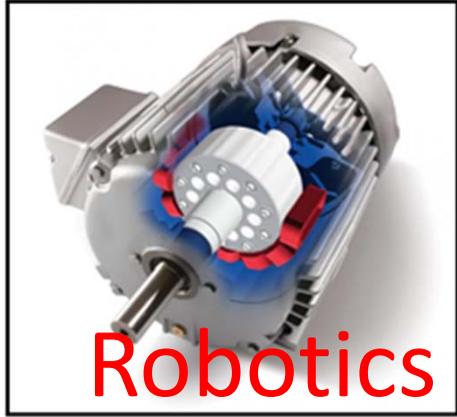
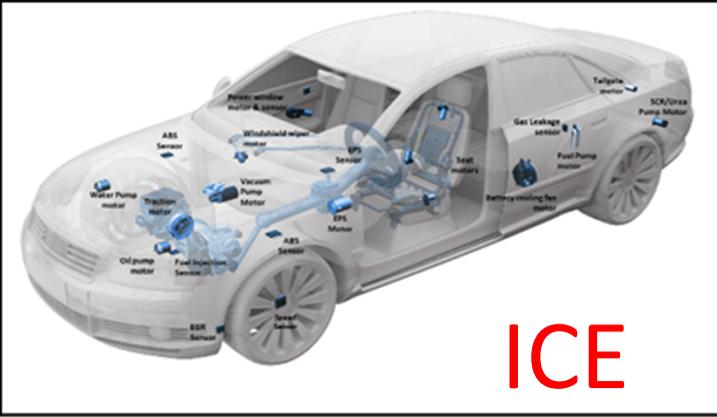
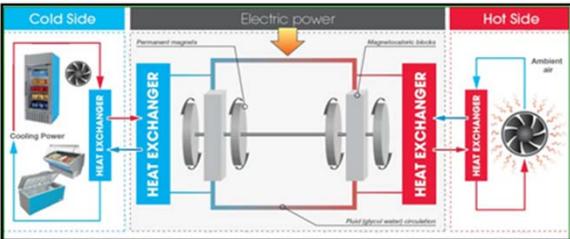


## Introduction - John Ormerod

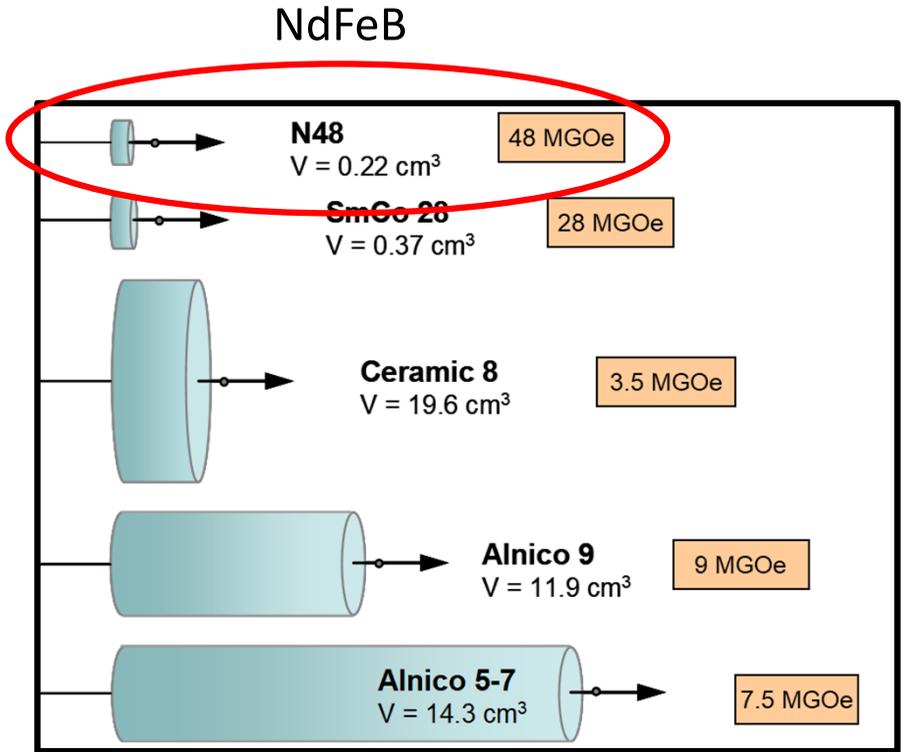
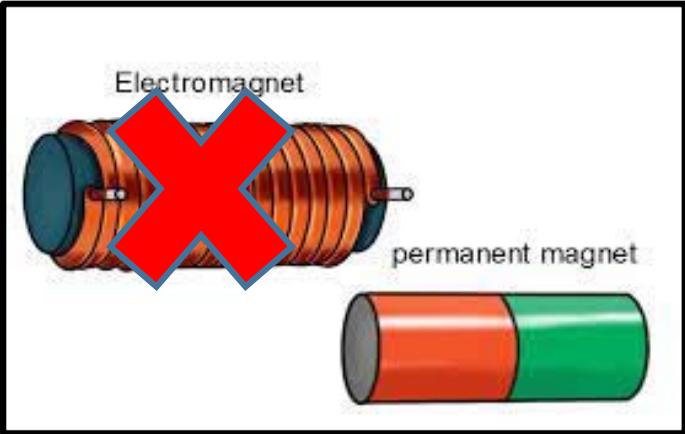
- BSc, MSC and PhD in Metallurgy from the University of Manchester (1972 – 1978).
- Magnetics career began for Philips (UK and Holland) – 1979 – 1990.
- Developed and commercialized SmCo5, 2:17 and NdFeB magnets.
- Joined Arnold Magnetic Technologies (US) responsible for soft and hard magnetic materials development and GM for permanent magnets ( 1990 – 2002).
- 2002 - 2014 President of Res Manufacturing in Milwaukee.
- Co-editor of recently published The Global PM Industry Report and Modern Permanent Magnets
- Principal of JOC LLC a business and technology consultancy for magnetics and metals related industries ([www.jocllc.com](http://www.jocllc.com)).

