



Magontec Qinghai

The world's greenest magnesium alloy producer

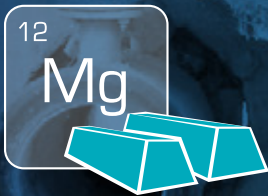
December 2017

MAGONTEC



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The Evolution of Magnesium Production

Over the last 30 years the global magnesium industry has been profoundly influenced by the emergence of China, now the world's largest manufacturer with a global share of more than 80%.

Chinese production has been based on the 'Pidgeon' Process, a 1940's technology abandoned in Western economies where production through electrolysis had become the dominant technology.

Access to low cost labour and energy gave the emerging Chinese 'Pidgeon' industry a strong advantage over electrolytic production resulting in the closure of many Western magnesium companies.

In 2018 'Pidgeon' magnesium is produced at over 60 sites across China. However, rising labour and energy prices and pollution from thermal energy sources present a new challenge to the magnesium industry.



Cheap labour and energy

China: 1990's



60+ 'Pidgeon' plants

Low volume process



Closure of Electrolytic plants

in the West

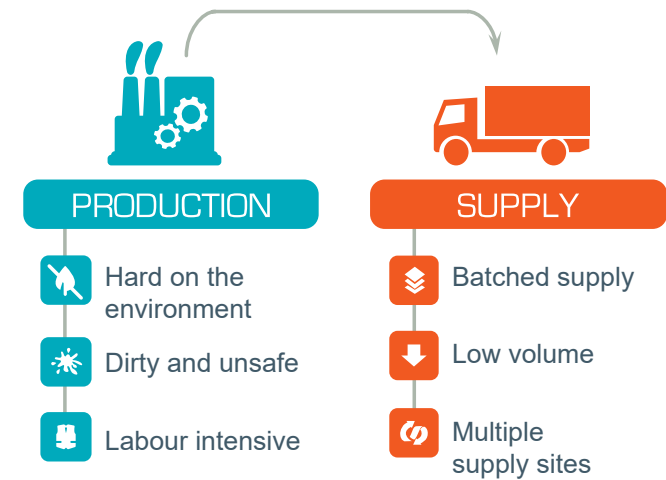


Limitations of 'Pidgeon' technology are driving a shift back to electrolytic process.

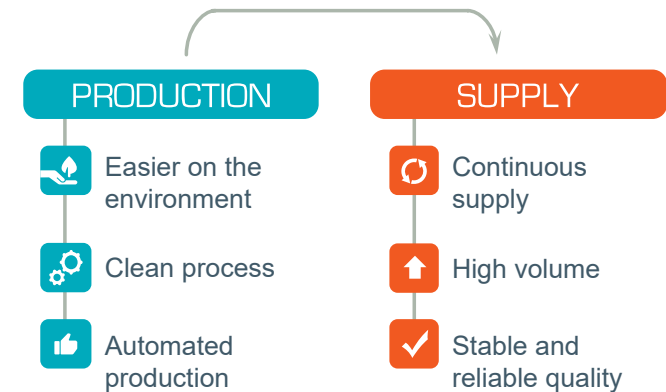
Magnesium production using 'Pidgeon' technology is a batched process, can be turned on and off at short notice and is manufactured at multiple sites across the country.

By moving to magnesium produced using electrolytic technology, Magontec will enjoy a continuous supply of liquid raw material in high volumes.

'Pidgeon' Process



'Electrolytic' Process





“The process of manufacturing magnesium using ‘Pidgeon’ technology is hard on the environment and working conditions are often primitive.”



“The QSLM electrolytic plant first stage will produce 100,000 metric tonnes per annum of pure magnesium using an automated and continuous process. The picture shows part of the electrolytic cell house where $MgCl_2$ raw material is separated into chlorine gas and liquid pure magnesium metal.”



Magontec Qinghai

Magontec's newest primary
alloy production facility



Continuous supply

The Qarham lake system will supply the world's largest magnesium manufacturing complex for decades to come.

Magontec Qinghai is located close to the City of Golmud in Qinghai Province PRC at 2,800 metres above sea level.

The complex at Golmud is ideally situated, adjacent to the historic Qinghai Salt Lake Industries Co. Ltd. potash manufacturing site and close to the Qarham Lake.

The Salt Lake waters are diverted into holding ponds from which the raw materials for potash, magnesium and other processes are drawn.

QSLM estimates that there are 4 billion tonnes of MgCl_2 in the Qarham lake system, sufficient to supply the world's largest magnesium manufacturing complex for many decades to come.



Ideally situated complex

4 Billion tonnes of MgCl_2
estimated in the Qarham lake system

The new cast house at Qinghai will produce high volumes in a modern and highly automated facility.

Under Agreements signed in 2014 Magontec has contracted to take 56,000 metric tonnes per annum of liquid pure magnesium from the QSLM electrolytic facility.

These Agreements confer on Magontec the exclusive right to manufacture magnesium alloys at this facility for the duration of the lease period.

This strategic partnership between Magontec and QSLM will deliver a steady, competitive and significant new supply of magnesium alloys into global markets under a long-term lease agreement.



Magontec's investment in the new cast house facility at Golmud signals our intention to remain a leading global supplier of magnesium alloy and magnesium alloy products.

QSLM plan to increase output at this facility by a further 50,000 mtpa in the near future with plans to raise that to 450,000 within the next 10 years.

Magontec, as the exclusive manufacturer of magnesium alloys at Qinghai, will also be able to grow production volumes and market share in a growing market.

1st
STAGE

Up to 60,000mtpa of Mg alloy output (100,000mt of pure Mg supply)

2nd
STAGE

QSLM plan to increase pure Mg output by a further 50,000 mtpa in the near future

3rd
STAGE

Up to 450,000 mtpa of pure Mg production capacity





Environmental responsibility

The QSLM facility at Golmud has the highest environmental standards in the global magnesium industry.

The facility will use renewable energy as its principal source of energy for the manufacturing process. Significant additional renewable energy sources will be installed in Qinghai Province in the coming years.

Material from Magontec Qinghai will set a new benchmark for low-carbon magnesium manufacturing for a material that already enjoys high recycling rates.



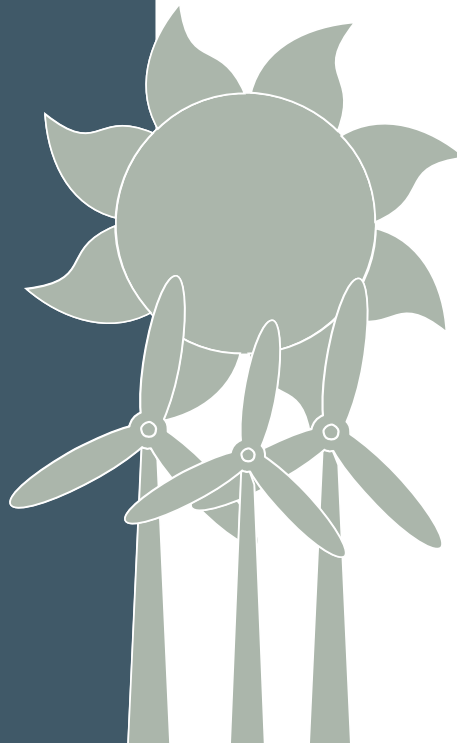
Use of renewable energy in the manufacturing process

Recycling and re-supply

CO₂ efficiency



Availability of significant new renewable energy sources



Haixi region – a renewable energy ‘Hotspot’ with high solar radiation intensity.

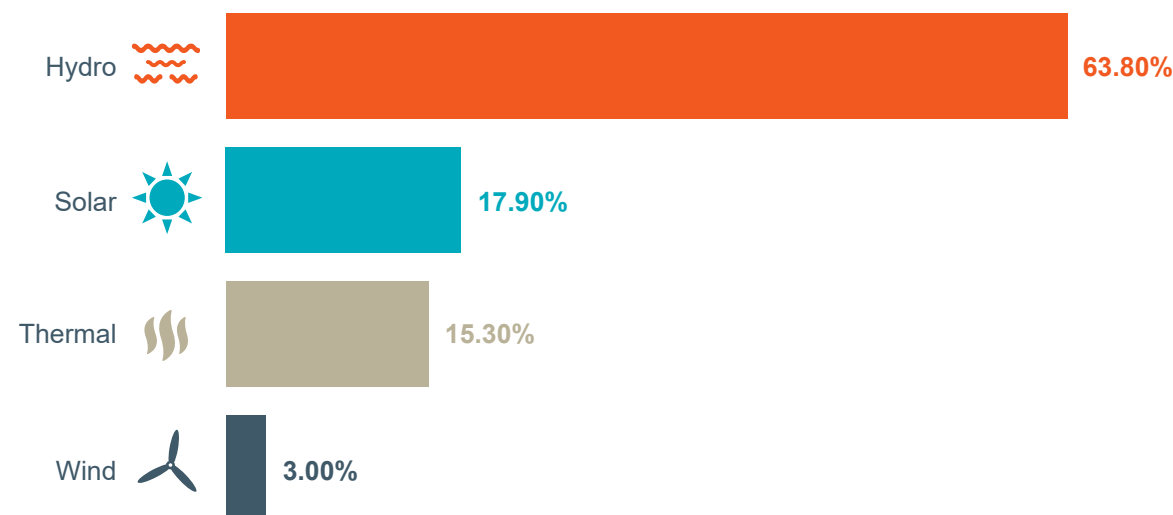
Qinghai Province already enjoys significant installed renewable energy sources, including hydro, wind and solar.

