RARE EARTHS & AUTOMOTIVE INDUSTRY
Learnings from the 2011 crisis - A useful warning signal...

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Environment, Energy & Raw Materials
Raw materials in automotive costs

Negative financial impact almost every year on Renault operations

Materials @Renault ~ 5.5 Bn€/yr

Direct Raw Material price variation impact on Renault Operating Margin

<table>
<thead>
<tr>
<th>Year</th>
<th>Impact (M€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>-357</td>
</tr>
<tr>
<td>2006</td>
<td>-430</td>
</tr>
<tr>
<td>2007</td>
<td>-236</td>
</tr>
<tr>
<td>2008</td>
<td>-359</td>
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<tr>
<td>2009</td>
<td>+148</td>
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<tr>
<td>2011</td>
<td>-509</td>
</tr>
<tr>
<td>2012</td>
<td>-55</td>
</tr>
<tr>
<td>2013</td>
<td>+86</td>
</tr>
<tr>
<td>2014</td>
<td>+134</td>
</tr>
</tbody>
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Source: Renault Financial Reports

Rare Earths content < 250 g per car

700 tons of yearly usage (La, Ce, Y, Nd, Dy)
Raw materials: A new paradigm for the manufacturing industry

1. Sharp **price increases in raw materials** since 2000 have erased all the real price declines of the 20th century
2. High **market volatility**...with (very) highs & lows (ie 2013-15)
3. More **concentration** (production, transformation), more **bottlenecks**

MacKinsey report - Towards the circular economy
Geopolitics of Automotive Raw Materials – A Chinese example

- **National Independence**
  - Rare Earths: Monopoly 95%
  - Graphite: 80% of global production
  - Lithium: Autosufficient
  - Ferrous metals
  - Non-ferrous

- **Supply**
  - Oil: 85% dependence
  - PGM (Pt, Pd, Rh): 100% dependence

- **Strong Dependence**

- **Extraction**
- **Refining**
- **Processed RM**
- **Component**

- **New Chinese Industry Pillars**
  - Graphite: Monopoly 95%
  - 80% of global production
  - Permanent Magnets
  - Solar panels
  - Batteries
  - Wind turbines
  - Hybrid & Electric Vehicles
  - Defense Industry

- **Former Chinese Industrial pillars**
  - Autosufficient
  - Graphite: 95%
  - 80% of global production

- **Alloys & New material formulations/compounding**

- **Processing**
  - Flat & Long Steel
  - Construction / infrastructures
  - Vehicles chassis & powertrains
  - Catalytic converters

- **Process**
  - Defense Industry
  - Autosufficient
  - Wind turbines
  - Batteries
  - Hybrid & Electric Vehicles
  - Skyscrapers & roads
  - Solar panels

- **Defense Industry**
  - Permanent Magnets
  - Wind turbines
  - Batteries
  - Hybrid & Electric Vehicles
  - Defense Industry

- **Component**
  - Processed RM
  - Component
  - Defense Industry
  - Hybrid & Electric Vehicles
  - Wind turbines
  - Flat & Long Steel
  - Construction / infrastructures
  - Vehicles chassis & powertrains
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  - Batteries
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- **Final Processing**
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  - Autosufficient
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The Renault Criticality Matrix
The 2011 case, with a strong emphasis on REE
New products sharpen the need for specialized materials

- Lithium
- Graphite
- Copper
- Alloy elements
- Lightweighting (Mg, Al, ….)
- Rare earth elements

R240 for Zoe (EV), April 2015
Cléon, France

Rare Earths content < 250 g per car
700 tons of yearly usage (La, Ce, Y, Nd, Dy)
Rare Earths, where in our cars?

Investigation in > 3000 parts

Supplier risk analysis

4 levers activated by OEMs
1. Usage reduction
2. Sourcing change (from FOB market to Chinese domestic market)
3. REE substitution
4. Technology change (w/o REE)

Some OEMs developed also stockpiling strategy to secure (mainly on Dysprosium)
What are the industry concerns about Rare Earths Elements?

- **Access to reliable & *shared* materials intelligence & scenarios**
  We need common tools to assess exposure & supply/demand scenarios

Joint Study of French automotive industry (CCFA, Renault, PSA, Valeo, Faurecia, PO)

- **Enhanced, focused technological innovation for usage optimization**

- **Promotion of local, short-loop flow schemes within an economical and industrial eco-system (circular economy)**

- **Secure access to a continuous supply chain**
Effect of countermeasures were quite efficient

Main objective for the industry is to avoid « hot » situations

Example – The Dysprosium case

New Development
Seat
IGN-Coil
SSG

Key Drivers
Alternator
EPS
Speaker

• REE market in 2015
  – Supply > Demand
  – Smooth start of non-Chinese production (LREE)
  – Lower REE price levels
Replacement

- Aluminum wiring as replacement for Copper...depending on Cu & Al prices

- Technologies for EV motors that eliminate our need for rare earths
  ➔ externally excited synchronous motor
  ➔ already applied to the Renault EV line-up
  ➔ switched reluctance motor,…
How to go further: Is it technically and economically possible to recover and recycle REE from End of Life Vehicles?

Identification of REE containing parts in EoL → Component shredding → REE rich-powder separation

Renault + Shredder → Chemical separation

Rare Earths Oxide recycling → Reduction to REE metals

Reuse by Renault Tier n suppliers

Solvay Rare Earths

Technico-economical analysis
Identification of Nd & Dy containing parts in End of Life Vehicles

Les principales pièces contenant du néodyme dans les véhicules Renault

Col Ass Elec
Haut Parleur
Vanne recy gaz échapp
Changeur CD
Capteur arbre came
Compresseur CA
Siegé
Autoradio navigation
Reservoir carburant GPL EQP
Commande vitesse EQP

Les principales pièces contenant du dysporsium dans les véhicules Renault

Col Ass Elec
Haut parleur
Compresseur CA
Alternateur
Capteur vitesse
Capteur point mort haut
Avertisseur sonore aide parking
Buzzer assy
Autoradio navigation
Reservoir carburant GPL EQP
Autoradio
Tableau bord
Siege conducteur AV D

Source: données Renault
With some surprises at the end of the road....

Loudspeakers analysis from Renault & other brands End of Life Vehicles

80 loudspeakers dismantled

→ 54 Renault
→ 26 other brands

→ No Nd speakers in other brands EoL vehicles
→ Technically feasible recycling process, unfortunately not economically...
Recommendations & Conclusions

- Share economic research on materials stocks & flows at EU level
  - by material class
  - by industry sector

- Give priority support to technological levers that
  - Reduce industry exposure (3R: Reduce, Replace and Recycle)
  - Increase our leverage (diversification of sourcing in the whole supply chain)

- Facilitate public-industry platforms to promote *lean* & *international* cooperation on “TOP 10” subjects
  - Shared databases on materials criticality
  - Substitution technologies

- Anticipate & innovate to secure mid-term sourcing!
New technologies & materials have always driven technical progress

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