Raw Material Backward Integration in RHI Magnesita
Development of processes to reduce CO2 emissions

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Agenda and divider slide

1. RHI Magnesita
2. Backward integration within RHI Magnesita
3. Projects on backward integration
4. Development of processes to reduce CO2 emissions
RHI Magnesita is the world leader in refractories and a truly global company

- €2.3bn: 2020 revenue
- 12,000: Employees
- €62m: Annual investment in R&D and Technical Marketing
- 18: Finished goods sites
- 125+: Countries shipped to worldwide
- 5: Raw material sites
- 7: Combined sites

Source: RHIM annual report 2020
Unrivalled competitive advantage through vertical integration, in multiple sites
A value chain from mining to the final product – and beyond
Unrivalled competitive advantage through vertical integration, in multiple sites
A value chain from mining to the final product – and beyond

<table>
<thead>
<tr>
<th>Production sites</th>
<th>Mine</th>
<th>City</th>
<th>Country</th>
<th>Mineral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brumado</td>
<td>Pedra Preta</td>
<td>Brumado</td>
<td>Brazil</td>
<td>Magnesite</td>
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<td></td>
<td>Pomba</td>
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<tr>
<td>Non Basics - Brazil</td>
<td>Uberaba</td>
<td>Uberaba</td>
<td>Brazil</td>
<td>Bauxite Clay</td>
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<td></td>
<td>Ponte Alta</td>
<td>Ponte Alta</td>
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<td>Agalmatolite</td>
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<td>Serra dos Ferreiras</td>
<td>Onça do Pitangui</td>
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<td>Chromite</td>
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<td>Santa Luz</td>
<td>Santa Luz</td>
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<td>Fire Clay</td>
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<td></td>
<td>Água Limpa / Funchal</td>
<td>Belo Horizonte</td>
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<td>Clay</td>
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<td></td>
<td>Porto Formiga</td>
<td>Pitangui</td>
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<td>York</td>
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<td>York</td>
<td>USA</td>
<td>Dolomite</td>
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<tr>
<td>Dashiqiao</td>
<td>Dashiqiao</td>
<td>Dashiqiao</td>
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<tr>
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<td>Chizhou</td>
<td>China</td>
<td>Dolomite</td>
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<tr>
<td>Eskisehir</td>
<td>Dutluca / Kocbal</td>
<td>Dutluca</td>
<td>Turkey</td>
<td>Magnesite</td>
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<tr>
<td>Hochfilzen</td>
<td>Hochfilzen</td>
<td>Hochfilzen</td>
<td>Austria</td>
<td>Magnesite Dolomite</td>
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<tr>
<td>Breitenau</td>
<td>Breitenau</td>
<td>Breitenau</td>
<td>Austria</td>
<td>Magnesite</td>
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<tr>
<td>Radenthein Millstatter Alpe</td>
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<td>Radenthein</td>
<td>Austria</td>
<td>Magnesite</td>
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<tr>
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<td>Millstatter Alpe</td>
<td>Millstatter Alpe</td>
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</tbody>
</table>

Certainty of supply
High quality materials
Cost competitiveness
Unique solutions for the market
Little geology effort in next years
Strategic approach to Recycling

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Projects on backward integration

Chizhou - dolomite

Hochfilzen - dolomite

Brumado – magnesite
RHI Magnesita – doloma business

- Biggest D* refractory grade producer world wide
- Investment of 85 Mio € within 4 years to secure the raw material supply and fulfil the D*demand
- Dolomite stand for approx 10% of the RHI Magnesita shipments and turnover

<table>
<thead>
<tr>
<th></th>
<th>YORK/US</th>
<th>VALENCIENNES/FR</th>
<th>FLAUMONT/FR</th>
<th>CHIZHOU/CN</th>
<th>HOCHFILZEN/AT</th>
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</thead>
<tbody>
<tr>
<td>DGG - Burned Dolomite shaped Products</td>
<td>x</td>
<td>x</td>
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<tr>
<td>DGU - Tempered Dolomite shaped Products</td>
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<td>x</td>
<td>x</td>
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</tr>
<tr>
<td>DU - Unshaped Dolomite Products</td>
<td>x</td>
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</tbody>
</table>
ChiZhou Site Location 池州工厂位置
ChiZhou Revival – Rotary Kiln
Site Overview actual
Hochfilzen total plant
Overview Plant Hochfilzen

Veitsch Radex GmbH&Co OG

Products/ Services
- Raw Material and Production Site
- Several Dolomite and Magnesite Mines
- Large Dolomite and Magnesite deposits
- DBM Production (Rotary Kiln)
- MU Production (Ankerharth, ..)
- DBD Production to start end 2021
- Own railway connection

Company Background
- Construction 1957
- DBM Production since 1960
- MU Production since 1986

