RARE EARTHS & AUTOMOTIVE INDUSTRY

Learnings from the 2011 crisis - A useful warning signal…

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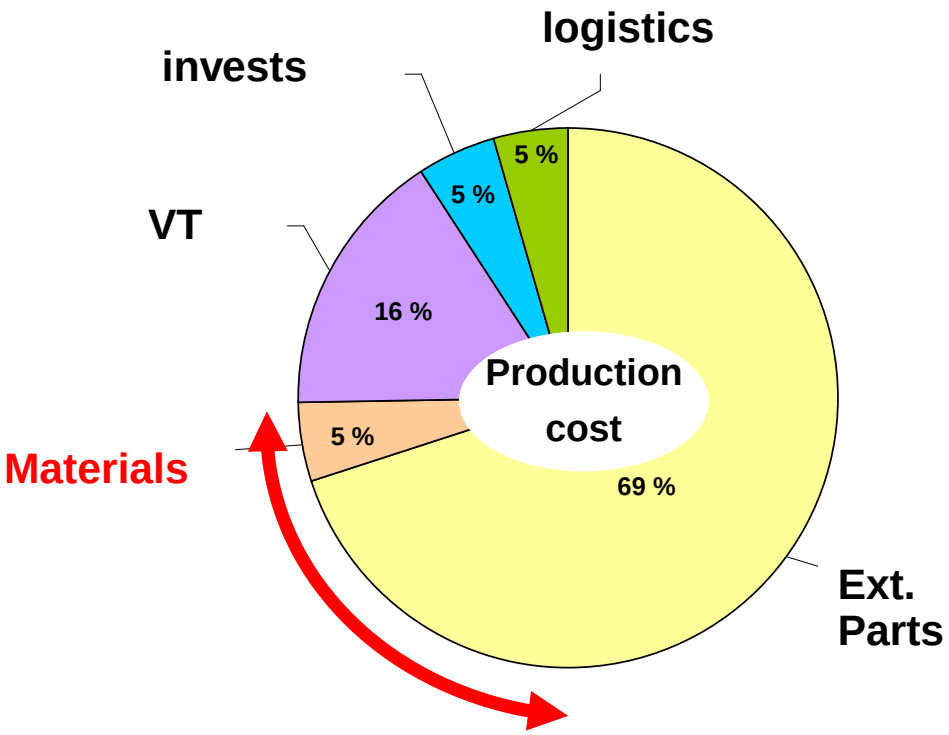
Environment, Energy & Raw Materials

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

2005	- 357 M€
2006	- 430 M€
2007	- 236 M€
2008	- 359 M€
2009	+ 148 M€
2010	- 148 M€
2011	- 509 M€
2012	- 55 M€
2013	+ 86 M€
2014	+ 134 M€

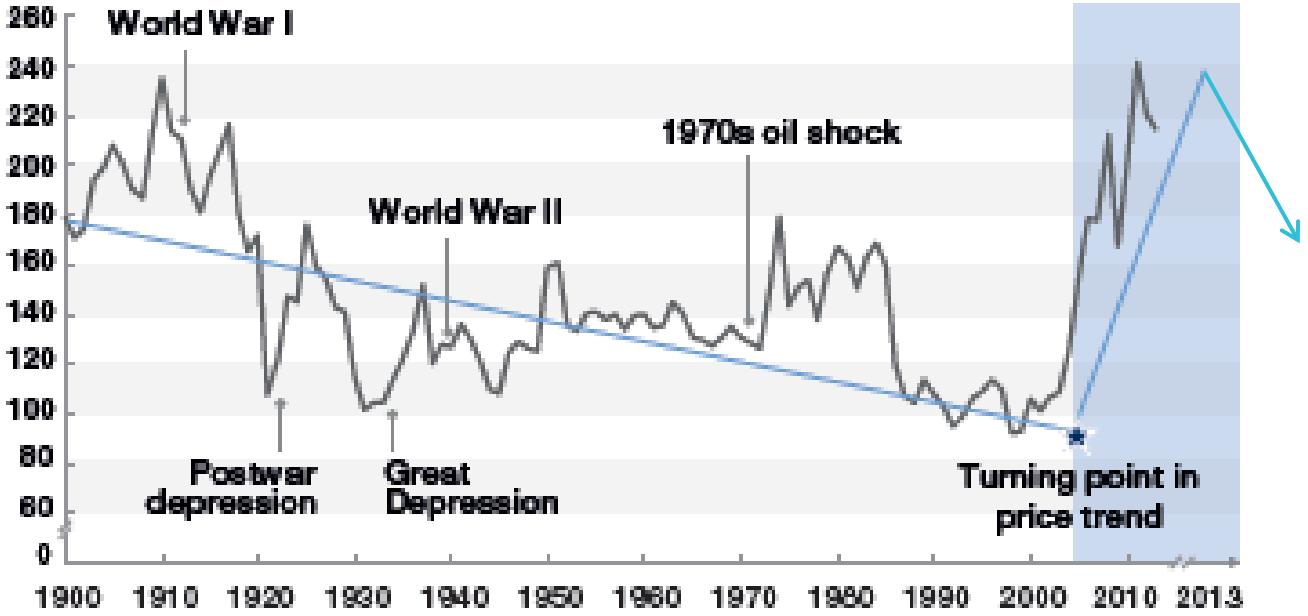
Source : Renault Financial Reports

Rare Earths content
< 250 g per car

→ 700 tons of yearly usage
(La, Ce, Y, Nd, Dy)