In common with other high-altitude locations, the Haixi region of Qinghai experiences high intensity sunlight; around 3,000 hours a year, which is almost twice the global average.

85% of the energy supplied to the QSLM and Magontec Qinghai magnesium manufacturing facilities will be sourced from renewable sources including hydro, solar and wind.

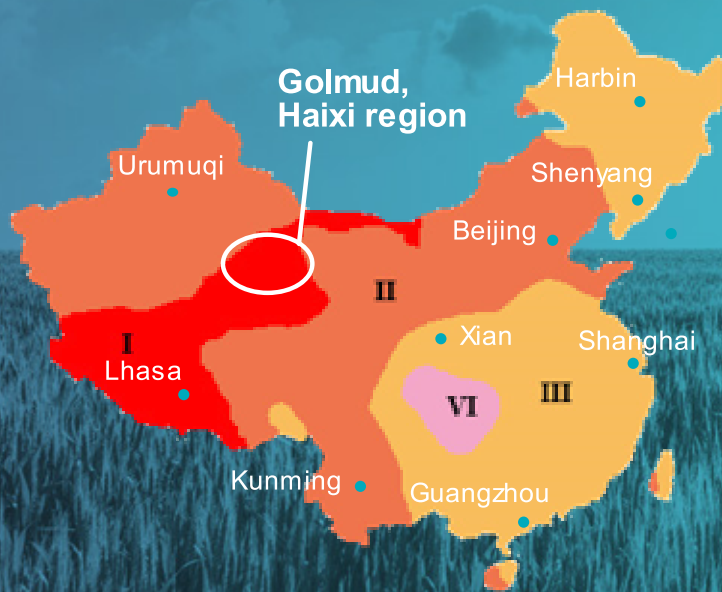
Region has targeted
90% of its energy
to come from renewable sources

Qinghai Province and QSLM energy source (2017)*



* Qinghai Economic and Information Committee, www.qhec.org.cn

Qinghai is a Chinese province blessed with clean air, considerable natural resources, modern infrastructure and access to copious renewable energy sources.

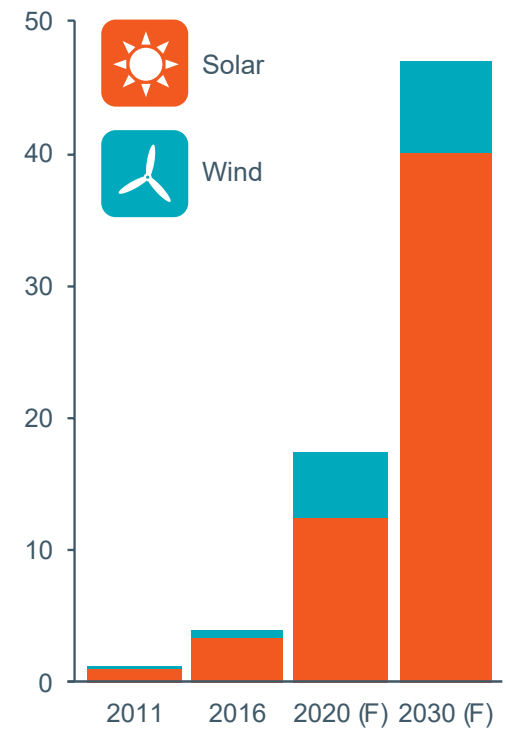


Located at 2,800 metres elevation on the Tibetan Plateau it is a dry and cool climate, ideal for the production of clean and green magnesium alloys.

The Province is a renewable energy hotspot, close to the source of the Yellow, Yangzte, and Lancang rivers, fed by the Himalayan and Kunlun mountain ranges, offering a reliable source of hydro power. The region is also blessed with significant installed solar and wind resources.

The Provincial and Chinese national governments, along with private enterprise, are investing heavily in further solar projects in the region. Authorities are targeting 100,000 square kilometres of solar panels that will generate 560 million kW. Up to 90% of the energy used in the Province is expected to come from renewable energy sources.

Installed and projected energy generating capacity* (millions of kW)



*Data source: <http://www.hxdrc.gov.cn/info/1031/1854.htm>

Magontec Qinghai will process the lowest CO₂ Mg ever produced.*

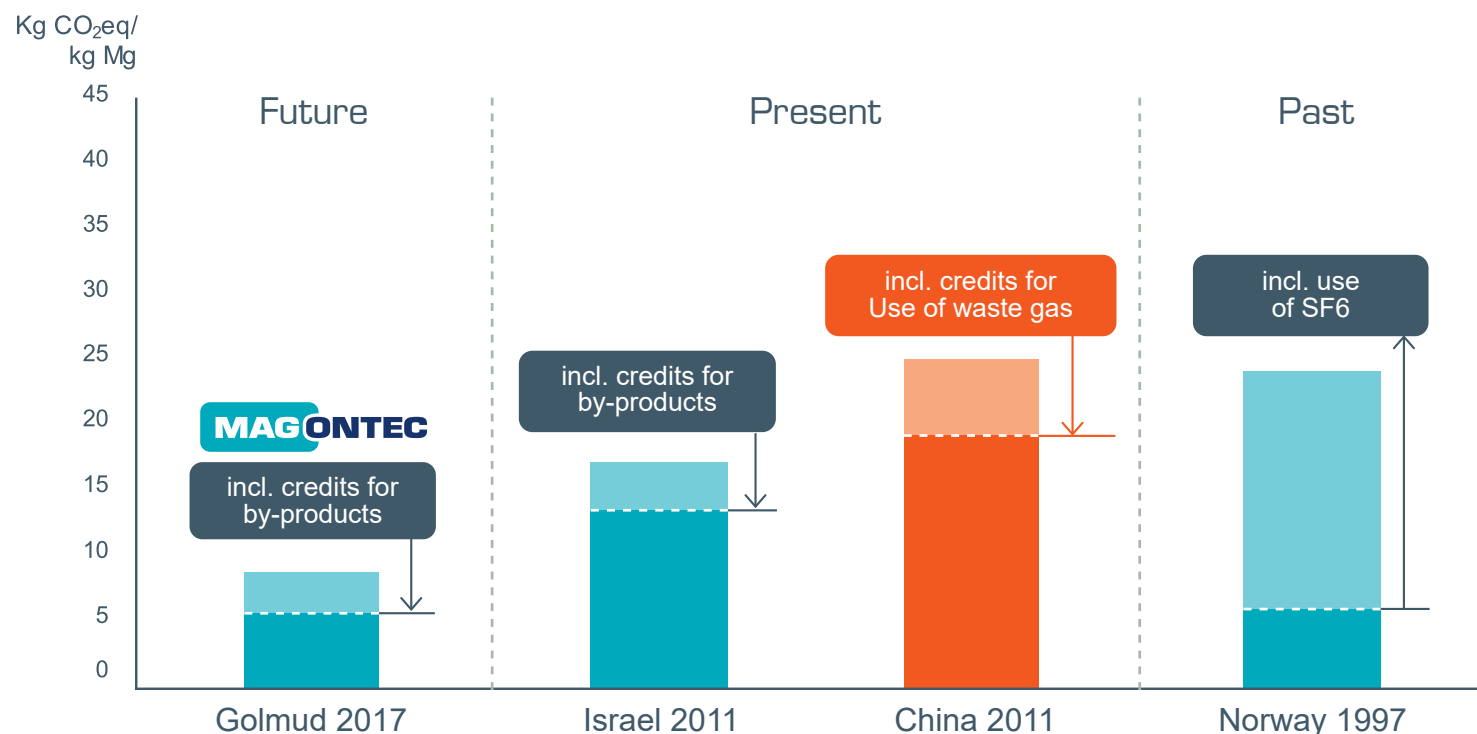
The manufacturing process at Qinghai sets a new benchmark for low carbon magnesium manufacturing.

