CARESTER

RARE EARTHS AND ENERGY

IRCE PARIS MAI 2019



15 Mai 2019, Paris

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WHY TALKING ABOUT RARE EARTHS IN A CONFERENCE DEVOTED TO ENERGY?

Because 2 technologies essential for the energy transition are dependent on Rare Earths

- Electric vehicles
- Wind turbines

ELECTRIC MOTORS AND ELECTRIC GENERATORS NEED PERMANENT MAGNETS TO BE LIGHTER AND MORE EFFICIENT



THE QUANTITY OF RARE EARTHS USED IN WIND TURBINES AND E-CARS (ND, PR, TB, DY) IS VERY SIGNIFICANT **Offshore Wind Turbines Electric Vehicles**

41 million by 2040 each containing an average of 1.7kg of Nd(Pr)



Permanent Magnets are used in high-speed gearbox designs as well as direct-drive, gearbox-free turbines Each contains 15 okg of Nd(Pr) per MW



THE NEODYNIUM MARKET GROWTH IS MAINLY DUE TO E-CARS



Forecast NdFeB Magnet Demand to 2030

The NdFeB market will double in 12 years,

In 2030 e-cars should represent more than 80% of this market

RARE EARTHS ARE MANDATORY, BUT WHAT ARE THE MAIN QUESTIONS AROUND THEIR MARKET?

1. THE RARE EARTHS AVAILABILITY

2. THE RARE EARTHS BALANCE

3. THE MAGNETS PRODUCTION: A COMPLEX VALUE CHAIN

RARE EARTHS ARE NOT RARE AND FAIRLY WELL DISTRIBUTED AROUND THE WORLD





The ww reserves of Rare Earths are estimated between 120 millions tons (USGS) and 190 millions tons compared to the forecasted ww consumption between 160 and 200 kT in 2020.

RARE EARTHS ARE NOT RARE, BUT...

... the EU considers Rare Earths as the elements with the highest supply risk among all the critical elements.







WHAT HAPPENED UNTIL 2010?

IN 2005 CHINA DECIDED TO LIMIT ITS EXPORTS BY A QUOTAS POLITICS



... and allowed China to develop its downstream industry



The quotas led to a major crisis with a dramatic impact on the prices and the market...



WHAT HAPPENED SINCE 2010?

2010 – 2013: The Junior minings era

- The known reserves of Rare Earths increased from 99 millions t REO in 2009 to130 millions t REO in 2015 (https://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/)
- In 2013 more than 60 Rare Earths mining projects have been financed outside of China for about 100 millions t REO (Technology Metals Research; http://www.techmetalsresearch.com/metrics-indices/tmr-advanced-rare-earth-projects-index/)

2013: The 1st new Rare Earths mines opened outside of China since the 1980s

- Molycorp (USA), Lynas (Australia & Malaysia) and Toyotsu RE (a JV between Toyotas and Indian RE) are the 1st non Chinese Rare Earths mining companies to start a production in 2013
- In June 2015 Molycorp filed Chapter 11 (bankruptcy protection).
- Since 2015, the investors are more careful and the project owners have difficulties to get financing

THE SITUATION OUTSIDE OF CHINA IN 2019

EXISTING MINES

In 2019, the production of rare earths outside of China represents about 20% of the Neodynium global production.

Deposit	Country	Yearly Capacity
Lovozero	Russia	3000t REO
Orissa	India	10000t REO
Mount Weld	Australia	20000t REO

After the banckrupty of Molycorp the Moutain pass mine in the USA has been bought by a Chinese company, Shenghe Resources and the concentrate is now sent to China

PROJECTS

- Some advanced projects are ready to start, waiting for financing (among them see examples below)
- Chinese companies try to take position outside of China

Deposit	Country	Yearly Capacity	Comments
Ngualla	Tanzania	10000t REO	Separation unit in the UK
Songwe	Malawi	5000t REO	Separation unit in the UK
Dubbo	Australia	6500t REO	
Serra Verde	Brasil	5000t REO	Concentrate to be sold in China
Brown Range	Australia	3300t REO	Concentrate to be sold in China
Tomtor	Russia	20000t REO	
Kvanefjeld	Greenland	20000t REO	Concentrate to be sold in China
			Alain Rolla [.]

OPENING OF NEW RARE EARTHS MINES IS MANDATORY

Increasing demand of Neodynium for magnets shows that it is necessary to increase the production of PrNd by 25kT (equivalent to 80kT to 150 kT of global REO*).

This is a great opportunity for non Chinese new mines.