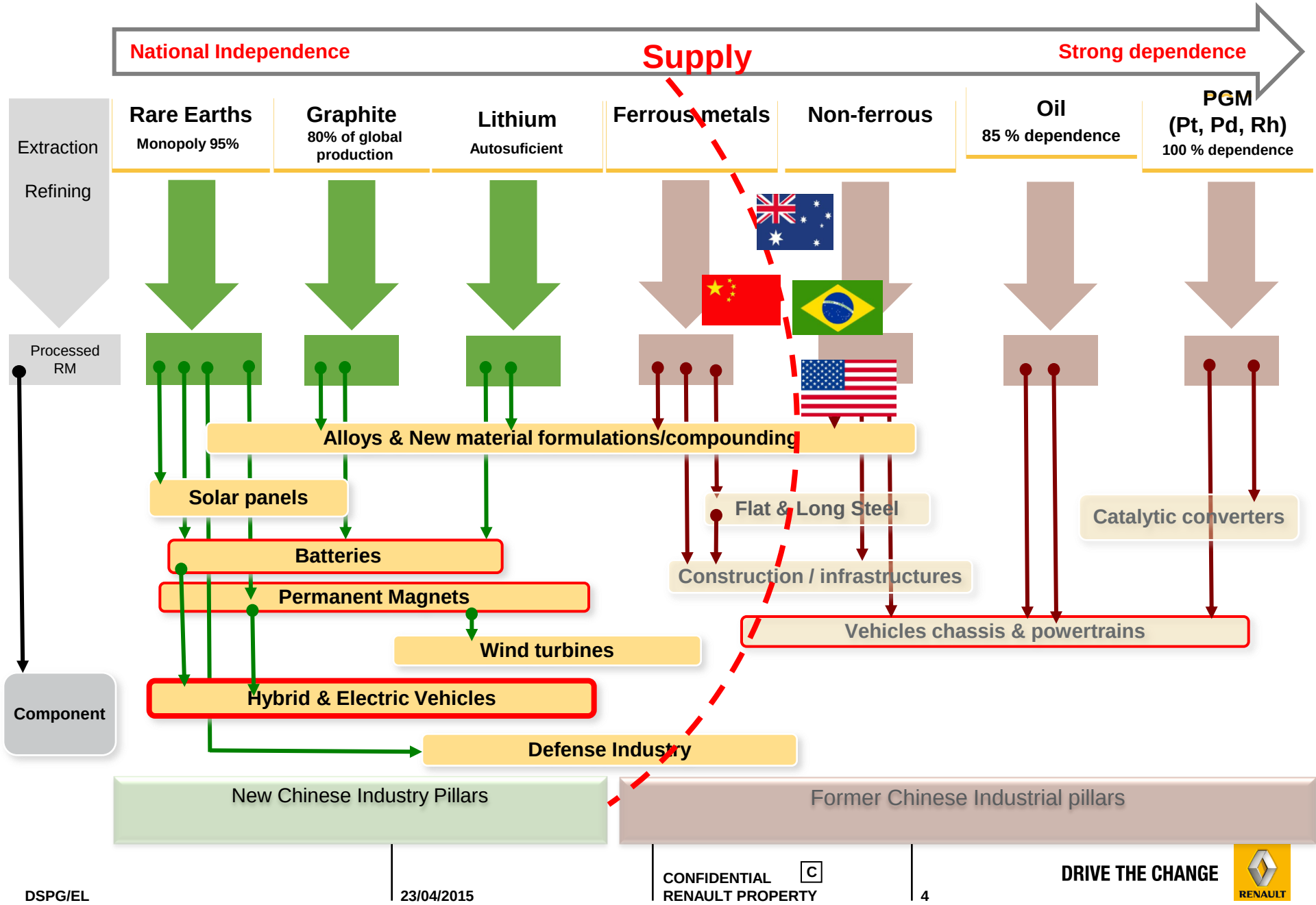
Raw materials : A new paradigm for the manufacturing industry