The German Institute of Vehicle Concepts estimates that Magontec Qinghai will generate just 7.1kgs of CO₂ equivalent per kg of magnesium produced.

This compares with an average of 25kgs of CO₂ equivalent per kg of magnesium produced by 'Pidgeon' process manufacturers and a global average of 12.7kgs of CO₂ equivalent per kg of aluminium.

For the first time in many years the magnesium industry offers the caster customers a truly competitive alternative to aluminium in terms of price, weight and environmental impact.

*German Aerospace Institute of Vehicle Concepts survey on CO₂ emissions from magnesium smelters around the World



Electrolysis



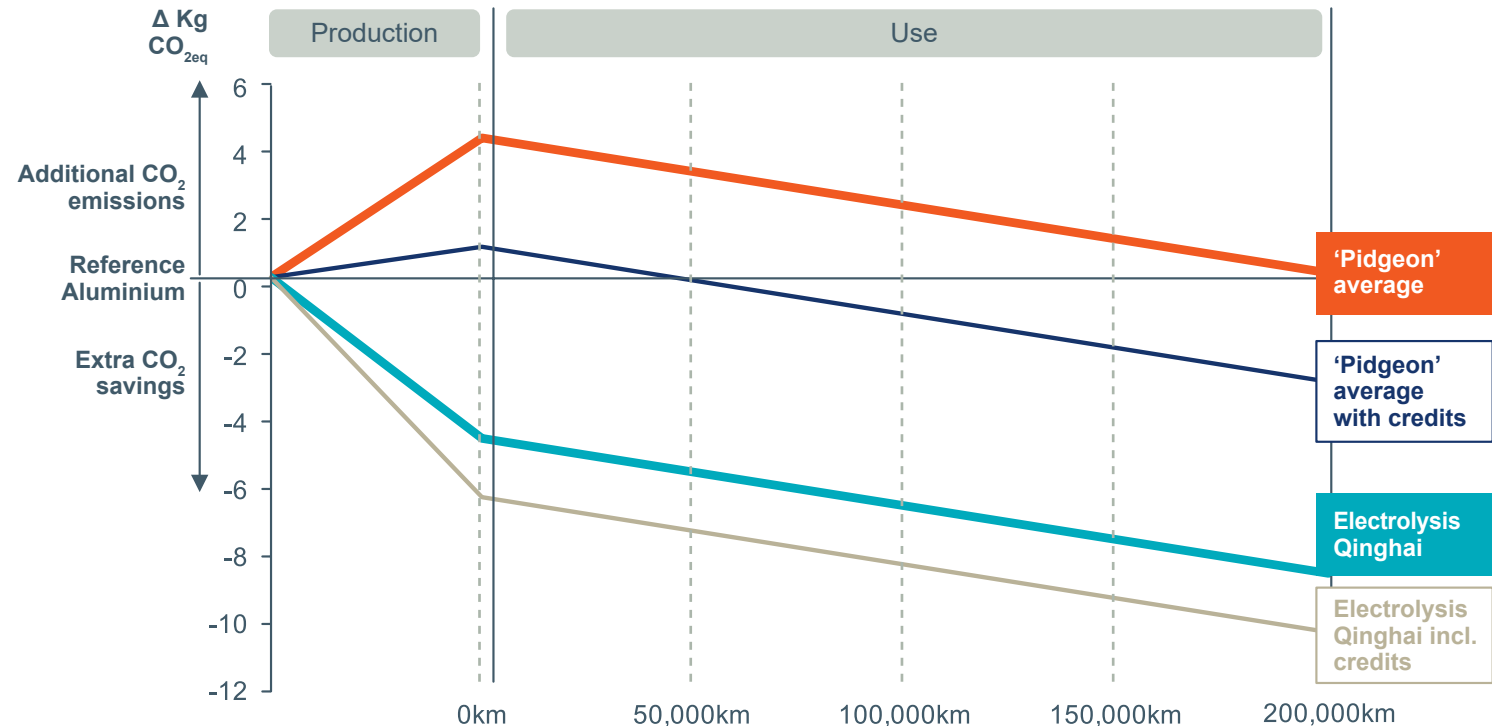
'Pidgeon' process

Lower tailpipe emissions give Magnesium an accelerating advantage over aluminium.

Life Cycle Analysis is an important metric for consumers and manufacturers. While magnesium offers considerable environmental benefits to consumers because of its lighter weight, these are entirely erased by high CO₂ emissions generated by the 'Pidgeon' magnesium production process.

The chart on this page compares the environmental Life Cycle of 'Pidgeon' magnesium and Qinghai magnesium with the global aluminium average (aluminium being the key competitor material).

Low CO₂ emissions associated with Qinghai magnesium offers both consumers and manufacturers the opportunity to benefit from light weight magnesium through the life of the product.



Comparison based on real automotive component – steering wheel, with a weight of 0.79kg for Al alloy and 0.55kg for Mg alloy.:

1. Dr. Simone Ehrenberger, DLR, Life Cycle Assessment of Magnesium Components in Vehicle Constructions, 2013
2. Dr. Simone Ehrenberger, DLR, Global Greenhouse Gas Balance – Magontec Group, 2014

Life Cycle Assessment
(LCA) Analysis:

Lower CO₂ emissions
than 'Pidgeon'

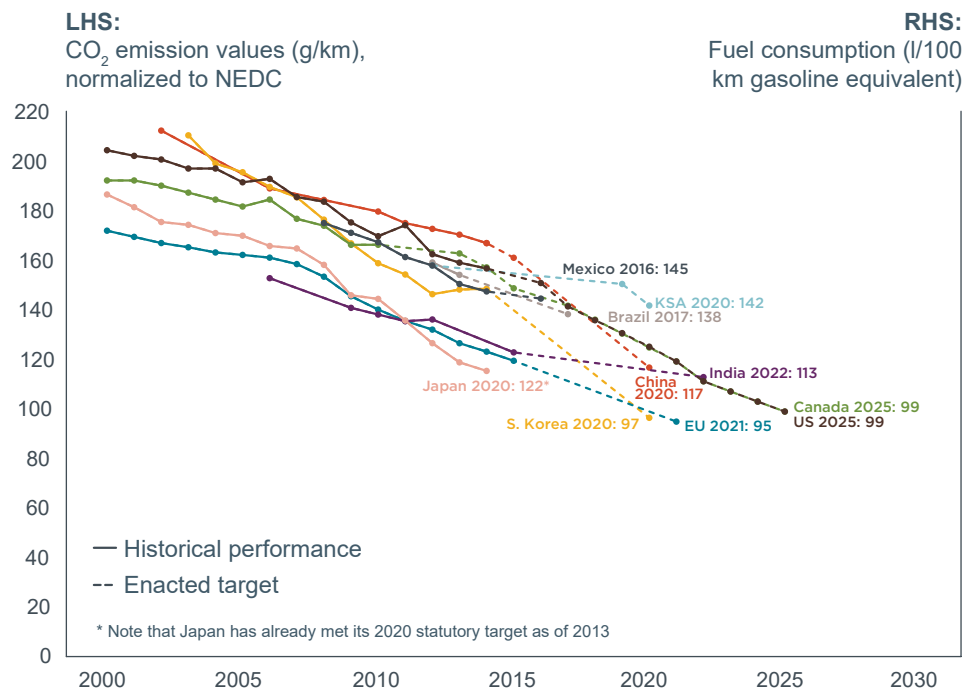
Lower CO₂ emissions than
aluminium global average

Government regulations are pushing automotive manufacturers to dramatically reduce tailpipe CO₂ emissions.

City, regional and national governments all over the world are bringing renewed focus to air quality and the motor vehicle plays a significant role in this debate.

While hybrid engines and other technologies will assist automotive manufacturers to meet the targets set for tailpipe emissions in the major economies, light weighting through the use of magnesium alloys will also play a part.

Whether an automotive is powered by a petro driven internal combustion engine (ICE), an electric power plant or a hybrid engine, light weight applications offer improved performance through lower tailpipe emissions or longer battery life and in all instances an improved power-to-weight ratio.