# Introduction To Permanent Magnets – Hidden But Essential!

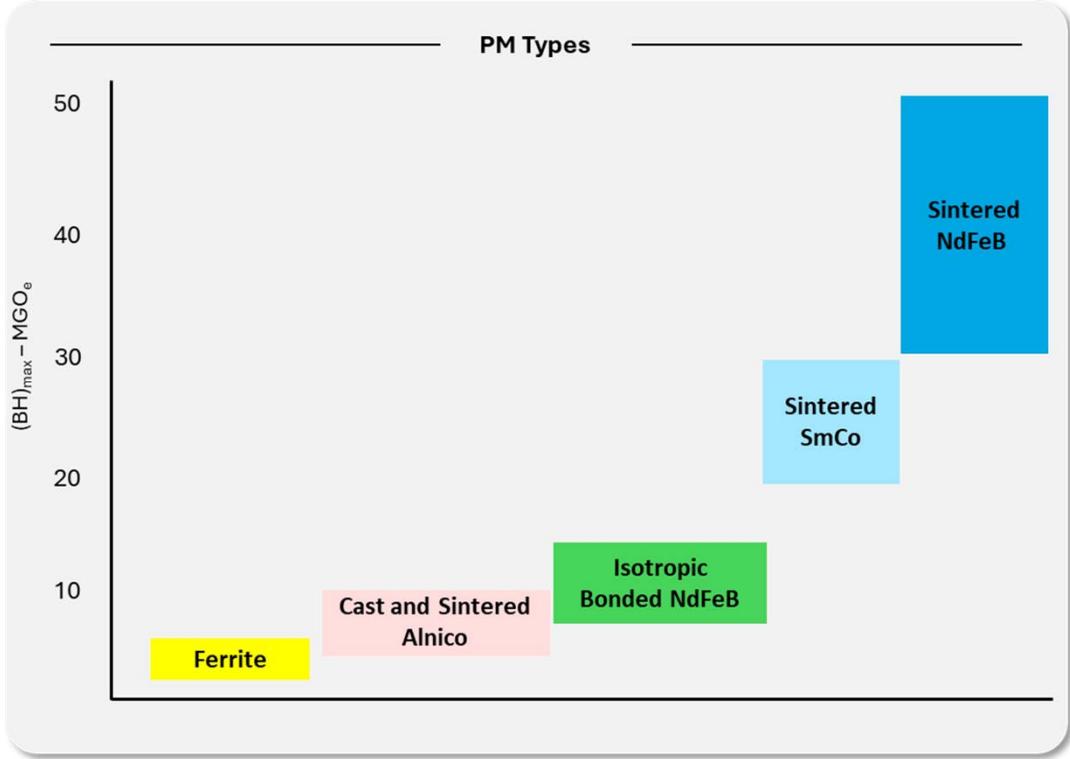


# What Is A Rare Earth (NdFeB) Magnet?

