

Calculation of the eco-costs, the VAR and the RSRI for Rare Earth Element metals.

For REE (rare earth element) metals there are not enough statistical data to calculate a 95% VAR {1}, since the geopolitical situation changed drastically over the last 2 decades [2]. For these materials we took the (moving) average for the 5 years 2013 – 2017 (data from [3]). The price peak (way above the average) was in 2011, caused by Chinese export restrictions in combination with short and heavy speculation in financial markets in metal prices. See Fig. 1 and 2. From Table 1 it is clear that the RSRI is rather high for some REE metals, causing the perception that REE metals are scarce. At this moment the supply risk is high indeed, because of the fact that over 90% of the supply comes from one country, China. It is the result of the low prices, enabled by low wages in China in combination with the fact that the standard for toxic emissions in this country is low, especially in illegal mining [4]. When the prices come back at a reasonable level, many mines in the US and Australia will be (re)opened [5]

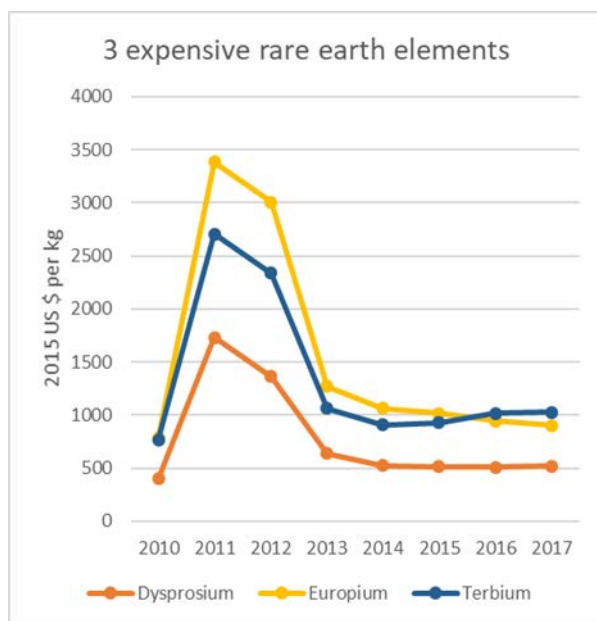


Figure 1 The price of expensive REE metals

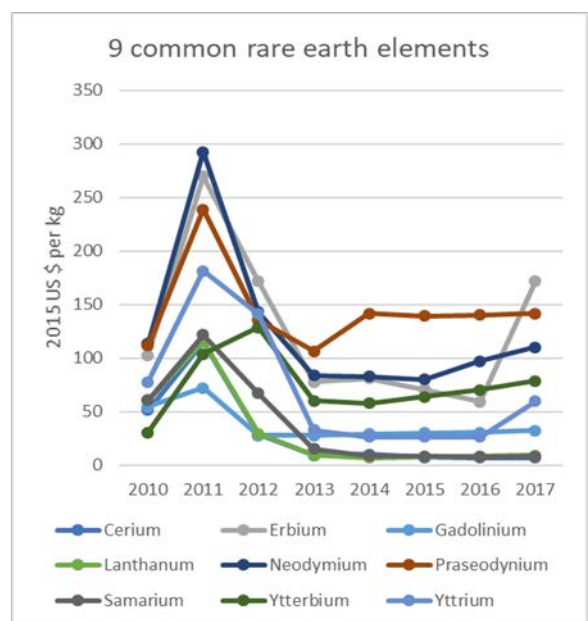


Figure 2 The price of common REE metals

The PPR of REE metals varies considerably, see Table 1:

- Dysprosium, Erbium, Europium, Neodymium, and Terbium have a RSRI range of 1.5 – 2.5.
- Cerium, Lanthanum, Samarium, and Yttrium have an RSRI range of 4 – 13.
- Gadolinium, Praseodymium, Scandium, and Ytterbium have an RSRI range of 0.7 – 1.5.

REE metal	CRM? (yes/no)	CRM supply risk *) (range 0 – 9)	Risk List index **) (range 3.3 – 10)	Long term scarcity ***) (year of depletion)	PPR	95% VAR \$/kg
Cerium, Ce	yes	5.7	9.5	over 3000	13.02	106
Dysprosium, Dy	yes	5.2	9.5	over 3000	2.20	1,189
Erbium, Er	yes	5.2	9.5	over 3000	1.93	177
Europium, Eu	yes	3.4	9.5	over 3000	2.26	2,345
Gadolinium, Gd	yes	5.1	9.5	over 3000	1.41	42.31
Lanthanum, La	yes	5.4	9.5	over 3000	12.88	107
Neodymium, Nd	yes	4.8	9.5	over 3000	2.22	201

Praseodymium, Pr	yes	4.6	9.5	over 3000	0.78	104
Samarium, Sm	yes	4.5	9.5	over 3000	11.42	111
(Scandium Sc)	yes	2.9	9.5	over 3000	0.44	3,292
Terbium, Tb	yes	4.8	9.5	over 3000	1.73	1,715
Ytterbium, Yb	yes	5.4	9.5	over 3000	0.94	62.40
Yttrium, Y	yes	3.8	9.5	over 3000	4.26	147

Table 1. Resource scarcity indicators for metals. Note. Scandium is lacking reliable data
*) European Commission (2017), **) British Geological Survey (2015), ***) Henckens (2016)

Notes:

- the 95% VAR is the eco-costs of materials scarcity
- Data are from [www. Statistica.com](http://www.statistica.com), assessed October 2018 [2]
- These data differ a bit from older data of: U.S. Geological Survey, 2013. Metal prices in the United States through 2010: U.S. Geological Survey Scientific Investigations Report 2012–5188, 204 pages, (<http://pubs.usgs.gov/sir/2012/5188>).
- Data for Scandium are not reliable, see “White Paper SCANDIUM, A review of the element, its characteristics, and current and emerging commercial applications” EMC Metals Corporation, at <http://www.scandiummining.com/i/pdf/Scandium-White-PaperEMC-Website-June-2014-.pdf>

References

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3. Available online www.statistica.com (assessed October 2018)
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