Historical fleet CO₂ emissions performance and current standards (gCO₂/km normalised to NEDC) for passenger cars



Light weighting –
an efficient way to
achieve those targets

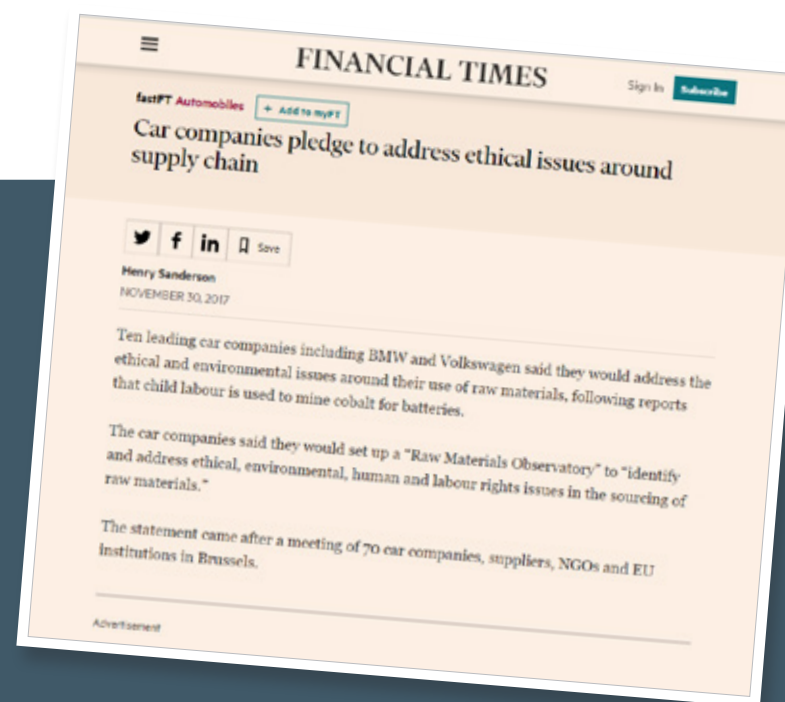


Automotive manufacturers, the largest magnesium alloy manufacturing sector, have a growing focus on environmental provenance.

“

Ten leading car companies including BMW and Volkswagen said they would address the ethical and environmental issues around their use of raw materials.”

Financial Times, November 30, 2017





Modern electrolytic process

The Qinghai electrolytic magnesium smelter complex.

The Qinghai smelter complex is the first greenfield electrolytic magnesium facility constructed anywhere in the world in the 21st Century.

The last major facility of this type to reach full production was constructed at Beçancour in Canada in 1996 by Norsk Hydro, a previous owner of Magontec Limited.

The Qinghai smelter is its direct descendant using the same technology, acquired by QSLM from Norsk Hydro in 2007.



Modern Complex



Proprietary technology



Automated production

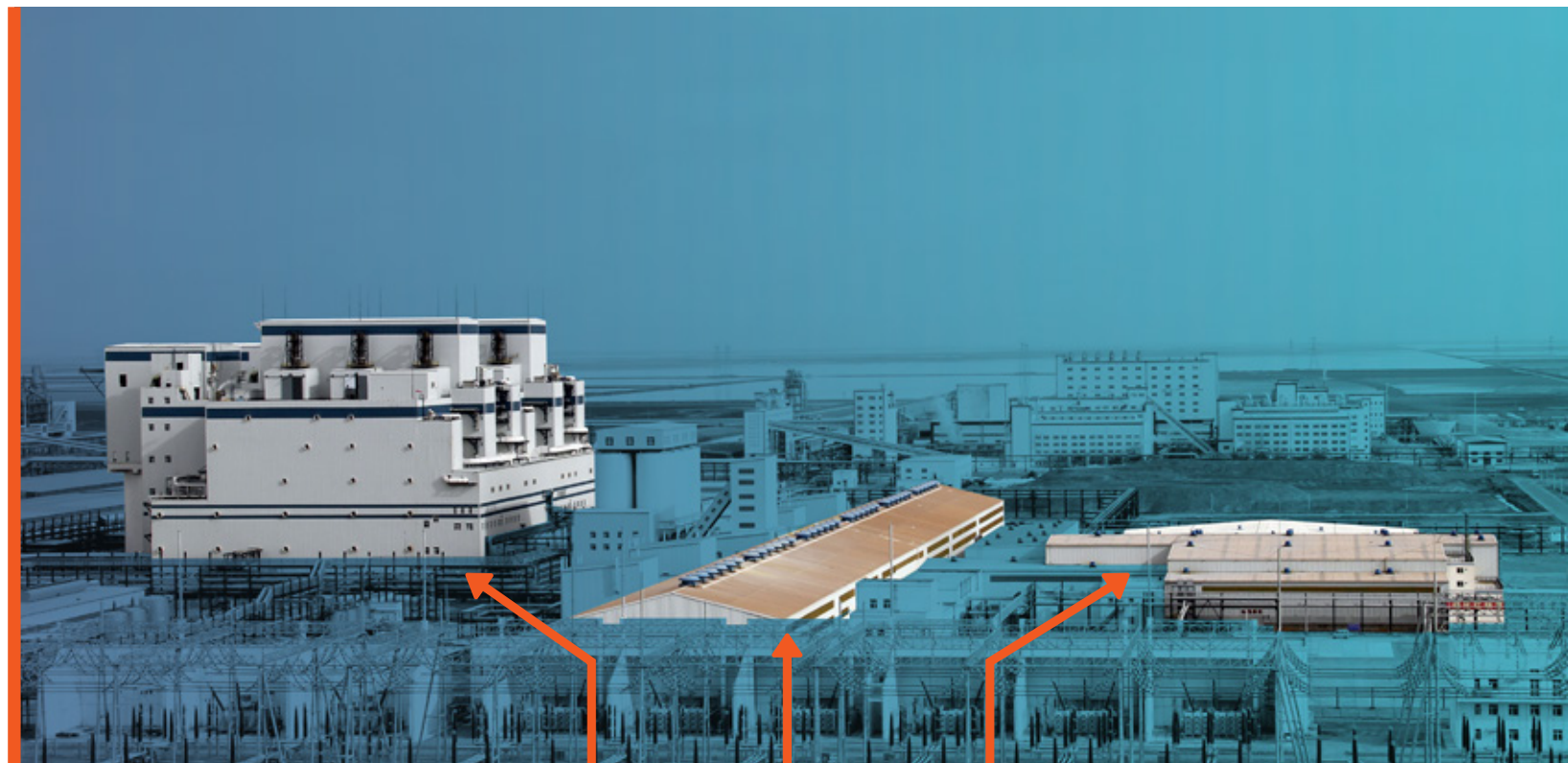




The QSLM facility takes a magnesium and chlorine-rich salt (MgCl_2), a by-product of an existing potassium manufacturing process, as feed stock for the initial brine purification process.

Purified brine is supplied to two 50,000 mtpa Dehydration Units and transferred to 68 cells in the Reduction Cell House (electrolysis). The cells reduce the MgCl_2 to pure magnesium and chlorine gas, the latter piped to an adjacent industrial site for the manufacture of ethylene. A “metal truck” collects liquid pure magnesium from the electrolytic cells and delivers it directly to the Magontec Qinghai alloying furnaces.

The Magontec Magnesium Alloy Cast House is designed to process 56,000 mt of liquid pure magnesium each year.



Dehydration



Reduction



Cast house

The QSLM electrolytic facility at Golmud is a fast and clean continuous process able to produce high volumes of high quality magnesium alloys.

It compares favourably with the 'Pidgeon' process, which requires hard rock mining of dolomite and ferro silicon, trucking between processing sites across China followed by calcining, ball milling and briquetting. The energy required to transform these raw materials into a usable product is considerable and the thermal reduction process that vaporises magnesium from the dolomite host rock, requires temperatures of 1200°C.

By comparison the electrolytic process separates magnesium and chlorine at a temperature of 700°C with the Chlorine gas then piped directly to another downstream industry and the pure magnesium taken in liquid form to the adjacent cast house.