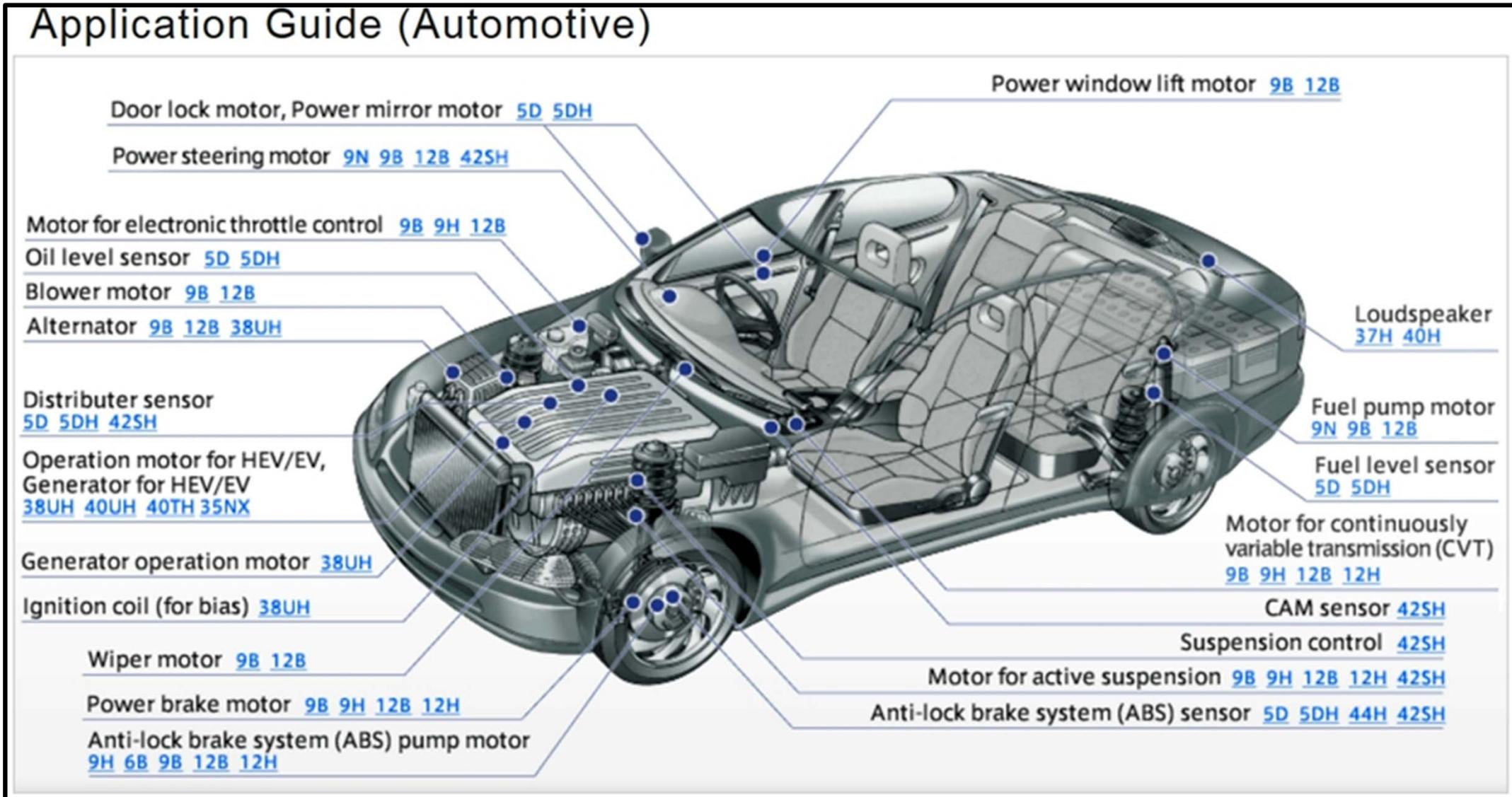
Permanent magnets are used in a device for only one reason, and that is to provide a magnetic field with no energy input.



