product, a unique mineral-based performance dewatering system for the mining, coastal and riverine dredging and tunneling sectors. The solution has been designed to deliver superior technical, cost and environmental performance. This innovative, high-performance system is an exceptional fit for the dewatering of hard-to-treat and fine sediments in a variety of industrial settings, across the fresh-to-salt-water environmental spectrum, delivering substantial economic, environmental and sustainability benefits for the customers. Drier, more compact and transportable solids make disposal logistics more cost efficient and economically viable. It is possible to achieve up to 20% improvement in dryness and 10% improvement in bulk volume, generating to up to 30% improvement in logistics. Possibility for re-use of sediments as raw materials to eliminate up to 100% of disposal costs. The solution offers the potential to achieve up to >90% reduction in contaminant loading[28].

[28] https://www.clariant.com/en/Business-Units/Functional-Minerals/Sediment-Management

Raw materials: Bentonite
Country: Germany
Replicated: Globally
Innovation: Resource optimization (re use of sediments as raw materials to eliminate up to 100% disposal)

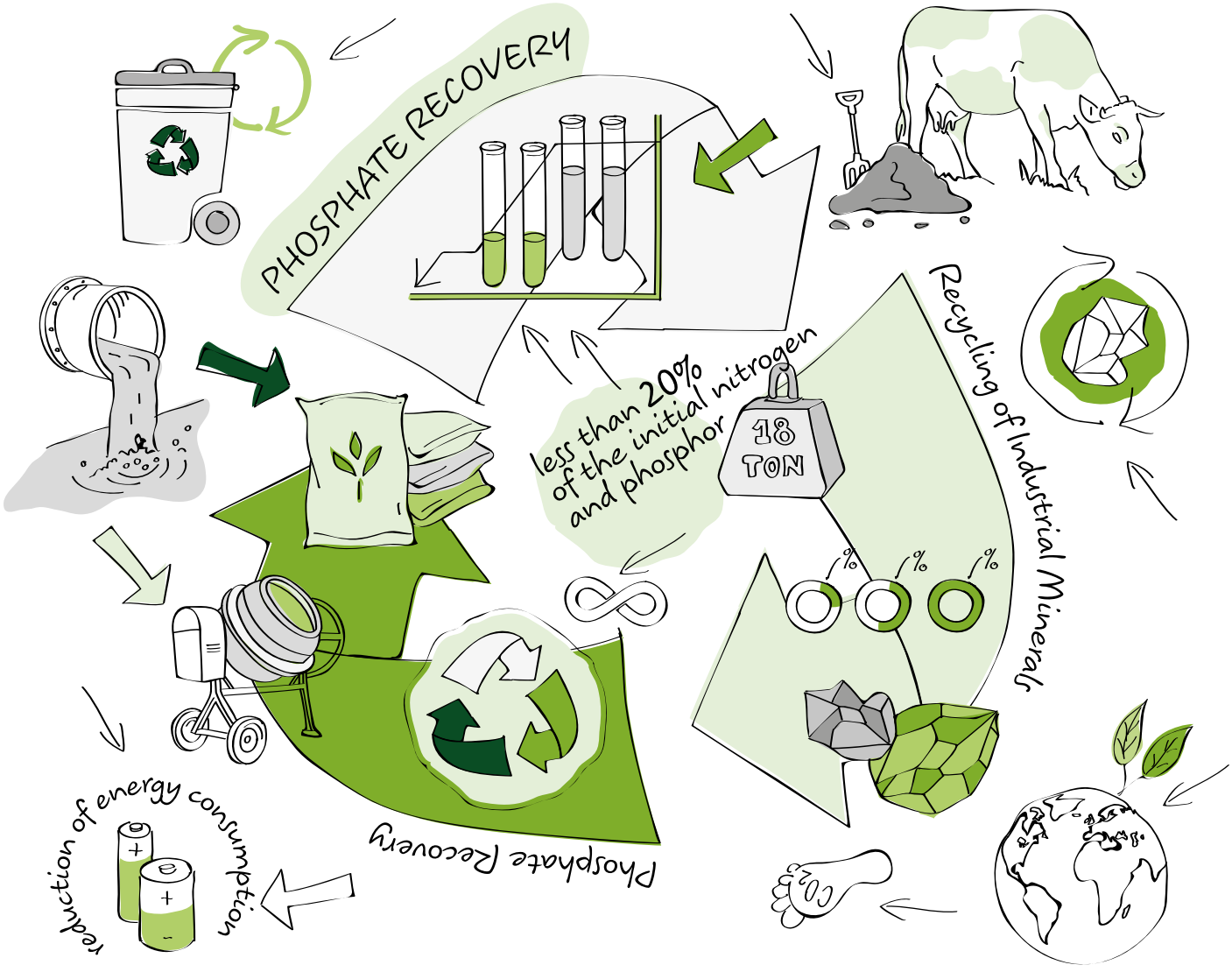




7. Minerals as enablers of circularity at the end of life

THE MYTH:
MINERALS DO NOT CONTRIBUTE TO CIRCULAR ECONOMY.