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**

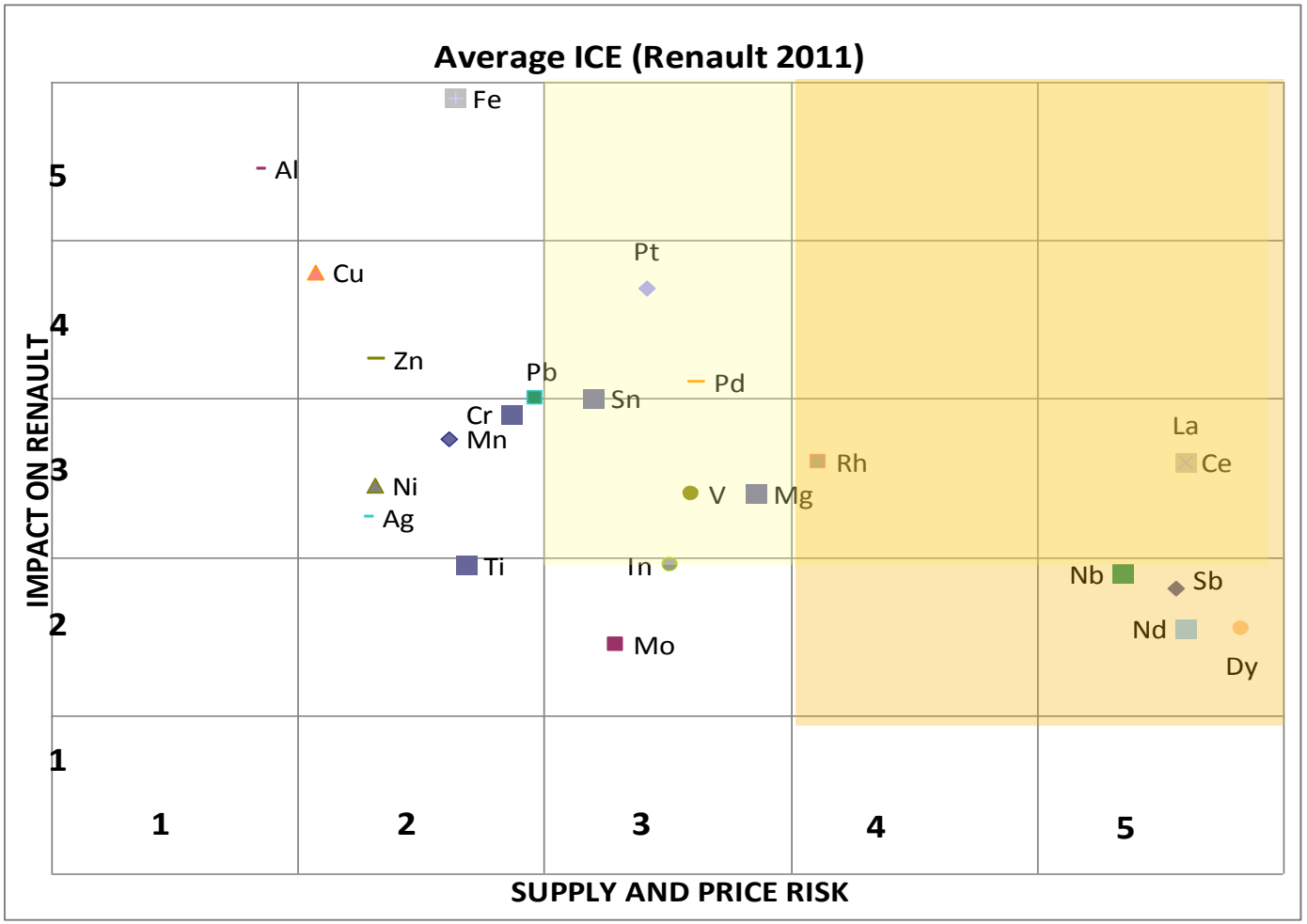


MacKinsey report - Towards the circular economy
WEF – Jan. 2014 – Ellen MacArthur Foundation

Geopolitics of Automotive Raw Materials – A Chinese example



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, ….)**

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

- **Rare earth elements**

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

RENAULT NEEDS	FY11 en Kg	FY12 en Kg	FY13 en Kg	FY14 en Kg
Dy - Dysprosium	9 025	8 205	3 784	3 402
Nd - Néodyme	92 872	88 677	63 033	57 077
Ce - Cérium	99 527	115 600	84 750	127 900
La - Lanthane	14 751	16 351	13 731	0
Pr - Praséodyne	24 775	23 475	16 900	13 838
Tb - Terbium	162	136	203	194
Y - Yttrium	702	894	783	0
Sm - Samarium	167	214	318	318