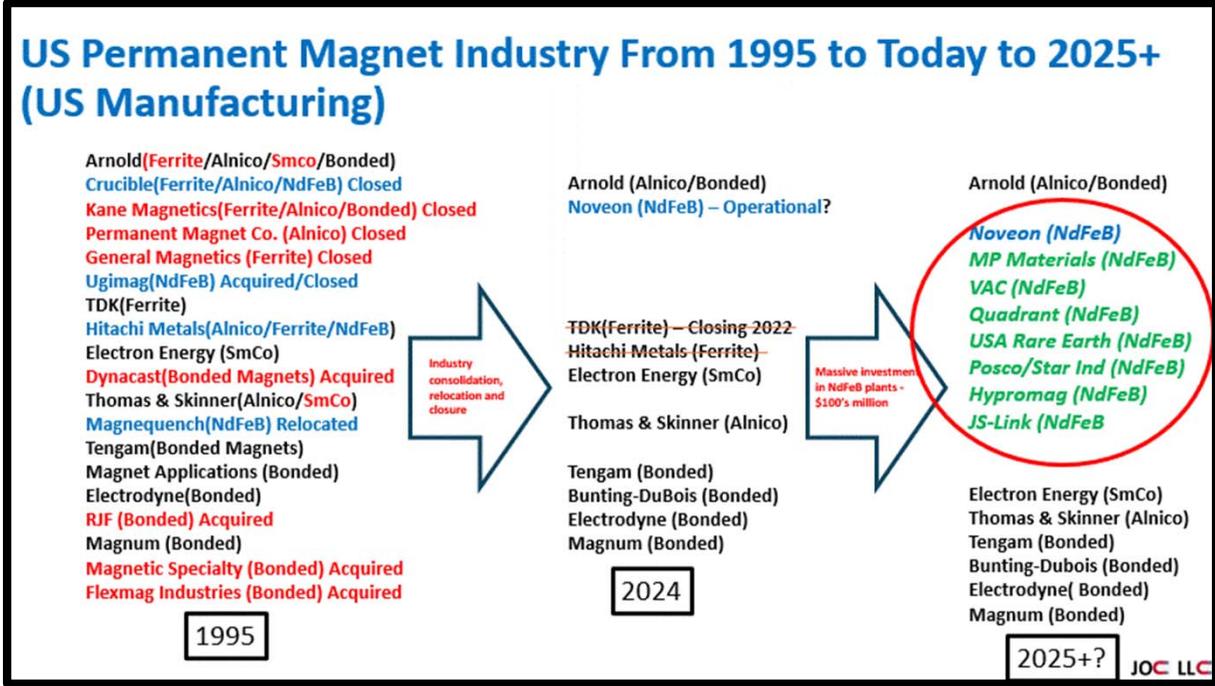
NdFeB magnets are used where weight or space is a constraint and magnetic field levels cannot be achieved by other material options.



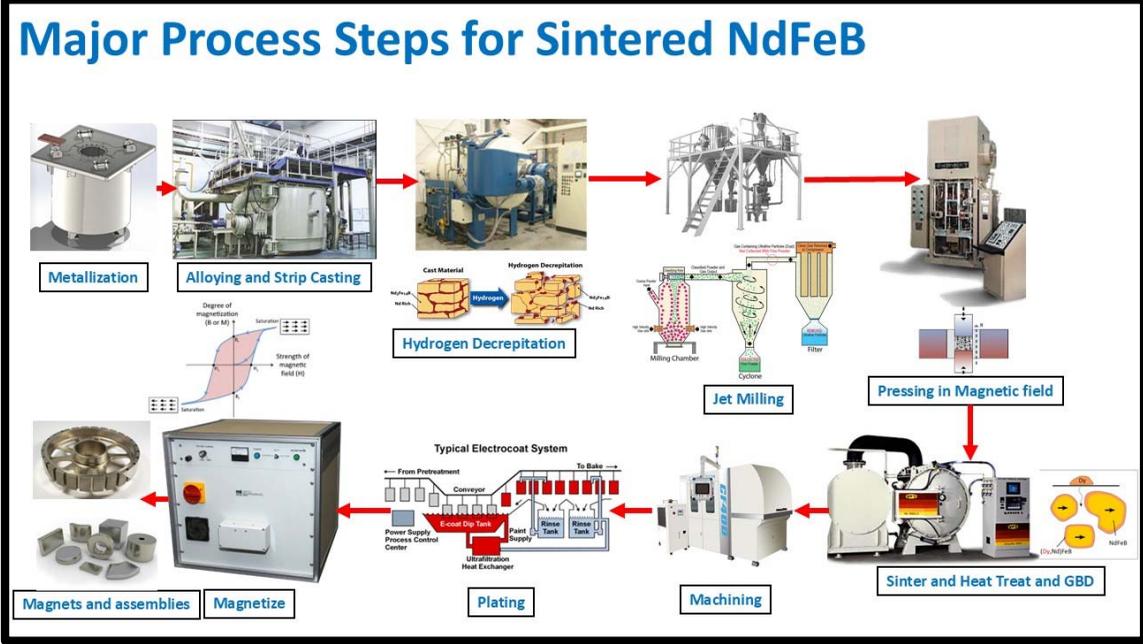
# Automotive (ICE and EV) Is The Largest Market For Permanent Magnets