Process Comparison

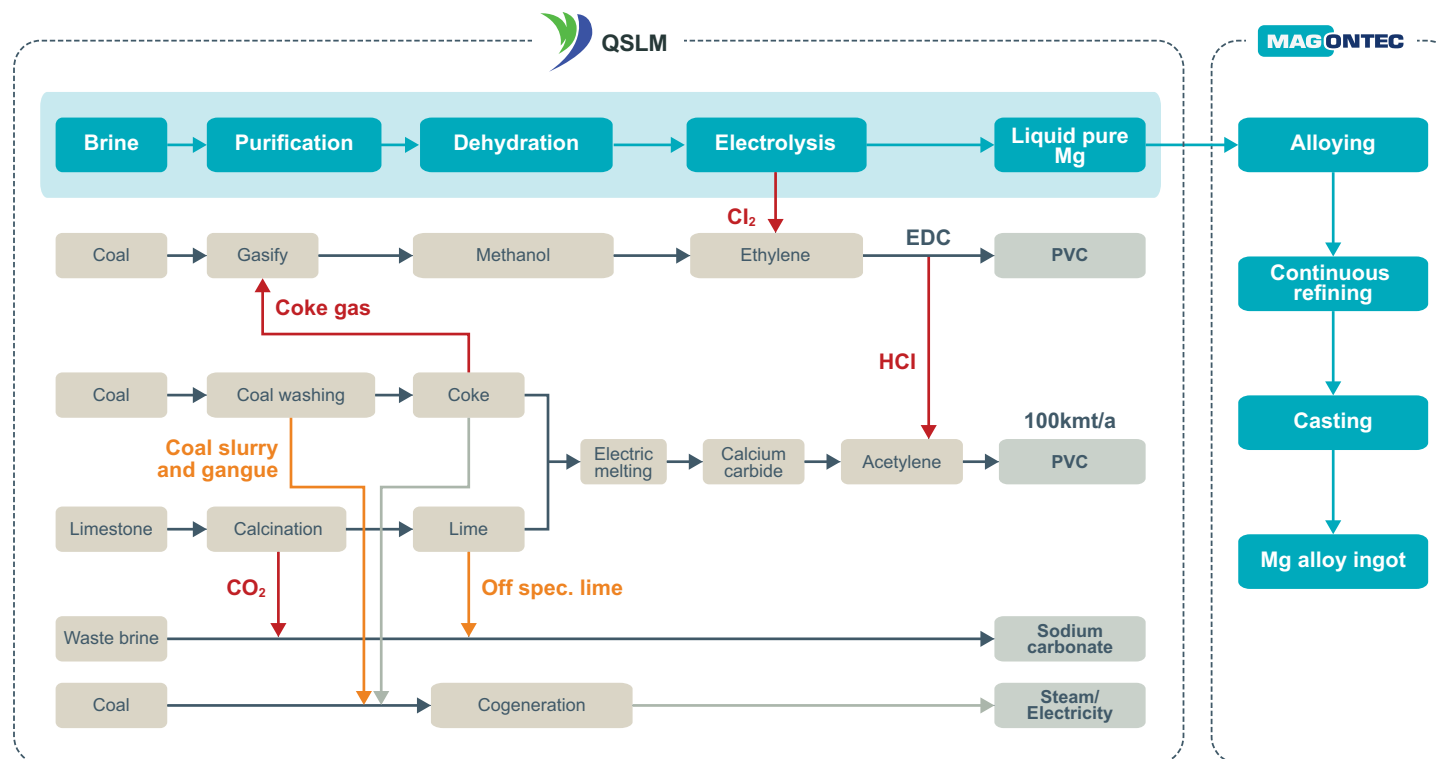
	Conventional process ('Pidgeon')	Energy	CO ₂	Automation	Quality	QSLM+ MAQ process (Electrolysis)	Energy	CO ₂	Automation	Quality
Raw Materials	Dolomite + FeSi	●	●	●		MgCl ₂ -rich Salt	●	●	●	
Pre-Processing	Calcination	●	●	●		Dissolving	●	●	●	
	Ball Milling/Blending	●	●	●		Brine Purification	●	●	●	
	Briquetting	●	●	●		Dehydration	●	●	●	
Extraction	Coke gas					Hydro/Solar/Wind power				
	Vacuum Reduction/1200°C	●	●	●		Fused Salt Electrolysis/700°C	●	●	●	
Alloying-Refining-Casting-	Melting Crowns	●	●	●		Liquid Transfer	●	●	●	
	Batch Refining	●	●	●		Continuous Refining	●	●	●	
	Ingot Casting	●	●	●		Ingot Casting	●	●	●	
Quality Control	Composition stability					Composition stability				●
	Cleanliness					Cleanliness				●
	Quality management					Quality management				●

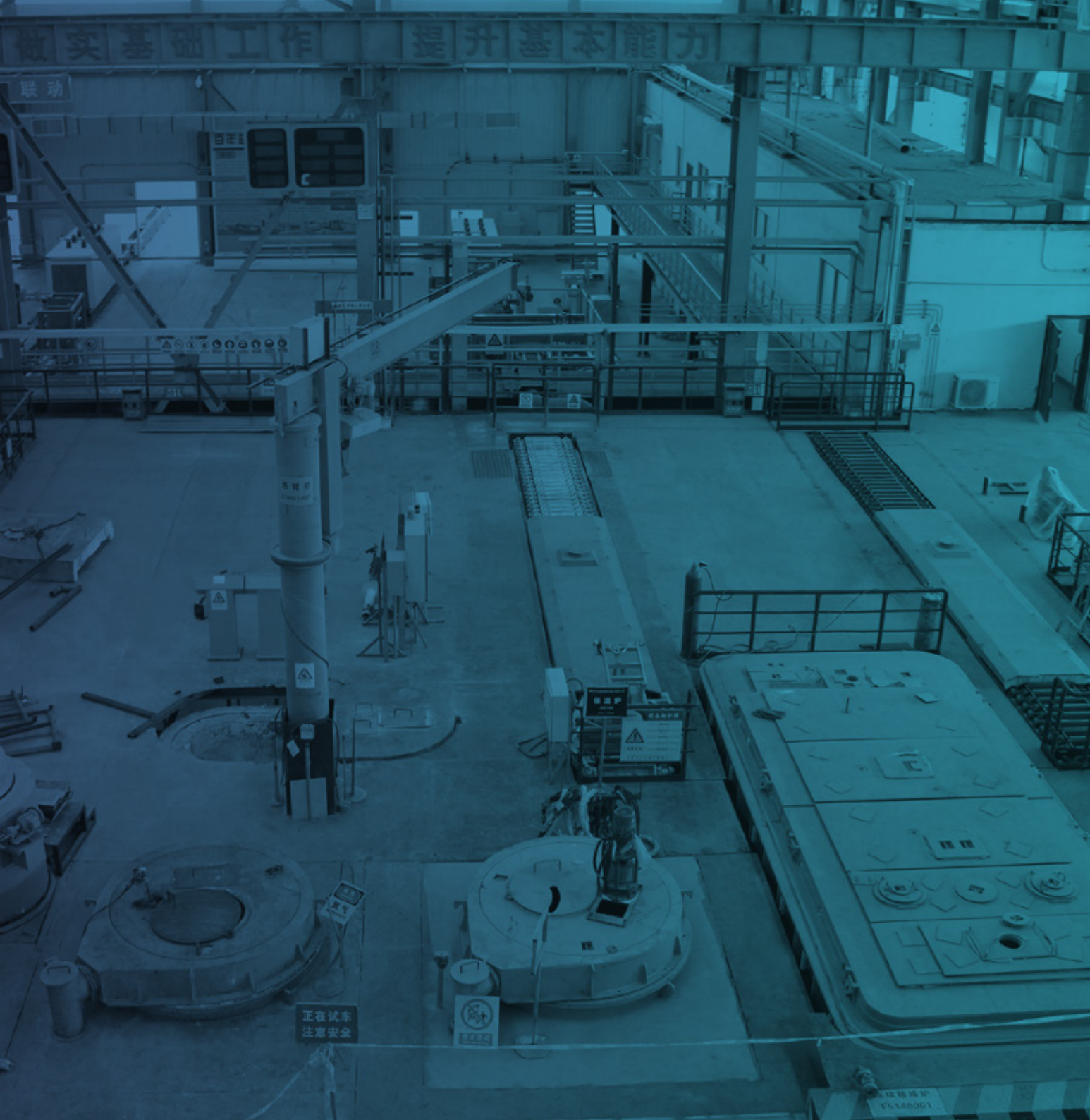
Magnesium Alloy Cast House

Magnesium is one of a number of industrial products manufactured at the Qinghai Salt Lake Industries complex.

The MgCl_2 brine is a residue from potassium manufacturing. Since the inception of the industrial operations at Golmud in the 1960s, large quantities of MgCl_2 salt have been stockpiled and are available for processing into magnesium and other products.

Magnesium is central to the economics of the wider QSLM complex with the production of Cl_2 off-gas from electrolytic reduction a key feed stock for ethylene and PVC production.





Proprietary technology

The Magontec Qinghai cast house is a highly automated production facility. Liquid magnesium alloy is piped between furnaces and casting belts using a PLC unit specifically designed for this cast house.

Metal flows are managed by way of a low GWP cover gas, the side benefits of which are a cleaner work environment and a less corrosive environment for ancillary equipment.



Advanced cover gas technology



Safe for employees



No negative impact on associated structures



Automated
production

The Magontec Qinghai manufacturing process is a vast improvement on current global industry standards.

The impact of a new large continuous process electrolytic magnesium producer is expected to result in a more stable supply chain and, in the long term, more stable pricing through the ability of Magontec Qinghai to offer multi-year contracts.