Answers recevied	Material	Parts name	Region	SAM	Tier1	TierN	Magnet supplier	Alloy supplier	FY11 Usage (Unit: kg/year	FY12 Usage (Unit: kg/year	FY12 quantity secured Y/N	FY13 Usage (Unit: kg/year	FY13 quantity secured Y/N	FY14 Usage (Unit: kg/year	FY14 quantity secured Y/N
	Dy	SPEAKER	EU	X. Gruson	FAITAL	N/A	San Huan	Baotou City San Long Rare Metals CO.,LTD	275	146	indexation	140	Y	90	indexation
	Dy	SPEAKER	Korea	X. Gruson	Bose	N/A	Tridus Magnetics	San Huan Lucky	681	576		510		510	
	Dy	SPEAKER	EU	X. Gruson	Bose	N/A	Tridus Magnetics	San Huan Lucky	568	622		555	Y	555	Y
	Dy	SPEAKER	EU	X. Gruson	PANASONIC	N/A	nc	nc	?	?		?		x	Y
	Dy	E-Compressor	EU	C. Ragot	DENSO				0	0		0			
	Dy	Steering	EU	A. Laffitte	TRW	TRW	San Huan	Magnequench	4 500	3 150	Yes	400	Yes	0	Yes
	Dy	Steering	EU	A. Laffitte	NSK	Nidec	Daido Electronics	MQI	1 700	1 600	Yes	0	Yes	0	Yes
	Dy	Steering	EU	A. Laffitte	JTEKT	Melco	Hitachi	not known	0	788	Yes	800	Yes	800	Yes
	Dy	Ignition Coil	EU	V. Cébé	ELDOR	ZHEJIANG DONGYANG DMEGC MAGNETICS Co., LTD			230	324		225		225	
	Dy	CAM/Crank angle sensor	EU	V. Cébé	CONTINENTAL	nc	VACCUMSCHMELZE	nc	197	307		210		210	
	Dy	CAM/Crank angle sensor	EU	V. Cébé	ELECTRIFIL	nc	nc	nc	193	223		107		107	
	Dy	EGR module	EU	F. Bernard	VALEO	nc	nc	nc	11	3		4			
	CuTe	Starter S&S	EU	M. Vezine	VALEO	nc	nc	nc	0	0		0		0	
	Dy	Module	EU	EH. Redouane	BOSCH	TBC	TBC								
	Dy	Module	EU	EH. Redouane	TI	TBC	TBC								
	Dy	Magnet on diesel EC pump	China	EH. Redouane	AISAN		Pacific Metals					22		22	
	Dy	DC4- DCT	Europe	N. Mahjoubi	GETRAG	Nidec	Epson/Hitachi/San Huan		457	259	Y	479	Y	525	Y
	Dy	DC4- DCT	Europe	N. Mahjoubi	GETRAG	Conti (Brose)	VAC/Atlas		136	147	Y	272	Y	298	Y
	Dy	UPA Buzzer	EUROPE	X. Helme-Guizon	VALEO				77	60	N	60	N	60	
	Nd2O3	Catalyst	Europe	L. Grepilloux	BASF/JM/UMICORE				9 351	9 491		5 110			
	Nd	Steering	EU	A. Laffitte	TRW	TRW	San Huan	Magnequench	23 900	16 730	Yes	1 300	Yes	0	Yes
	Nd	Steering	EU	A. Laffitte	NSK	Nidec	Daido Electronics	MQI	24 800	24 100	Yes	16 200	Yes	15 000	Yes
	Nd	Steering	EU	A. Laffitte	NSK	Nidec	Daido Electronics	MQI	18 200	18 200	Yes	6 100	Yes	5 000	Yes
	Nd	Steering	EU	A. Laffitte	JTEKT	Melco	Hitachi	not known	0	4 183	Yes	17 600	Yes	20 000	Yes
	Nd	SPEAKER	EU	X. Gruson	BOSE	N/A	Tridus Magnetics	San Huan Lucky	6 628	7 412		6 606	Y	6 606	Y
	Nd	SPEAKER	EU	X. Gruson	BOSE	N/A	Tridus Magnetics	San Huan Lucky	6 822	5 769		5 112	Y	5 112	Y
	Nd	SPEAKER	EU	X. Gruson	PANASONIC							x		x	
	Nd	Magnet on diesel EC pump	China	EH. Redouane	AISAN		Pacific Metals					120		120	
	Nd	UPA Buzzer	EUROPE	X. Helme-Guizon	VALEO				230	200	N	170	N	170	
	Nd	Steering Angle Sensor	EUROPE /KOREA	X. Helme-Guizon	YAZAKI	Bosch			32	40	N	40	N	40	
	Nd	Moteur glissières X91-X95	Europe	H. Néant	FAURECIA	SHB / L&B	?	2,3 g/moteur	95	88	NO	75	NO		
	Nd	DC4- DCT	Europe	N. Mahjoubi	GETRAG	Nidec	Epson/Hitachi/San Huan		2 202	1 802	Y	3 329	Y	3 643	Y
	Nd	DC4- DCT	Europe	N. Mahjoubi	GETRAG	Conti (Brose)	VAC/Atlas		610	662	Y	1 224	Y	1 339	Y
	Nd	FPM	EU	EH. Redouane	TI	TBD			3	1		47		47	
	Nd	M/Crank angle sen	EU	V. Cébé	CONTINENTAL	nc	VACCUMSCHMELZE	nc				540		540	
	Nd	M/Crank angle sen	EU	V. Cébé	ELECTRIFIL	nc	nc	nc				19		19	
	Nd	Ignition Coil	EU	V. Cébé	ANG DMEGC MAGNETICS Co., LTD				230	324		870		870	
	CeO2	Catalyst	EU	L. Grepilloux	BASF/JM/UMICORE				99 527	115 600		84 750		127 900	
	La2O3	Catalyst	EU	L. Grepilloux	BASF/JM/UMICORE				14 600	16 200		13 580			
	La	Engine cooling	EU	C. Ragot	BOSCH				151	151		151			
	La	FPM	EU	EH. Redouane	TI	TBD			0	13		95		95	
	La	Magnet on gasoline DC pump (EFP5.6)	China	EH. Redouane	AISAN		TDK		21	21		0		0	
	La	Magnet on gasoline DC pump (EFP8.5)	China	EH. Redouane	AISAN		TDK			27		59		59	
	La	Magnet on diesel DC pump	China	EH. Redouane	AISAN		TDK			168		373		373	
	La	Starter Motor	EU	M. Vezine	MITSUBISHI	TDK			1 693	1 651	Y	1 975	TBC	2 563	TBC
	La	Starter Motor	EU	M. Vezine	HITACHI	TDK			N/A	N/A	Y	2	TBC	35	TBC
	La	Starter Motor	EU	M. Vezine	BOSCH				N/A	N/A	Y	27	TBC	277	TBC
	La	Magnet on DC motor	China	V. Cébé	AISAN		TDK		334	428		637		637	
	Pr	Steering	EU	A. Laffitte	NSK	Nidec	Daido Electronics	MQI	16 100	15 400	Yes	100	Yes	80	Yes
	Pr	Steering	EU	A. Laffitte	NSK	Nidec	Daido Electronics	MQI	600	600	Yes	15 000	Yes	13 000	YEs
	Pr6O11	Catalyst	EU	L. Grepilloux	BASF/JM/UMICORE				5 700	6 200		580			
	Pr	Moteur glissières X91-X95	Europe	H. Néant	FAURECIA	SHB / L&B	?	0,26g / moteur	11	10	NO	9	NO		
	Pr-oxide	Moteur glissières X91-X95	Europe	H. Néant	FAURECIA	SHB / L&B	?	0,64g / moteur	26	24	NO	21	NO		
	Pr	SPEAKER	EU	X. Gruson	FAITAL	N/A	San Huan	Baotou City San Long Rare Metals CO.,LTD	2 338	1 241		1 190	Y	758	Y
	Tb	SPEAKER	EU	X. Gruson	FAITAL	N/A	San Huan	Baotou City San Long Rare Metals CO.,LTD	103	55		53	yes indexation	30	Y
	Tb	Starter Motor	EU	M. Vezine	VALEO	(TBC)			N/A	N/A	Y	0	TBC	0	TBC
	Tb	DC4- DCT	Europe	N. Mahjoubi	GETRAG	Nidec	San Huan		59	81	Y	150	N	164	
	Y2O3	Catalyst	EU	L. Grepilloux	BASF/JM/UMICORE				600	800		700			
	Yttrium-oxide	Boitier mémo X91-X95	Europe	H. Néant	assemblé par fournisseurs carters extérieurs boitier Lear			2-3 mg / pièce selon version, 1 pièce par siège mémo	102	94	NO	83	NO		
	Sm	Magnet for Gear S/A		V. Cébé			TDK		167	214		318		318	

