UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT
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COMMODITIES AT A GLANCE

Special issue on rare earths

N°5

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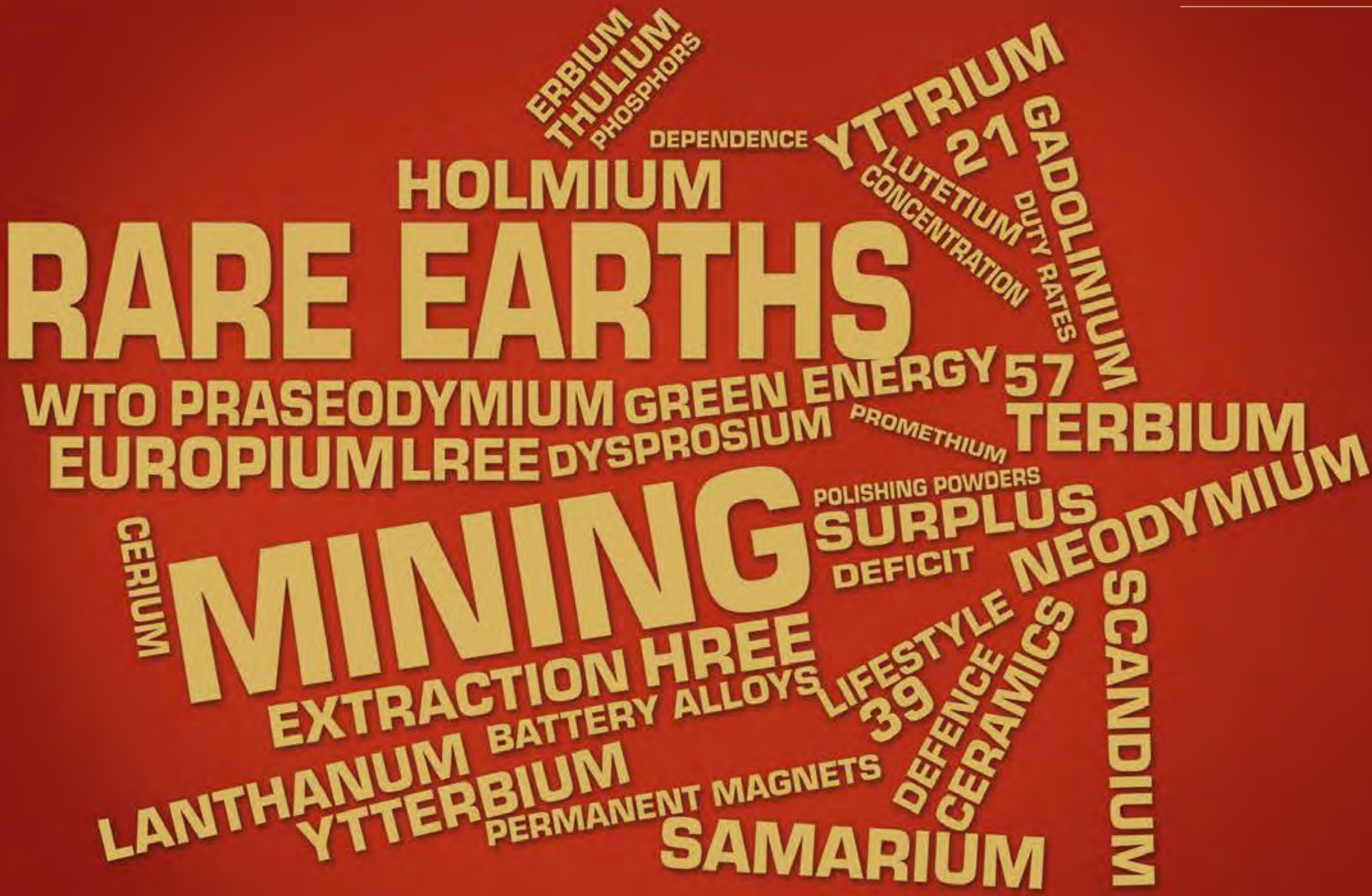

UNITED NATIONS

New York and Geneva, 2014

NOTES

The *Commodities at a glance* aims to collect, present and disseminate accurate and relevant statistical information linked to international primary commodity markets in a clear, concise and friendly format.

This edition of the *Commodities at a Glance* has been prepared by Alexandra Laurent, Statistical assistant for the Special Unit on Commodities (SUC) of UNCTAD, under the overall guidance of Samuel Gayi, Head of SUC, and the direct supervision of Janvier Nkurunziza, Chief of the Commodity Research and Analysis Section of SUC.

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Desktop publishing and graphics were performed by the Prepress subunit with the invaluable collaboration of Nathalie Loriot of the UNOG Printing Section.