Stable
supply

Pricing
stability in the
longer term



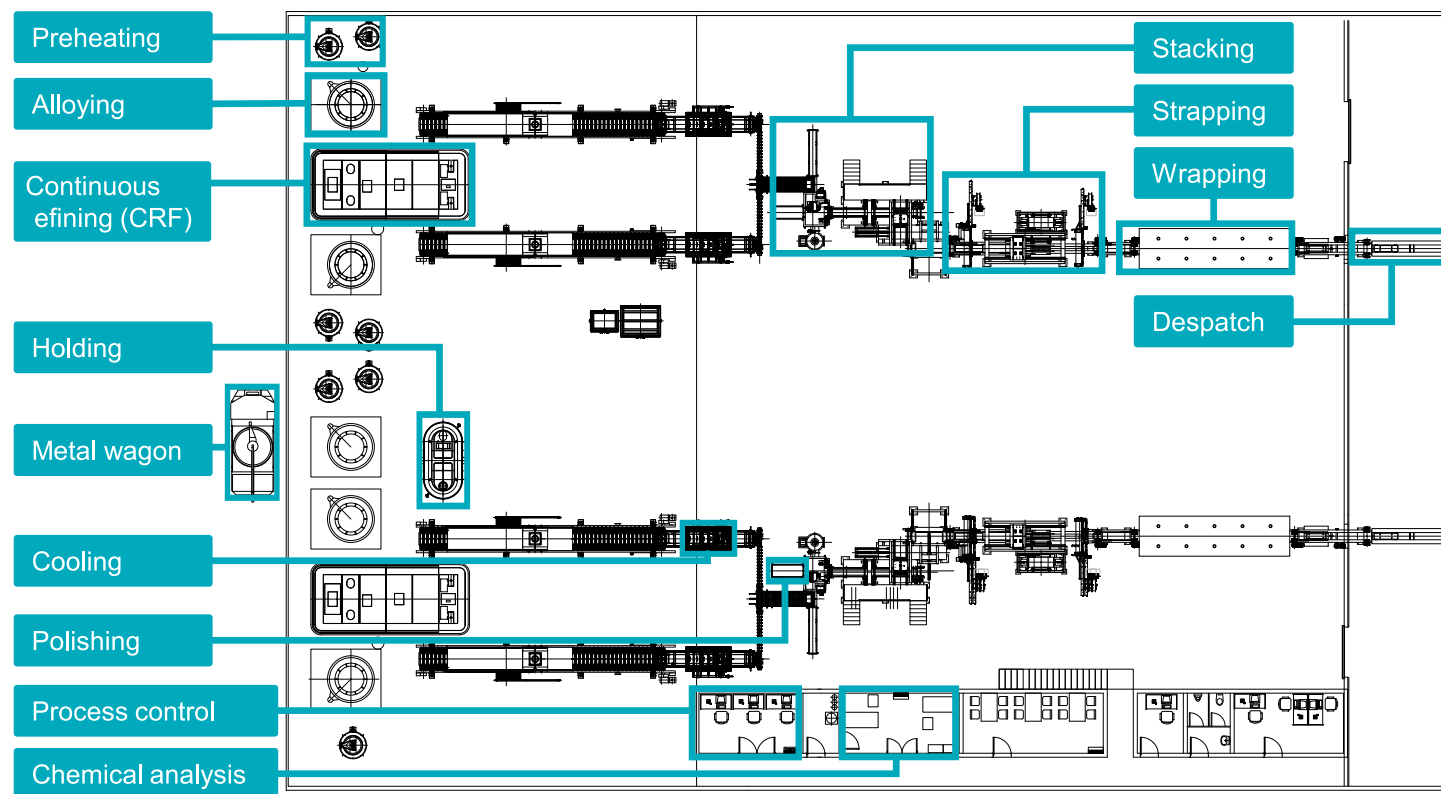
Magontec Qinghai's Magnesium Alloy Cast House (MACH) has been designed and constructed for optimum utility and efficiency.

Pure magnesium arrives in liquid form via a Metal Wagon.

Alloying and casting is managed by operators in the adjacent process control room.

Two Continuous Refinery Furnaces (CRF's) allow a longer refining time producing higher quality metal and stable material composition.

Each ingot is marked with identifying details including batch number and time and arranged on pallets to a defined shape and style.



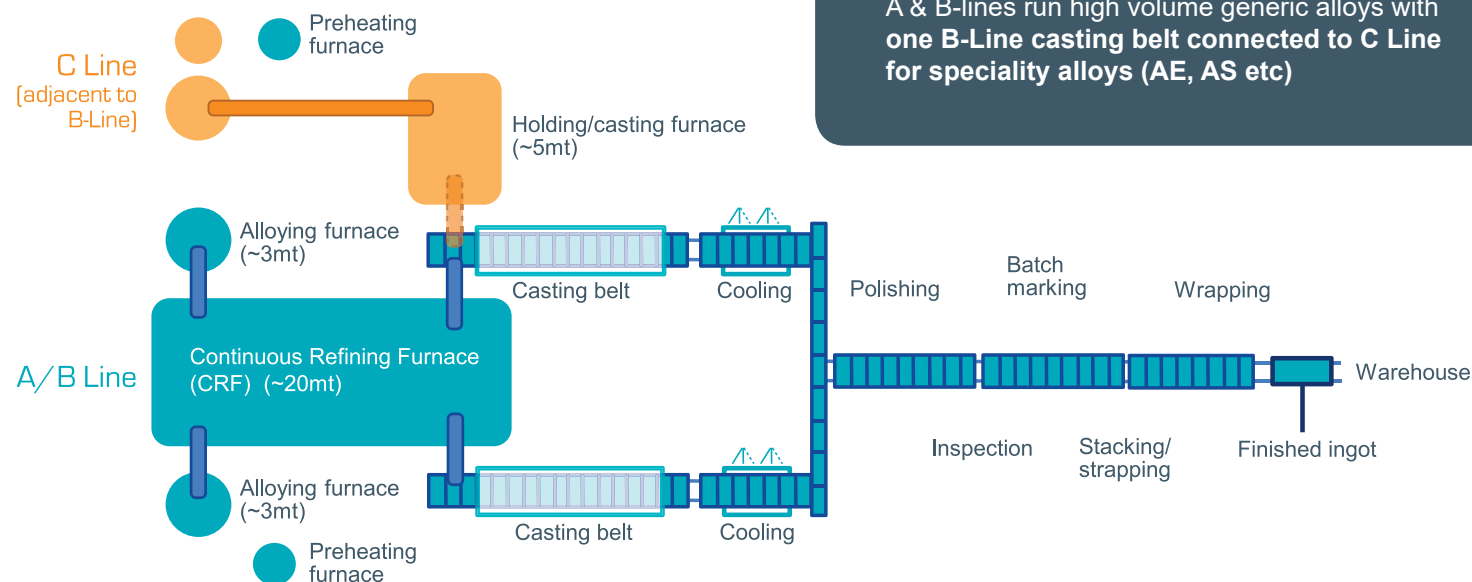
QSLM have acquired a fleet of 'metal trucks'. These vehicles collect liquid pure magnesium from electrolytic cells in the adjacent reduction cell house and transport the material to the alloying furnaces of Magontec Qinghai.



The Magontec Qinghai cast house is set up to manufacture high volumes of magnesium alloys on two lines with two casting belts per line.

Both Line A and Line B comprise two alloying furnaces and a CRF supplying liquid magnesium alloy to two casting belts.

Adjacent to Line B is Line C, which adds flexibility to the Magontec Qinghai production process. Line C is designed for smaller production runs of speciality alloys and is connected to one of the two casting belts of Line B.





Reputation for quality

Magontec uses a highly efficient and widely recognised quality control process at its plants all over the world. Like all Magontec plants, the new Magontec Qinghai facility has been subjected to and passed external certification processes.

Magontec's primary magnesium alloy experts have been producing in-spec product in China since 2002. Experienced production management personnel and other staff will transfer to Magontec Qinghai from the Company's other Chinese facilities.



Automated processes



State of the art equipment



IATF 16949
Certification



Quality control is critical feature of every manufacturing process.