THE FACT:
END PRODUCTS IN WHICH MINERALS ARE USED ARE HIGHLY RECYCLABLE. MINERALS SUPPORT RECYCLING AT THE END OF LIFE.



Use of waste glass to save energy and resources in sanitaryware production

SANITSER project assessed the feasibility of integrating virgin raw materials with glass cullet from urban solid waste recycling, resulting in energy intensity decrease during the production process. Usually, the remaining scrap after the first industrial waste glass separation is still landfilled thanks to an advanced separation process, SANITSER gives new life and value to this secondary material, providing an extra amount of useful glass to generate new products. This project was developed and tested in the facilities of Minerali Industriali in Italy[29].

[29] http://www.sanitser.eu/it

Raw materials: Feldspars, Quartz
Country: Italy
Replicated: On going
Innovation: 32% of the minerals deriving from the recovery of historical white granite quarries
From 19% to 44% Glass Cullet from treatment process of glass scraps discarded after the primary urban waste separation, ceramic scraps, sand and minerals deriving from the recovery of historical white granite quarries
10-20% energy savings during the firing stage

Lodocal

The sludge originated by wastewater treatment plants are governed by very tight requirements through legislations/EU directives. However, they can be purified and later reused in the field as mulch or for composting. Faced with stronger requirements, the industry looks for viable alternatives to current uses. Several studies have shown that adding lime to the sludge can eliminate pathogens. Specifically, lime can help to create physicochemical conditions which can stop the biological degradation of organic matter they contain, avoiding thus the production of odors. The project demonstrated that: The WWTP sludge treatment with lime, sanitizes, reduces the concentration of bacteria below the detection limits; Stabilizes the sludge in the long term by avoiding the decomposition of organic matter and reduces its moisture, thereby facilitating handling; The application of lime enables sludge sanitation, either for reuse for soil improvement as a sanitized agricultural amendment, or for regeneration of degraded environments without risk to plant, animal or human health[30].

[30] 2018. EuLA Innovation report. Pp. 72.

Raw materials: Lime
Country: Spain
Replicated: Not reported
Innovation: From waste sludge to agriculture land liming material
Other benefits (reduce the concentration of bacteria below the detection limit, avoid decomposition of organic matter)

Phosphate Recovery from cattle manure

The abolition of the milk quota on 1st April 2015 led to a growing dairy cattle stock in the Netherlands. The consequence is that the animal manure puts an increasing pressure on the environment. Phosphate and nitrogen are needed as fertilizer, but when these minerals are not absorbed by the crops they leach in the soil and pollute the ground water. For this reason, farmers are strictly regulated in the period and amount of phosphate and nitrogen they may use on their land. Also, the need for e.g. nitrogen and phosphorous varies in the growth season depending on the crop availability and the soil type. Many farms struggle to stay within these limits and have to balance the demand for nitrogen and phosphorous with the supply. The project has been carried out at a farm with approximately 500 dairy cattle. The animal manure is digested together with coproducts in an anaerobic digestion plant. Together with technology partner Lhoist has developed a process to recover and concentrate nitrogen and phosphate from digestate in separate fractions by a physicochemical treatment with a specially developed lime-based product. By this, 18.000 tons of a thin fraction can be produced, which contains less than 20% of the initial nitrogen and phosphor. The nutrients are concentrated in a stream of ammonium sulfate and a phosphate fertilizer and can be valorized where needed and used in agriculture[31].

[31] EuLA 2018. Innovation in the lime sector 2.0. EuLA, 2018. Pp. 74.

Raw materials: Lime
Country: Netherlands
Replicated: Not reported
Innovation: Recycling and recovery of P at the end of life
Resource optimization (18.000 tons which are used in agriculture)

Phosphate Recovery at the end of life

Phosphate is a CRM, because of it occurrence outside of EU. As a way to mitigate this multiple EU, national projects have developed way to recover P and mitigate dependency from the primary raw material. In Germany, the current use of phosphate fertilizer is around 110,000 t/year. Average phosphate content in sludge is 4% to 6% (approx. 25,000 t phosphate p.a.) in Germany. Phosphate recovery from sewage water for utilization as fertilizer and usage of residual phases within the cement industry was tested. Through process optimization, the recovery of phosphate containing phases with lime products, the use of metal salts can be minimized to maintain the runoff parameters. In Germany, the project developed a crystallization process for recovering phosphate fertilizers from the waste water purification process with complete recovery of the remaining phases for use in the cement industry[32].