# Who Makes Permanent Magnets?



Country or Region	2005	2010	2015	2020	2025	2030
China	36.1	48.8	51.4	57.0	62.7	66.1
Japan	29.7	23.4	20.3	16.4	13.3	10.1
USA	4.3	2.8	2.5	2.3	1.8	1.7
Europe	6.4	4.6	4.1	3.5	2.9	2.2
India	5.4	4.9	5.6	5.1	5.2	5.3
SE Asia	6.5	5.9	6.5	7.2	6.6	6.5
South America	4.4	3.6	3.5	3.1	2.7	2.4
All Others	7.2	6.0	6.1	5.5	4.7	5.6
<b>Totals</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>

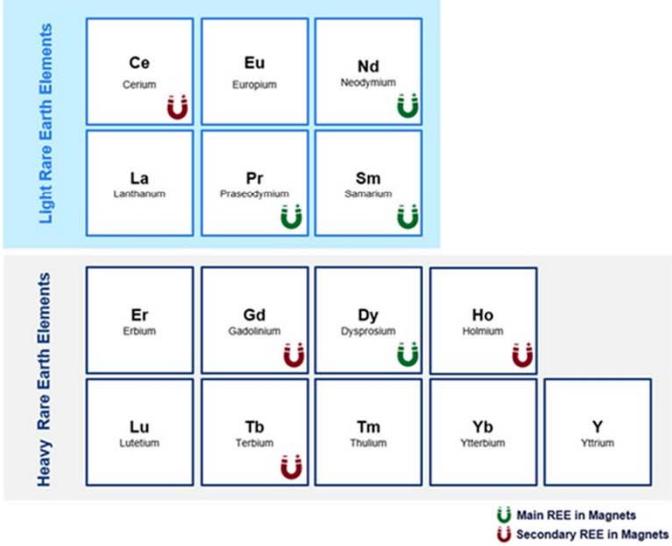


# What Are The Rare Earth Elements?

**Rare Earth Elements  
(21, 39, and 57-71)**

H 1																	He 2
Li 3	Be 4											B 5	C 6	N 7	O 8	F 9	Ne 10
Na 11	Mg 12											Al 13	Si 14	P 15	S 16	Cl 17	Ar 18
K 19	Ca 20	Sc 21	Ti 22	V 23	Cr 24	Mn 25	Fe 26	Co 27	Ni 28	Cu 29	Zn 30	Ga 31	Ge 32	As 33	Se 34	Br 35	Kr 36
Rb 37	Sr 38	Y 39	Zr 40	Nb 41	Mo 42	Tc 43	Ru 44	Rh 45	Pd 46	Ag 47	Cd 48	In 49	Sn 50	Sb 51	Te 52	I 53	Xe 54
Cs 55	Ba 56	57-71	Hf 72	Ta 73	W 74	Re 75	Os 76	Ir 77	Pt 78	Au 79	Hg 80	Tl 81	Pb 82	Bi 83	Po 84	At 85	Rn 86
Fr 87	Ra 88	89-103	Rf 104	Db 105	Sg 106	Bh 107	Hs 108	Mt 109	Ds 110	Rg 111	Uub 112	Uut 113	Uuq 114	Uup 115	Uuh 116	Uus 117	Uuo 118
		<b>Lanthanide Series</b>	La 57	Ce 58	Pr 59	Nd 60	Pm 61	Sm 62	Eu 63	Gd 64	Tb 65	Dy 66	Ho 67	Er 68	Tm 69	Yb 70	Lu 71
			Ac 89	Th 90	Pa 91	U 92	Np 93	Pu 94	Am 95	Cm 96	Bk 97	Cf 98	Es 99	Fm 100	Md 101	No 102	Lr 103