Forecast NdFeB Magnet Demand to 2030

*Pr+Nd = 15% to 30%/global REO depending on deposit

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THE KEY QUESTION OF THE IMBALANCE BETWEEN RARE EARTHS

The applications need pure Rare Earth elements

Property	Final Application	Main RE
Magnetism	E-cars, Wind turbines – Elecronics	Nd, (Pr, Dy, Tb)
Polishing	Flat screen – Electronics	Ce, (La, Pr)
Fuel cracking	Petrochemistry	La, (Ce, Pr, Nd)
H storage	NiMH batteries	La,(Ce, Pr, Nd)
Depollution Catalyst	Automotive Industry	Ce, (La, Pr, Nd, Y)
Luminescence	Lighting	La, Ce, Eu, Tb, Y



Magnets need Neodynium and Dysprosium, but there is no ore of Neodynium or Dysprodium. All the rare earths are associated in the ores all together and the ratios between adjacent rare earths are quite fixed.

The typical Ce/Nd ratio in the ores is 2.5 to 4. When 1 t of Nd is produced 2.5 to 4 t of Ce is coproduced. But does the market for this Ce exist?

THE KEY QUESTION OF THE IMBALANCE BETWEEN RARE EARTHS

The difference between the effective Rare Earths distribution in the ores and the Rare Earths used in the applications creates a imbalance between the demand and the supply and this imbalance is growing with the increasing magnet market.

Rare Earth Oxide	Demand (including recycling of magnet materials)	Supply/Production (including illegal production in China)	Excess/deficit	Main Application
	T REO	T REO		
Lanthanum	49 425	60 750	11 325	FCC
Cerium	72 175:	76 950	4 775	Auto cat
Praseodymium	14 200	13 725	-475	Magnets
Neodymium	44 175	42 975	-1 200	Magnets
Samarium	1 600	4 725	3 125	Magnets
Europium	250	675	425	Lighting
Gadolinium	3 675	5 400	1 725	Nuclear
Terbium	400	675	275	Magnets
Dysprosium	1 850	3 150	1 300	Magnets
Erbium	900	900	0	Optical fibers
Yttrium	9 675	13 275	3 600	Ceramics
Ho-Tm-Yb-Lu	275	1 800	1 525	
Total	197 500	225 000	27 500	

Forecast Global Demand and Supply for Individual REs 2020 (±25%) (From Kingsnorth)

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Rare E Oxic		The cost of the RE without			
Lanthanum	m	iarket must	be suppor	tea c	
Praseodym					inets
Neodymiun		tha maa	mat mat lea	+	inets
Samarium		LIE MAC	ΠΕΓΠΑΓΚΕ		jnets
Europium					nting
Gadolinium		3 675	5 400	1 725	Nuclear
Terbium		400	675	275	Magnets
Dysprosium		1 850	3 150	1 300	Magnets
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FROM THE ORE TO THE FINAL MAGNET A LONG AND COMPLEX VALUE CHAIN



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ONLY CHINA CONTROLS THE 6 STEPS FROM ORE TO MAGNETS AT INDUSTRIAL SCALE

	Mining	Ore concentation	Ore attack	RE separation	Metal production	Magnet production
CHINA	+++	+++	++++	++++	++++	+++
EU				+	+	+
USA	+	+				
JAPAN					+++	+++
AUSTRALIA + MALAYSIA	++	++	++	++		
RUSSIA	+	+	+			
INDIA	+	+	+	+		
VIETNAM				+	+	

EU NEEDS TO REBUILD A MAGNET INDUSTRY

The EU has a weak position in the Magnet value chain. The possibility for the EU to limit geopolitical risk must be considered in cooperation with other developped countries (USA, Canada, Japan and Australia). There is a possibility to build a non Chinese value chain, but to this end both policymakers and economic leaders must assume their responsability.

The policymakers must help industry rebuild the Rare Earths supply chain. This should include End of Life recycling, but as this source will not be sufficient for the needs, primary extraction will remain mandatory.

Rare Earths end users companies (Wind turbins and car manufacturers) must support non Chinese Rare Earths players throughout the industrial chain by accepting the fact that independence has a cost.

CARESTER HAS THE AMBITION TO BE A PARTNER FOR THE EUROPEAN RARE EARTHS VALUE CHAIN

Carester is a new company created in February 2019 with the ambition to participate in the challenge of building a new Rare Earths value chain outside of China.

The knowledge of the company is based on the expertise of former Solvay specialits representing more than 200 years of experience in Rare Earths processing An ambition based on 4 pilars:

- Deliver technological services to Rare Earths industry
- \succ Design an optimized software for Rare Earths solvent extraction
- \geq Be an actor of Rare Earths recycling business in Europe
- \blacktriangleright Developp green processes for Rare Earths separation

SUMMARY / CONCLUSIONS

 \geq Rare earths are essential for the energy transition

The very important growth of the permanent magnets market will increase the imbalance issue between Rare Earths which should lead to price increase of the Rare Earths used in magnets

➤ While the global rare earths reserves are huge there is a risk of shortage due to geopolitical reasons. In the last years China has lost its monopoly position for Rare Earths raw materials production, but the Chinese position remains dominant and as long as new Rare Earths mines outside China will not open, the independence of western countries will not be ensured

Thank you for your attention