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STATISTICAL DATA SOURCES

Data on Rare Earths are sparse and there is no dedicated international public institution that monitors the rare earth market to provide authoritative and objective statistics on the sector. As a result, this report has attempted to combine several sources of information in order to present the most possible accurate picture on the rare earths market. All data sources are indicated under each graph and table and a list of references is provided at the end of the document.

When there are large differences among sources of information (as in the case of reserves, for instance), all sources of information are presented individually.

As usual in this report series, only data that are accessible free of charge are used in order to allow the reader to follow-up easily on the information provided. Note that given the rapid changes in market information, new developments may have occurred since the drafting of the document.

ABBREVIATIONS IN THIS PUBLICATION

REE	Rare Earth Elements
LREE	Light Rare Earth Elements
HREE	Heavy Rare Earth Elements
USGS	United States Geological Survey
ROW	Rest of the world
REO	Rare Earth Oxides
BRICS	Brazil, Russian Federation, India, China, South Africa
BRIC	Brazil, Russian Federation, India, China
DSB	Dispute Settlement Body
US$	United States Dollar
MW	Megawatt

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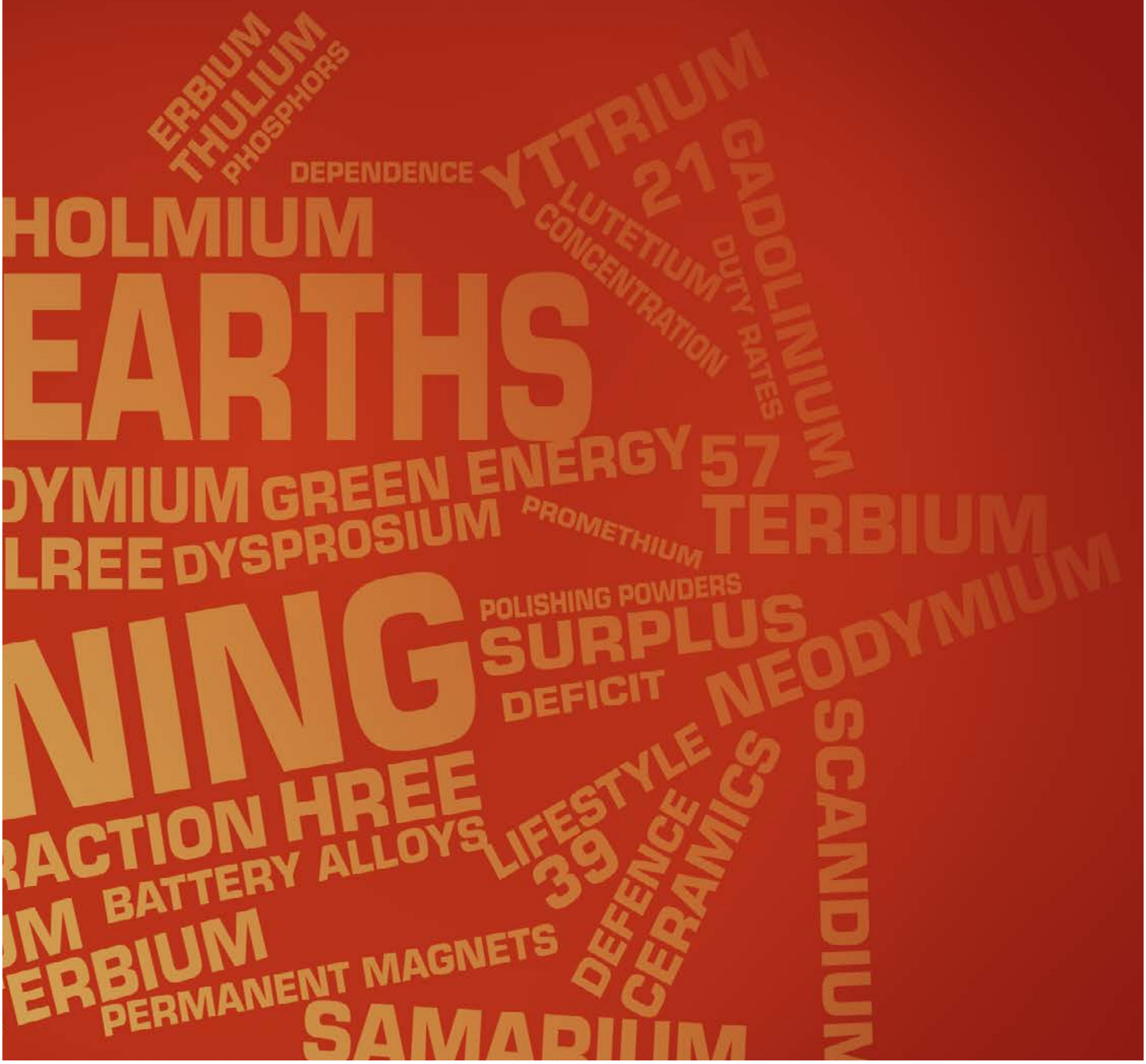
INTRODUCTION



The first question to consider when beginning this report is to know why rare earths are considered by UNCTAD as commodities as some analysts do not think that they are.