Supplier risk analysis

4 levers activated by OEMs

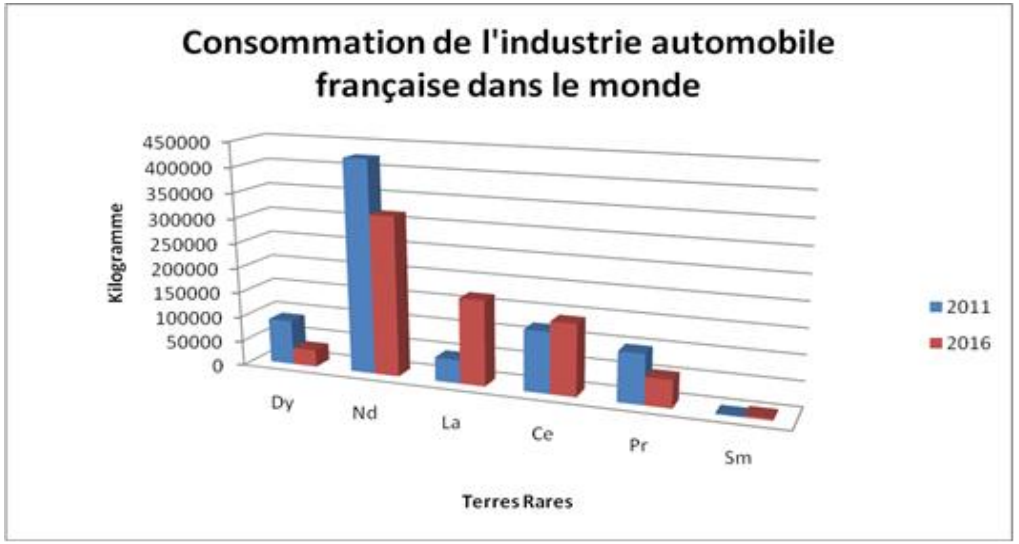
1. Usage reduction
2. Sourcing change (from FOB market to Chinese domestic market)
3. REE substitution
4. Technology change (w/o REE)

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)