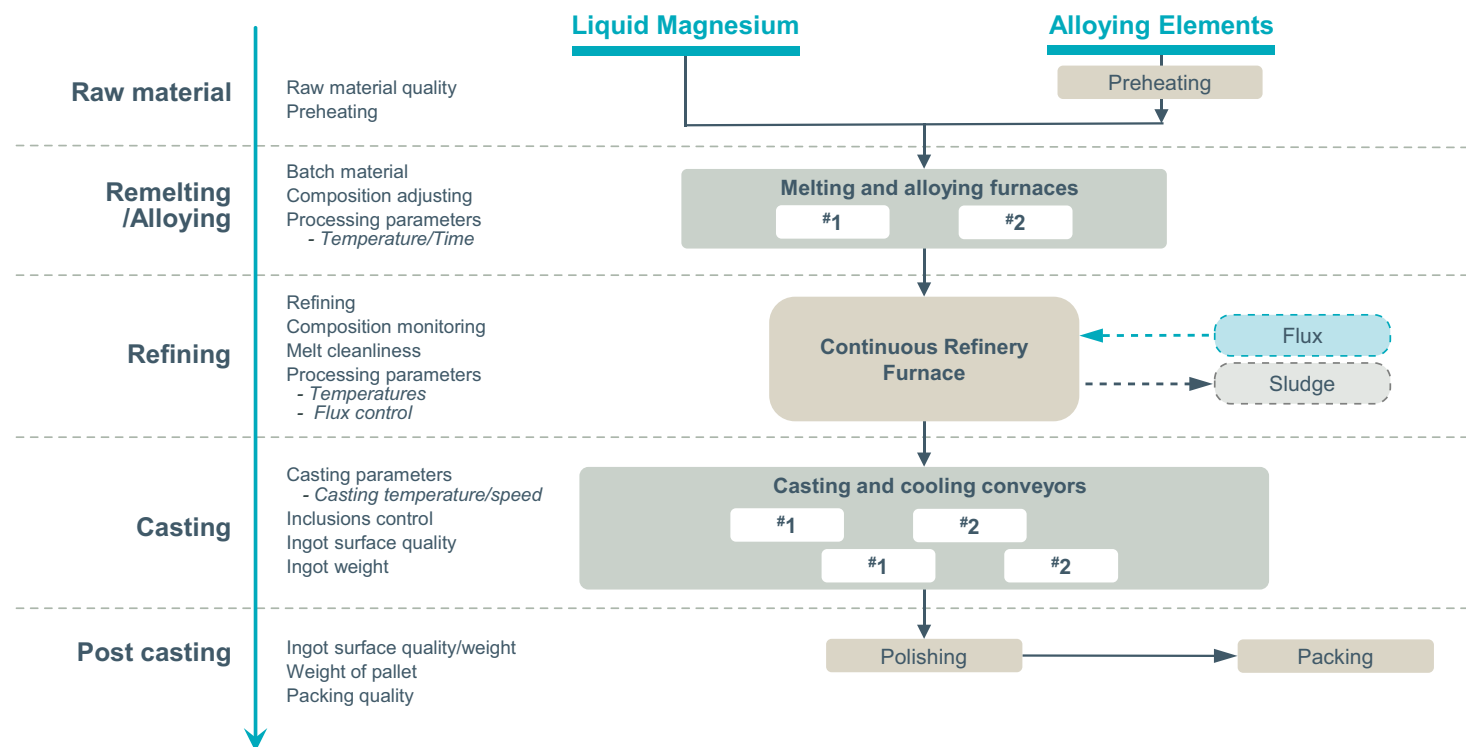
Magontec Qinghai employs the latest technologies and checks are made at each point of the manufacturing process.

Liquid pure magnesium material and solid alloying additives are quality checked on arrival.

Material is assessed for chemistry, temperature and time through alloying and refining.

Composition, melt cleanliness and flux are monitored throughout.

Prior to dispatch, product is inspected for surface quality, ingot weight, pallet weight and packaging quality



State of the art laboratory equipment for humidity and chemical analysis

Equipment

Spectrometer Lab
Spectrometer Maxx
Spectrophotometer
Chemical analysis
Muffle furnace
Microscope (Leica)
Humidity chamber

Capabilities

Composition analysis for pure Mg
Composition analysis for various Mg alloys
Quantitative analysis for Cl- content
Qualitative analysis for Cl- content
Wet chemical analysis for flux
Microstructure observation and characterisation
Inclusion test and evaluation



Pure magnesium raw material and magnesium alloy chemical composition from Magontec Qinghai production have been assessed internally and by external laboratories.

Output is within ASTM and EN specifications and, in most respects, comparable to material currently supplied to magnesium alloy die cast customers all over the world.

Chemical composition of pure Mg produced by QSLM (in weight percentage)

	Mg	Fe	Si	Ni	Cu	Al	Mn
Typical pure QSLM	99.9	0.022	0.0059	0.0007	<0.0005	0.0049	0.0054
Typical pure 'Pidgeon' process	99.9	0.0034	0.017	0.0006	0.0004	0.021	>0.04

Chemical composition of AZ91D produced by MAQ (in weight percentage)

	Al	Zn	Mn	Si	Fe	Cu	Ni	Be	Pb	Others each
MAQ (17wk431003)	8.94	0.68	0.22	0.01	0.003	0.0001	0.0008	0.0011	0.0016	–
ASTM	8.5–9.5	0.45–0.9	0.17–0.4	<=0.08	<=0.004	<=0.025	<=0.001	0.0005–0.0015	–	<=0.01
EN	8.5–9.5	0.45–0.9	0.17–0.4	<=0.05	<=0.004	<=0.025	<=0.001	0.0005–0.0015	–	<=0.01

Chemistry of QSLM pure Mg and MAQ Mg ingot (AZ91D)



Magontec

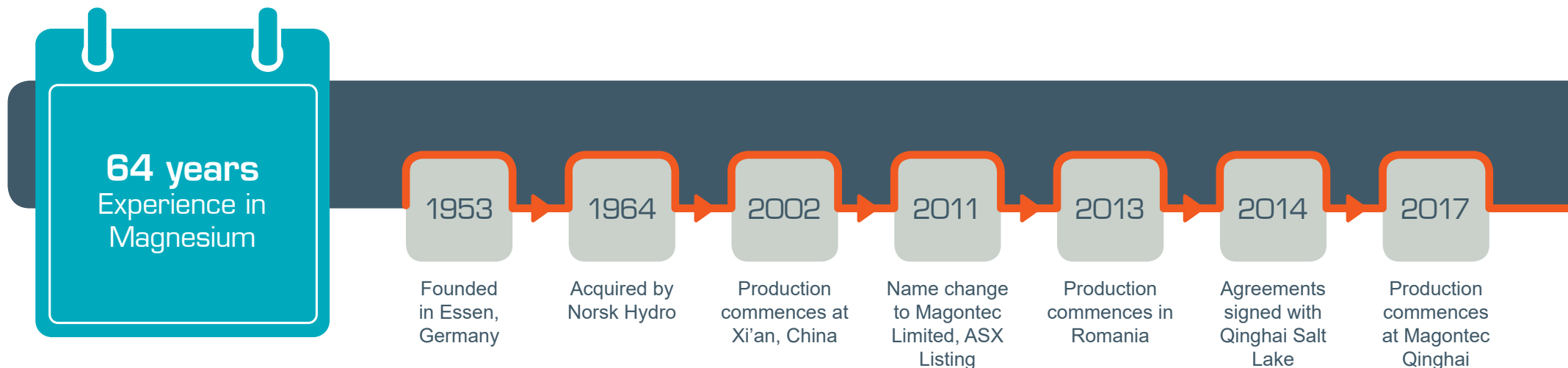
An overview

Magontec Limited has a long history. Formed in 1953 in Essen it became the primary magnesium alloy asset of the Norwegian industrial giant, Norsk Hydro in 1964.

In 2002 Norsk built its first Chinese site magnesium alloy site at Xi'an.

In 2011 the company became Magontec Limited, an independent magnesium alloy and cathodic corrosion protection products manufacturing company listed on the Australian Securities Exchange.

In 2014 Magontec Limited and the Qinghai Salt Lake Magnesium Co. Ltd. signed a series of Agreements and began construction of the world's largest and greenest magnesium production facility at Golmud in Qinghai Province.



Today Magontec offers a truly global magnesium alloy service including the world's 'greenest' primary magnesium alloy plant in Qinghai and a magnesium alloy recycling service across Europe and Asia.

Magontec Limited also manufactures downstream products such as magnesium anodes for supply to the water heater industry.

Magontec Limited is headquartered in Sydney, Australia and has R&D facilities and associations in Melbourne, Australia, Xi'an in China and Bottrop in Germany.

Magontec Limited is a leading manufacturer and recycler of magnesium alloys servicing customers directly in Europe, Asia and North America.