As defined by the General Agreement on Tariffs and Trade, a « *primary product is understood to be any product of farm, forest or fishery, or any mineral, in its natural form or which has undergone such processing as is customarily required to prepare it for marketing in substantial volume in international trade* ».[1] The notion of "fungibility" is also regularly associated with this definition. This means that a good may be substituted by any other of the same type when there is a slight differentiation between them. Rare earths clearly meet these definitions as they are defined according to some agreed standards such as their purity, which also determine their price. Moreover, traded quantities even though they appear to be small compared to other minerals, ores and metals markets, are increasing very rapidly. However, a difference between Rare earth market and some other major commodity markets that could be considered as "more homogeneous" is that Rare earths are not defined by international standards and/or are not traded on international commodity exchanges, as is the case for other commodities such as cereals, coffee, cocoa or some other minerals, ores and metals.

Rare earths are a group of 17 elements including the 15 lanthanides, plus Scandium and Yttrium. Rare earths can be classified either as Light Rare Earth Elements (LREE) or Heavy Rare Earth Elements (HREE). Rare Earth Elements (REE) are considered as "light" when their atomic number ranges from 57 to 63 or "heavy" when it ranges from 64 to 71 (table 1). According to the British Geological Survey, the classification of REEs as light or heavy is *"somewhat arbitrary"*.[2] Depending on the sources of information, Scandium and Yttrium are or not classified in either of these categories. In the current publication, Yttrium and Scandium are presented separately from LREEs or HREEs. In instances where they are aggregated with one of these categories, the information is clearly indicated. A third category is sometimes added between LREEs and HREEs and called Middle Rare Earth Elements (MREEs). This group brings together REEs with atomic numbers from 63 (Europium) to 67 (Holmium). However, in the present document, we decided to present separately LREEs and HREEs as

[1] The General Agreement on Tariffs and Trade, article XVI, Section b, point 2 http://www.wto.org/english/docs_e/legal_e/gatt47_e.pdf

[2] Walters, A. et al. (2011). Rare Earth Elements. British Geological Survey

Table 1. "Light" and "Heavy" rare earth elements

Atomic number	Name	Symbol	LREE / HREE
57	Lanthanum	La	LREE
58	Cerium	Ce	LREE
59	Praseodymium	Pr	LREE
60	Neodymium	Nd	LREE
61	Promethium	Pm	LREE
62	Samarium	Sm	LREE
63	Europium	Eu	LREE
64	Gadolinium	Gd	HREE
65	Terbium	Tb	HREE
66	Dysprosium	Dy	HREE
67	Holmium	Ho	HREE
68	Erbium	Er	HREE
69	Thulium	Tm	HREE
70	Yterrbium	Yb	HREE
71	Lutetium	Lu	HREE
39	Yttrium	Y	
21	Scandium	Sc	

Source: UNCTAD Secretariat from the British Geological Survey

Table 2. Comparative table on the concentration of REEs and selected industrial and precious metals in earth crust (parts per million (ppm)

Atomic number	Name	Symbol	Crust abundance (ppm)	Group
58	Cerium	Ce	62	Rare Earth Elements
60	Neodymium	Nd	33	Rare Earth Elements
57	Lanthanum	La	32	Rare Earth Elements
39	Yttrium	Y	29	Rare Earth Elements
21	Scandium	Sc	22	Rare Earth Elements
59	Praseodymium	Pr	9	Rare Earth Elements
62	Samarium	Sm	7	Rare Earth Elements
64	Gadolinium	Gd	6	Rare Earth Elements
66	Dysprosium	Dy	6	Rare Earth Elements
68	Erbium	Er	3.03	Rare Earth Elements
70	Ytterbium	Yb	2.93	Rare Earth Elements
63	Europium	Eu	1.80	Rare Earth Elements
67	Holmium	Ho	1.17	Rare Earth Elements
65	Terbium	Tb	0.94	Rare Earth Elements
69	Thulium	Tm	0.47	Rare Earth Elements
71	Lutetium	Lu	0.46	Rare Earth Elements
61	Promethium	Pm	*n/a (infinitesimal)*	Rare Earth Elements
13	Aluminium	Al	79’000	Industrial Metals
26	Iron	Fe	55’350	Industrial Metals
12	Magnesium	Mg	26’000	Industrial Metals
22	Titanum	Ti	6’302	Industrial Metals
25	Manganese	Mn	1’156	Industrial Metals
24	Chromium	Cr	131	Industrial Metals
28	Nickel	Ni	90	Industrial Metals
30	Zinc	Zn	76	Industrial Metals
29	Copper	Cu	59	Industrial Metals
82	Lead	Pb	13	Industrial Metals
50	Tin	Sn	2.27	Industrial Metals
74	Tungsten	W	1.29	Industrial Metals
42	Molybdenum	Mo	1.27	Industrial Metals
47	Silver	Ag	0.0750	Precious metal
46	Palladium	Pd	0.0082	Precious metal
78	Platinum	Pt	0.0036	Precious metal
79	Gold	Au	0.0032	Precious metal
76	Osmium	Os	0.0018	Precious metal
44	Ruthenium	Ru	0.0010	Precious metal
45	Rhodium	Rh	0.0010	Precious metal
77	Iridium	Ir	0.0008	Precious metal