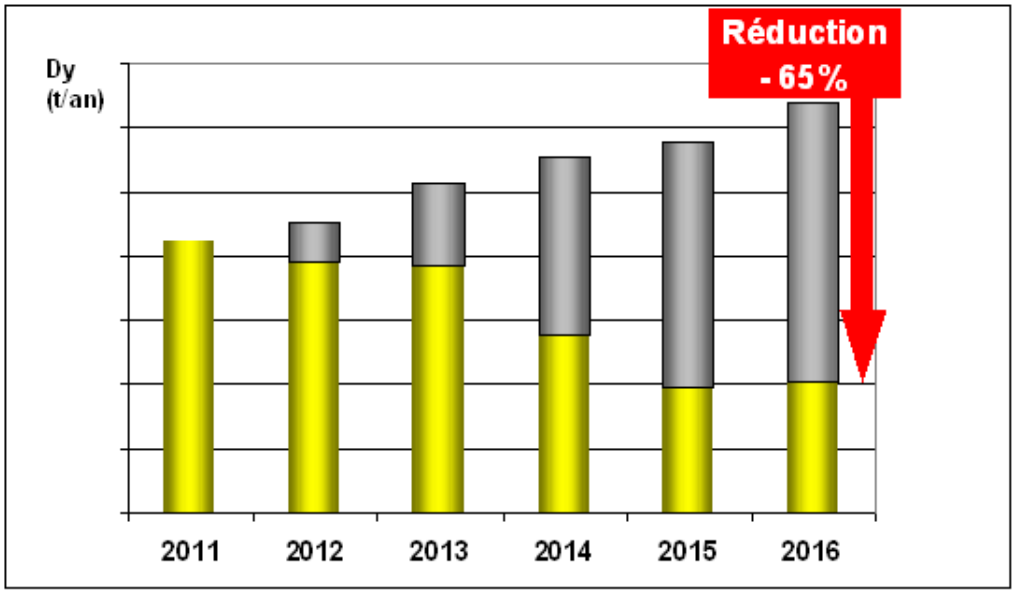


- **Enhanced, focused technological innovation for usage optimization**
- **Promotion of local, short-loop flow schemes within an economical and industrial eco-system (circular economy)**
- **Secure access to a continuous supply chain**

Effect of countermeasures were quite efficient

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

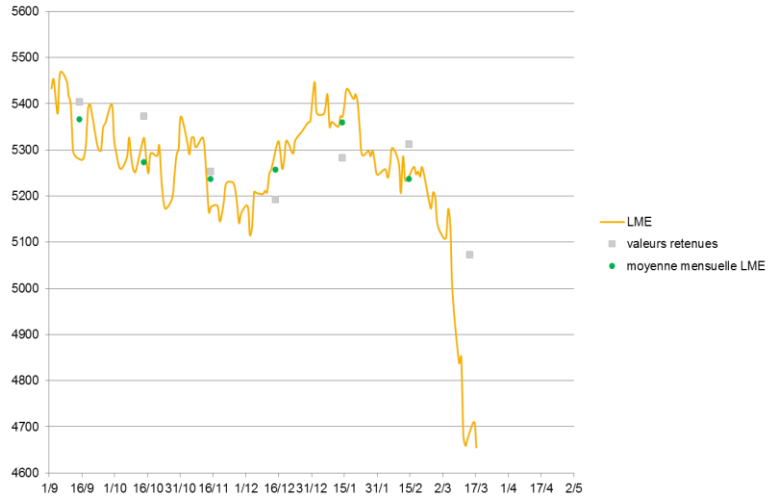
Example – The Dysprosium case

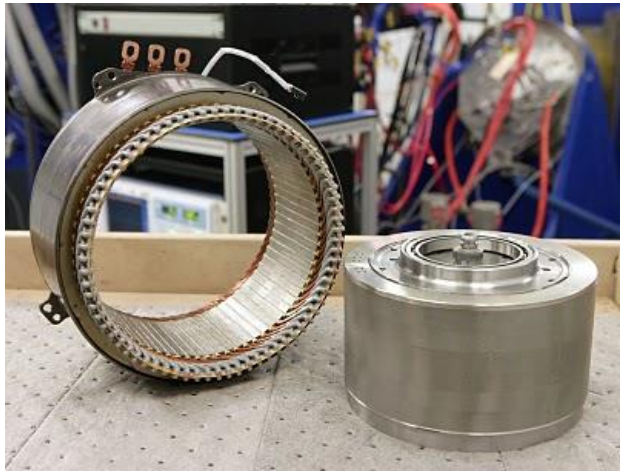


- **REE market in 2015**
  - Supply > Demand
  - Smooth start of non-Chinese production (LREE)
  - Lower REE price levels