Location
Hochfilzen

Employees
90
Hochfilzen - deposits

Geographical view

- “Weißenstein” Magnesit/Dolomit
- “Bürgl” Magnesit/Dolomit
- “Schipflalm” Dolomit
- “Recycling” Magnesit/Dolomit

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Hochfilzen – dolomite quarry
Raw ore conveying route from mine to plant

- Access and maintenance tunnel 245 m
- Shaft 110 m high
- Entry portal 1060 m ü.A.
- Exit portal 990 m ü.A.
- Conveyor tunnel 1185 m

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Hochfilzen - Planned rotary kiln
raw ore processing, rotary kiln and railway loading station
Mineral Rights, Geology and Mine Planning

- 9 Active Mines;
- 5 States;
- 36 Municipalities;
- 8 Mining Groups;
- 73 Mining Concessions (~26 kha);
- 10 Mining Application (~3 kha);
- 41 Exploration permit (~38 kha);
- 1 Exploration Application (~19 ha)
Brumado – Pedra Preta quarry

Shaft Kiln

Rotary Kiln

- Red magnesite (MGV)
- Light coloured magnesite (MGC)
- Magnesitic marble (MMG)
- Hematitic marble (MHN)

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Agenda and divider slide

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Our strategic focus until 2025 consists of three pillars

1. Initiatives to reduce CO₂ emissions in existing facilities - 15% until 2025
   - Recycling
   - Fuel switch
   - Energy efficiency
   - Renewable Energy

2. New technologies on CO₂ - focus on capturing and usage
   - CO₂ capture & usage
   - Clean production processes
   - Focus on own raw material production

3. New Business Models to generate value with our customers
   - Cost-Per-Saving model is great development
   - Leverage 4.0 (APO/ARO)
   - Coating technology

1. Ongoing R&D + implementation (€15-20m)
2. New Technology Development (€50m)
   New: Program Green

Roll-out

2021 2023 2025 2030 and beyond
We focus on raw material production

Global RHI Magnesita CO2 emissions 2020 – 4,2 Mio. t

- Scope 1 Raw Material
- Scope 1 Energy
- Scope 2
- Scope 3 Raw Material
- Scope 3 others

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What are our “Geogenic emissions”:

50%-wt of the Magnesite ore is being released as Carbon dioxide (CO\textsubscript{2}) when the raw magnesite (MgCO\textsubscript{3}) is processed into magnesium oxide (MgO), the basis for many refractory products.

\[ \text{MgCO}_3 = \text{MgO} + \text{CO}_2 \uparrow \]
Capturing the CO$_2$ in our processes is what we need first...

Solution strongly depending on specific site conditions

Process flow

- **Option 1**
  - Mining
  - Crushing
  - rotary kiln (Oxy-fuel)
  - Post-combustion CC

- **Option 2**
  - rotary kiln
  - externally heated
  - Amine
  - Cryogenic
  - PSA
  - or combination

- **Option 3**
  - elec. heated
  - MHF
  - CCM
  - grinding
  - shaft kiln (Gas- or Elec. heated)
  - CCM
  - Briquetting
  - rotary kiln
  - DBM
secondly we have to find our way to utilize the carbon..
..but not everything is already usable on industrial scale

1. Capture the CO₂

2. As higher the CO₂ concentration as higher the value
   - CO₂ in atmosphere: 0,04%
   - Offgas Cement rotary kilns: 14%
   - Offgas RHIM rotary kilns: 16-20%
   - High purification for most application: 99,9%

3. Utilization & Conversion
   - No global CO₂ market
   - Always regional solutions necessary
   - Several technologies applicable but most very energy intense or on low TRL

4. Sequestration (CCS)
   - High dependancy on proximity to sea coast
   - Logistics unclear (rail, water, pipelines)
   - Liquid transport by rail just with limited range
Deep dive ➔ CC Calix

How such CO₂ reduction chain could look like..

- Green Electricity Production
- Transport
- PEM Electrolysis

- Mining ➔ Crushing ➔ Grinding ➔ Shaft kiln ➔ Briquetting ➔ Rotary kiln ➔ Mixing ➔ Shipping

- CO₂ ➔ H₂ ➔ Heat (65°C) ➔ H₂O ➔ O₂

Specific challenges on pilot projects:

- The power grid and the availability of (green) electricity is a major restriction
- Significant demand on water depending on process
- Onsite waste heat to be considered for CCU
- Finding project partners can gain synergies in technology, does reduce risk and Investment costs and can increase the probability to gain significant fundings.

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Potential impact on Refractory product cost (Indicative)
Cost per ton of refractory product

Worst case (on top)  Medium case (on top)  Best case  Assumed case
Worst case  Medium case (on top)  Assumed case
Best case (on top)  Not considered in calculation

Today  Capturing  Utilization  Impact of Green (today)  CO2 tax saving  Price of Green electricity/hydrogen  Subsidies  Technological progress  Impact of Green (future)

(Price mark-up compared to today: -20% to +70%)

Assumed case

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