[32] fg-kalk-moertel.de/forschungsberichte

Raw materials: Lime
Country: Germany
Replicated: Not reported
Innovation: Recycling and recovery of phosphate at the end of life
Resource optimization

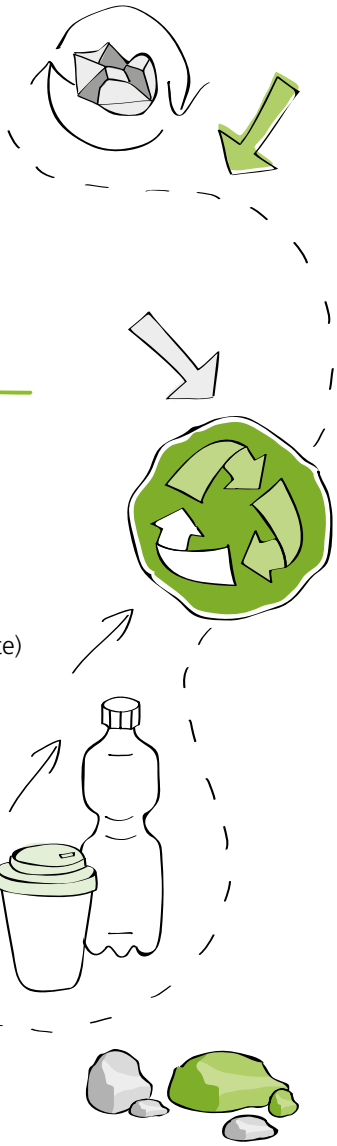
Recycling of Industrial Minerals from end applications

Industrial Minerals are used in a wide range of applications and products. Recovering these minerals from their manufacturing products would be technically challenging, energy consuming and, ultimately environmentally unsound. However, although the minerals may not be recyclable per se, many of them live second, third, fourth or even an infinite number of lives thanks to the recycling of the applications they are used in, thus contributing to the circular economy. The IMA-Europe Recycling Sheets gather publicly available data on the recycling rate of the main applications and products in which industrial minerals are used as primary raw materials.
For each mineral, IMA-Europe present the consumption by market and the recycling rates of their specific application, showing that, thanks to this recycling, it is up to 50% of the industrial minerals that find subsequent uses in our aspirational circular economy[33].

Industrial Mineral	Bentonite	Calcium carbonate	Silica	Talc	Feldspar	Kaolin	Clay	Lime
Recycling rate of end products	35%	49%	43%	58%	50%	52%	45%	63%

[33] IMA recycling sheets 2018.

Raw materials: Bentonite, Calcium carbonate, Silica, Talc, Feldspar, Kaolin, Clay, Lime
Country: Europe
Replicated: Not reported
Innovation: Recycling at the end of life
Focus area: Waste to product & Synergies in supply chain recycling



Flue Gas Treatment as a product making process

The use of lime/calcium carbonate in Flue Gas Treatment (FGT), creates a new product 'Gypsum' from the precipitation of the Flue gas emissions from the coal fire plants in EU.

Raw materials: Lime, Calcium carbonate
Country: EU
Replicated: Globally
Innovation: Waste to product (50% of Gypsum comes from this recovery route)

High 5: Glass recycling plant

Sibelco partnered with High 5 to develop technology that revolutionize glass recycling, making it faster and more efficient. High 5's processing quality allows to improve the processing yield, increase the throughput and ultimately recycle more glass waste. The advance glass recycling technology means that it can treat waste streams that other recyclers can't. At the cope site and MRF plants there is no need to separate glass wastes, meaning fewer waste collections processes run faster and operators can focus on the value streams that are most valuable for them. A pioneer in glass recycling in Europe, the High 5 plant offers the glass industry the opportunity to produce glass with 90% recycled raw materials and at the same time reduce its energy consumption and its carbon footprint, with savings in raw material, CO_2 and energy consumption[34].

[34] https://www.suez.com/en/our-offering/Success-stories/Our-references/High-Five-glass-recycling-plant

Raw materials:	Silica sand, Carbonate, Lime
Country:	Belgium
Replicated:	Belgium (Charleroi, Antwerpen)
Innovation:	Recycling and recovery of glass at the end of life Resource efficiency (220,000 tonnes of virgin raw materials – sand, carbonate, lime) Lower CO2 footprint (100,000 tonnes of CO_2 saved due to the melting of a lower quantity of raw materials containing carbonate) Energy efficiency (321,000 MWh of energy saved, or the amount consumed annually by 37,000 people) Water saving (257,400 m^3 of water or the amount consumed annually 4,200 people)

Projects delivering on circularity

The use of multiple residual materials as kaolinitic waste, sewage sludge, schist fines and wasted glass (cullet fines) to produce expanded lightweight granulates for use in multiple applications reduce the pressure on primary raw materials and reduce the waste flows[35]. Imerplast project (2014) aims at integrating plastic waste to make new and sustainable raw materials. This project also meets the policy objective of reducing plastic waste flows[36].

[36] Kanari N., Diot F., Gauthier C. and Yvon J. 2016. Use of residual materials for synthesis of lightweight granulates by thermal treatment process. Applied Clay Science 123, Pp. 259-271. DOI 10.1016/j.clay.2015.12.027
[36] IMA awards 2016.

Raw materials:	Kaolin waste, Plastic waste
Country:	UK, France
Replicated:	USA
Innovation:	Recycling of mining waste and plastic waste Waste valorization to make new products

Notes

Notes

Acknowledgements

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