Replacement

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

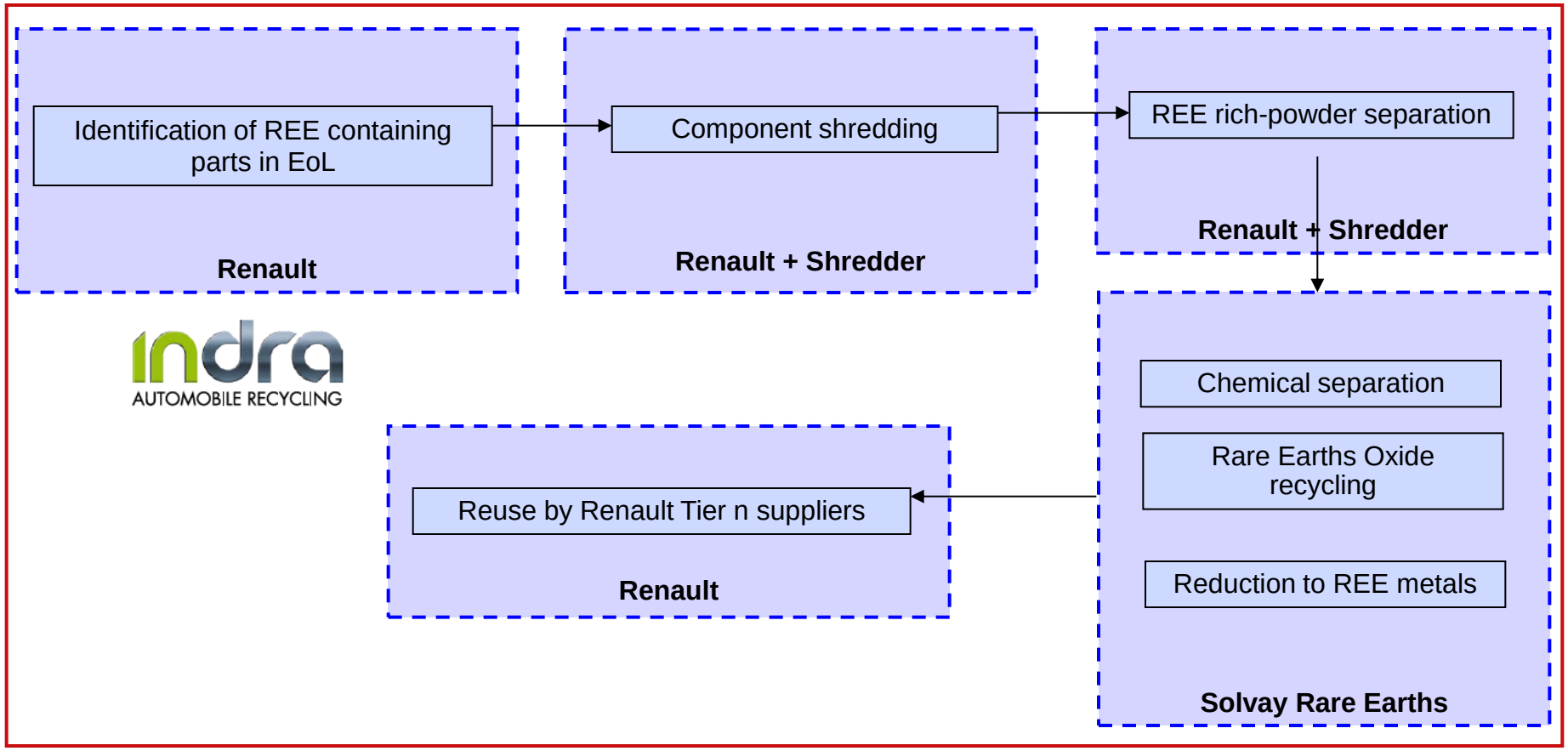




- **Technologies for EV motors that eliminate our need for rare earths**
  ➔ externally excited synchronous motor
  already applied to the Renault EV line-up

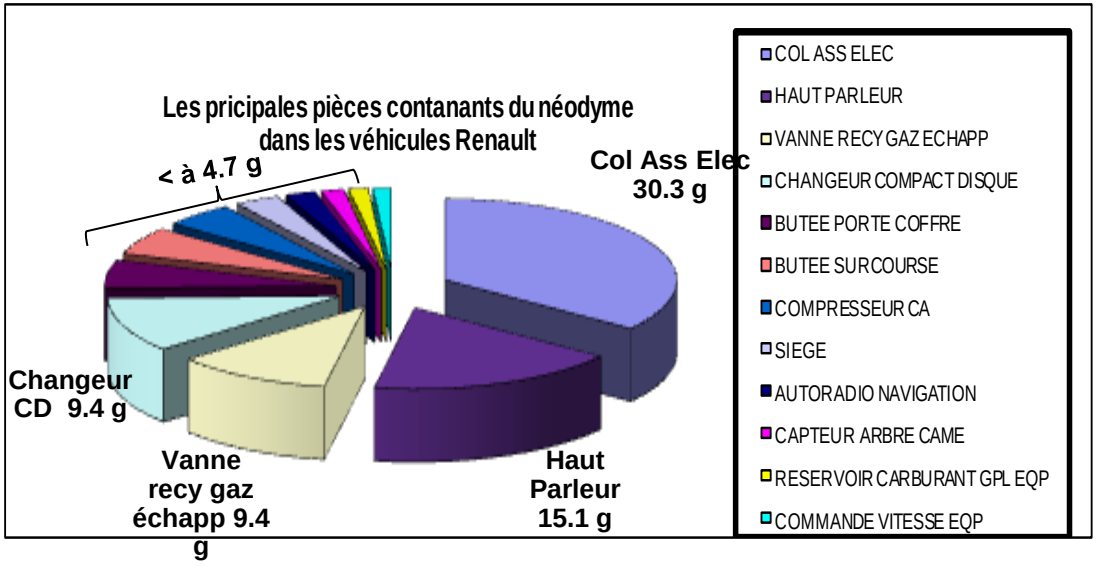
  ➔ switched reluctance motor,…

How to go further: Is it technically and economically possible to recover and recycle REE from End of Life Vehicles ?