Production



Sales Office



Technology
Centre



Cast House
Project

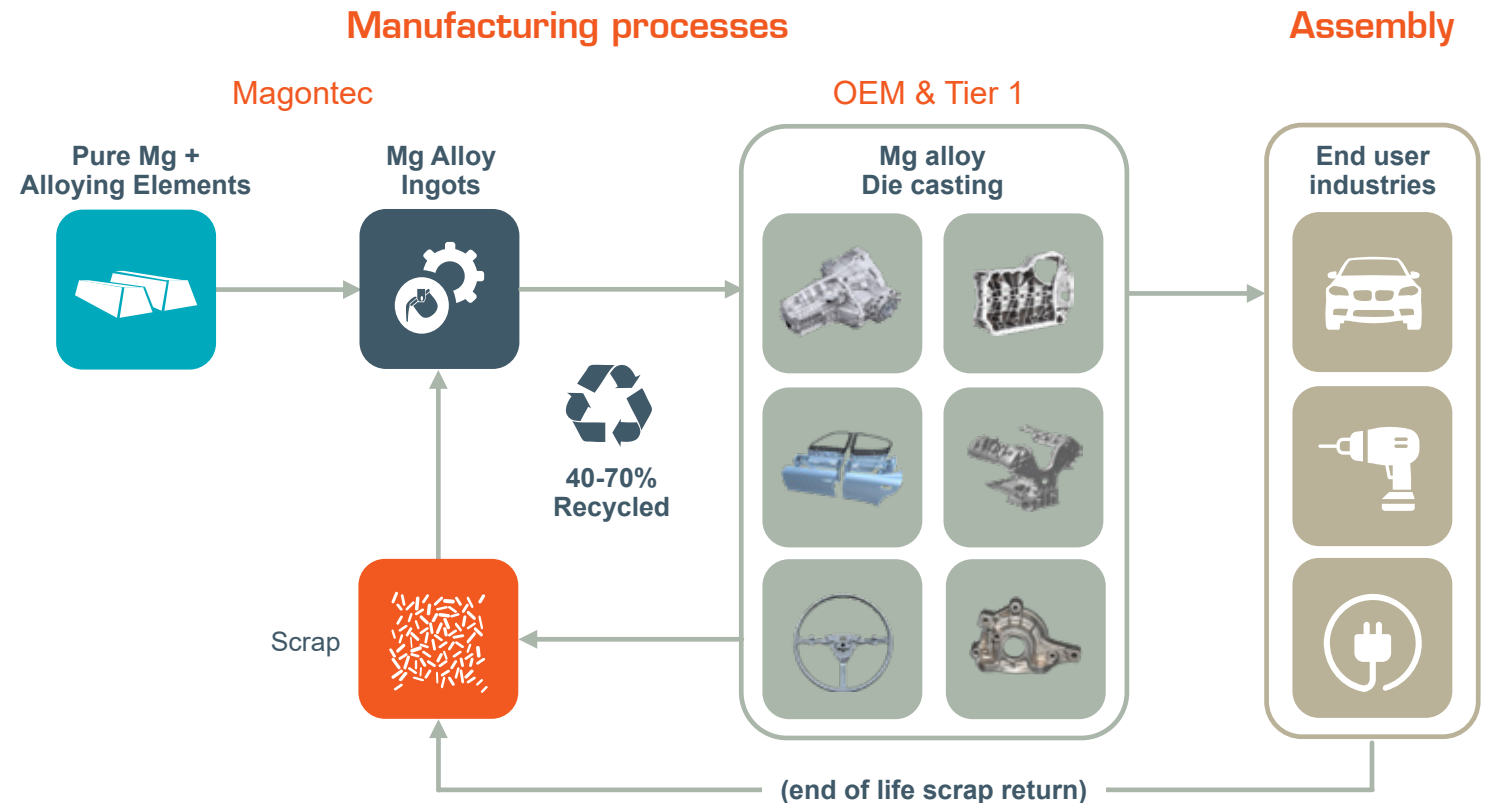


Headquarters

Through its capital investment programs in China and Europe, Magontec has focussed on helping its automotive customers meet efficiency standards for Internal Combustion Engine (ICE) and New Energy Vehicles (NEV).

Magontec also works with other magnesium alloy die casters developing light weight magnesium alloys for use in new applications in the power tool and electronics industries.

The supply of 'green' magnesium alloy from Magontec Qinghai, together with Magontec's global commitment to material recycling, will promote magnesium alloy as a leading material contender for applications and consumer groups that place a high value on environmental performance and provenance.



Magontec Limited is also a leading developer of new magnesium alloys investing significant sums each year in association with the Australian Government, RMIT and Monash University in Australia.

The Company is also in the process of establishing a new R&D facility at Xi'an in China in collaboration with the Qinghai Salt Lake Magnesium Co. Ltd.

Magontec has developed the leading high temperature and creep resistant "AE" family of alloys that now includes a thermal conductivity variant suitable for telecoms and electric automotive applications. Together with global automotive manufacturers Magontec is also developing an 'AE' variant targeted at structural application.



Leading developer of new magnesium alloys

Original R&D research in partnership with leading manufacturers



Leading high temperature and creep resistant "AE" family of alloys

Thermal conductivity alloy variant suitable for telecoms and electric automotive applications

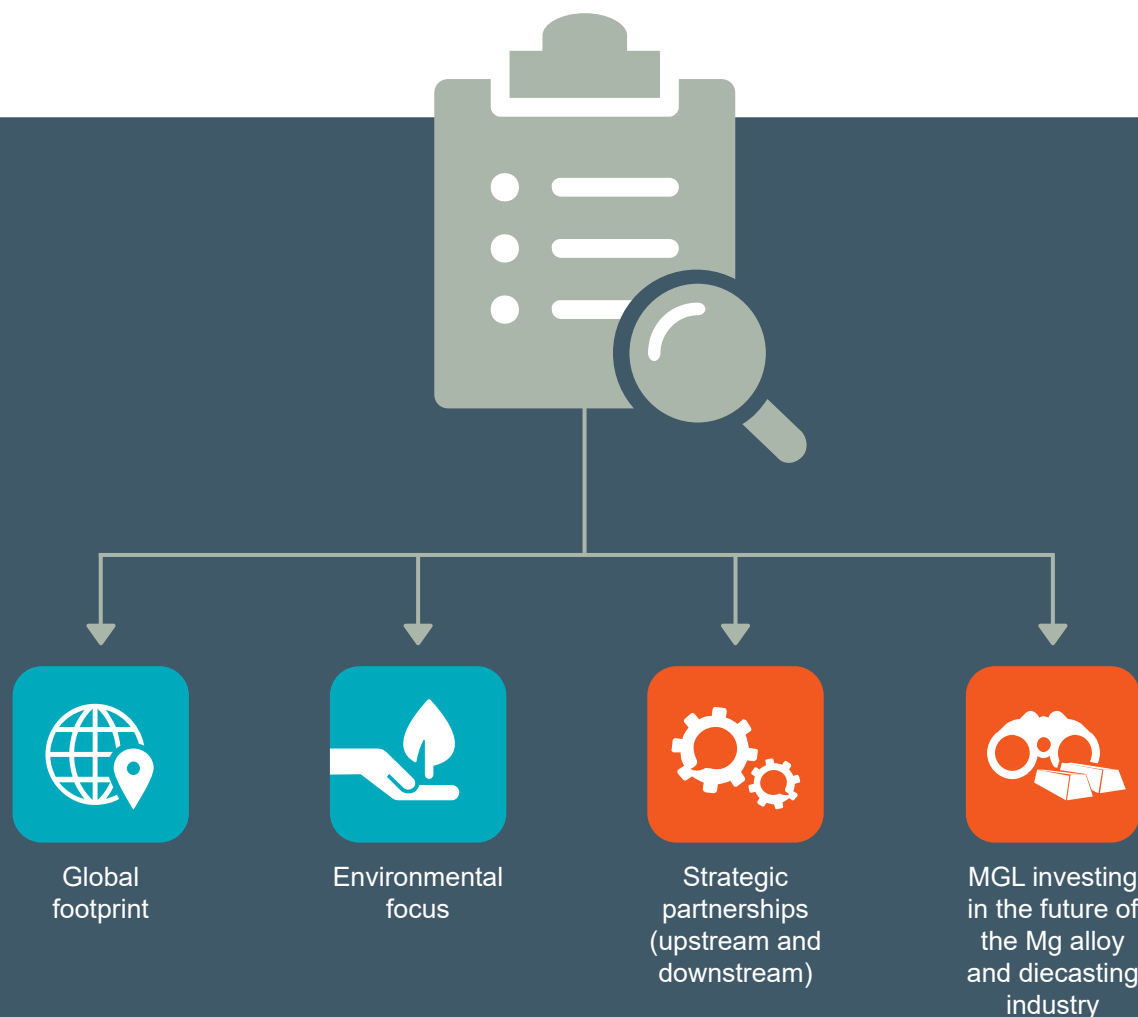
Structural alloy variant under development



Magontec Limited has made a significant investment in new primary and recycling production facilities in China, Romania and Germany.

The Company has a strong environmental focus reflected in the nature of the facilities it constructs and the material that it manufactures.

Over the years ahead Magontec will continue to innovate and build strategic partnerships to enhance its offering to customers in the magnesium alloy die cast industry around the world.



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