## Classification of REEs based on their application in magnets





# Integrated Rare Earth Magnet Supply Chain

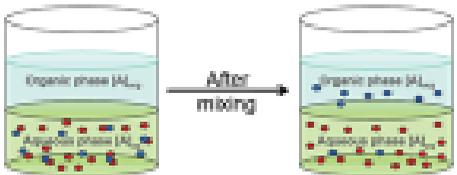
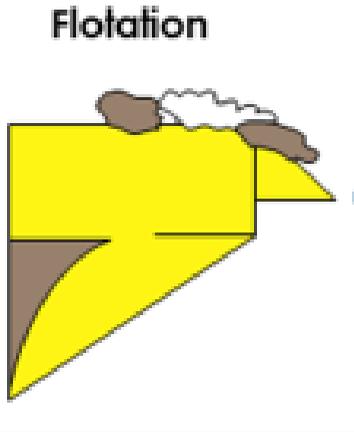
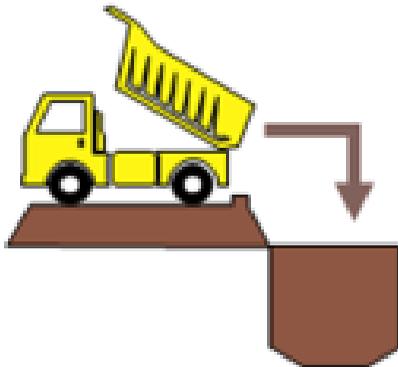
Mine

Mixed REE Concentrate

Separation

Reduction to metal

Alloying and Magnet Making



Chinese Global %

60%

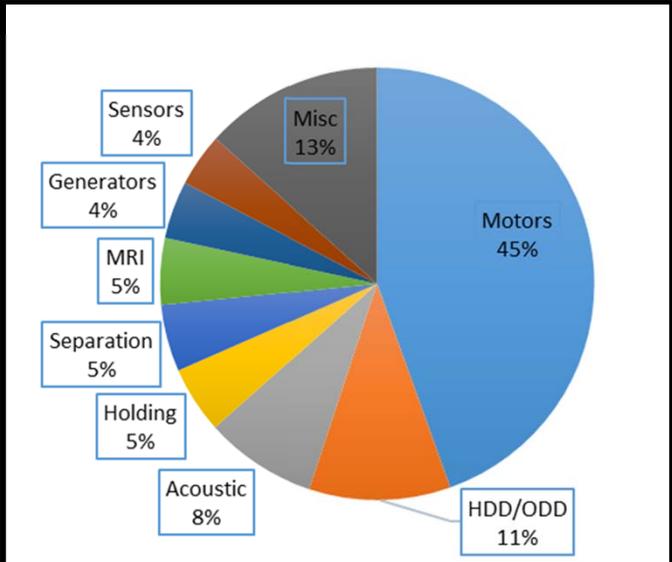
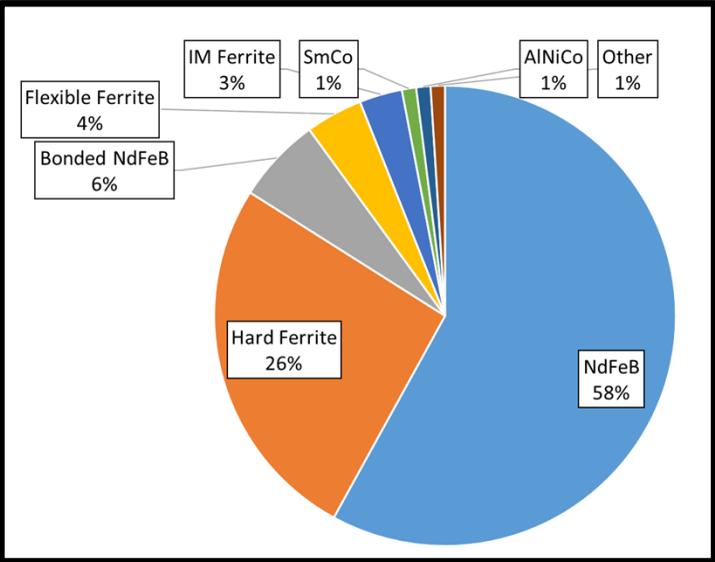
60%

85%

75%

>80%

# What Are The Markets And Applications?



	2020	2030	2040
<b>Material</b>	<b>Weight (000's kg)</b>	<b>Weight (000's kg)</b>	<b>Weight (000's kg)</b>
<b>NdFeB</b>	190,000	450,000	600,000
<b>Ferrite</b>	900,000	950,000	1,000,000
<b>Bonded NdFeB</b>	12,000	24,000	34,000
<b>SmCo</b>	4,400	4,700	5,000
<b>Alnico</b>	6,750	6,850	7,000
<b>Other</b>	2200	2,500	3,000