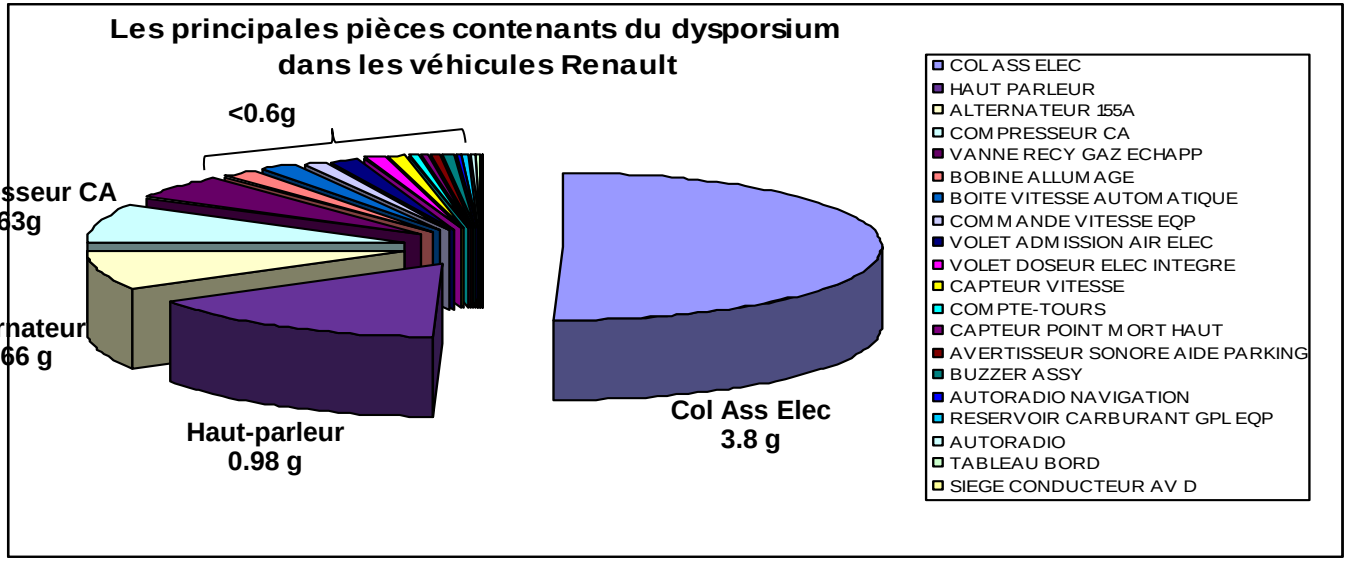


Technico-economical analysis

Identification of Nd & Dy containing parts in End of Life Vehicles



Source: données Renault

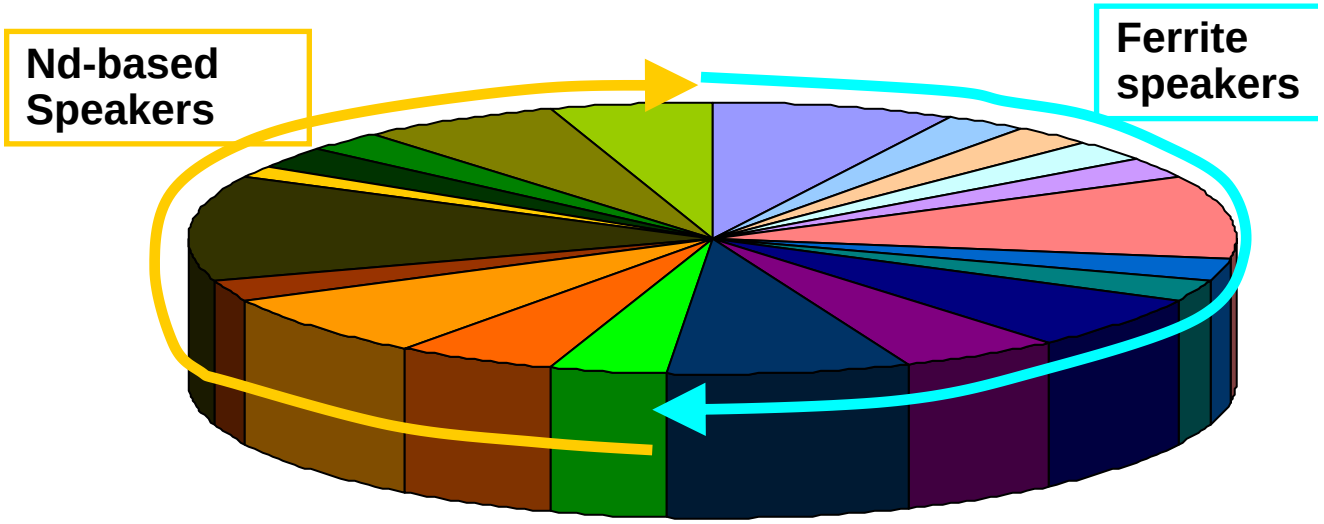


With some surprises at the end of the road….

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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