Source: UNCTAD Secretariat

well as scandium and Yttrium, but not to consider the MREEs as a separate category.

REEs are qualified as "rare" given that they are generally not concentrated in commercially viable quantities, as well as due to the complexity of their separation process - which make them difficult to extract and recover cost effectively. Furthermore, some ores may be associated with radioactive elements (e.g. uranium), making them difficult and expensive to handle safely. However, even if named "rare", REEs should not be considered as the rarest elements in earth crust as all of them but Promethium are more common than precious metals. Some REEs are also sometimes more common than some major industrial metals. For example, with 62 parts per million (ppm), Cerium is more common than Copper in earth crust and 11 out of the 17 REEs are more largely present than Tin (table 2). In nature, LREEs are more widely available than HREEs, except for Promethium which is found in infinitesimal quantities.

REEs are essential in the day to day life of people inhabiting developed and developing countries alike, given their large range of uses (e.g. oil refining uses rare earth catalysts, and red and green colours in TV and monitors are made possible by the use of REEs). REEs are also considered as "critical raw materials" by some countries and companies given their vital importance in the manufacturing of high-tech devices, military and defence applications as well as in green energy technologies. The European Union defines REEs – as well as 13 other materials - as *"critical raw materials"* as they *"display a particularly high risk of supply shortage in the next 10 years and… are particularly important for the value chain".*[3] The strategic importance of REEs stems from three main factors: first, their weak substitutability, second, their low recycling rate, and third, the concentration of the market within a limited number of actors. As an example, China was the main REE market player in 2012, dominating production (91 per cent of world production), demand (64 per cent of world demand) and exports (66 per cent of world exports).

The large gap existing between the various estimates of world rare earth reserves given by the various sources of information shows not only the difficulty existing in estimating minerals' reserves worldwide, but also the high degree of political and economic sensitivity of the REE topic on the international scene. According to most sources, China holds the largest world reserves (between 23 per cent[4] and 55 per cent[5]) and most of the HREEs as well as Yttrium world reserves.

While about 200 minerals may contain REEs, they are mainly recovered from three main sources, namely (1) Bastnäsite (also written bastnaesite) which accounts for about 90 per cent of world reserves and is mainly mined in the United States and China, (2) Monazite for most of the difference (e.g. Australia, Brazil, China, India, Malaysia, South Africa) and (3) Xenotime (e.g. Duncan Deposit, Mount Weld, Australia), which is a more marginal source of REEs.

As of January 2013, the United States Geological Survey (USGS) evaluated world REE reserves to be about 110 million tons. According to the various sources of information, China currently has the largest share of world rare earth reserves and the United States more than a tenth (figure 1). However, some few REE deposits exist in other countries or territories[6], mainly in Australia, Brazil, Canada, India, Kyrgyzstan, Malaysia, South Africa, Sweden, the United States and Greenland. According to most sources, together, the members of the Commonwealth of Independent States (CIS) hold about 17 per cent of current world reserves. New deposits are sometimes discovered; however, mining projects are often not developed due to their high cost. As an example, a Japanese team led by Y. Kato showed in a paper issued in 2011 that *"deep-sea mud contains high concentrations of rare-earth elements and yttrium at numerous sites throughout the eastern South and central North Pacific".* In this document, they also estimated that *"an area of just one square kilometre, surrounding one of the sampling sites, could provide one-fifth of the current annual world consumption of these elements".*[7] However, this source of REEs supply has not been mined due to the costs of production that such an extraction would entail.

In China, most of Light Rare Earth Elements are concentrated in the north of the country (Inner Mongolia Autonomous Region and other Northern areas), while Heavy Rare Earth Elements are mostly present in the South (Jiangxi, Fujian, and other

[3] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Tackling the challenges in commodity markets and on raw materials. European Commission. (2 February 2011)

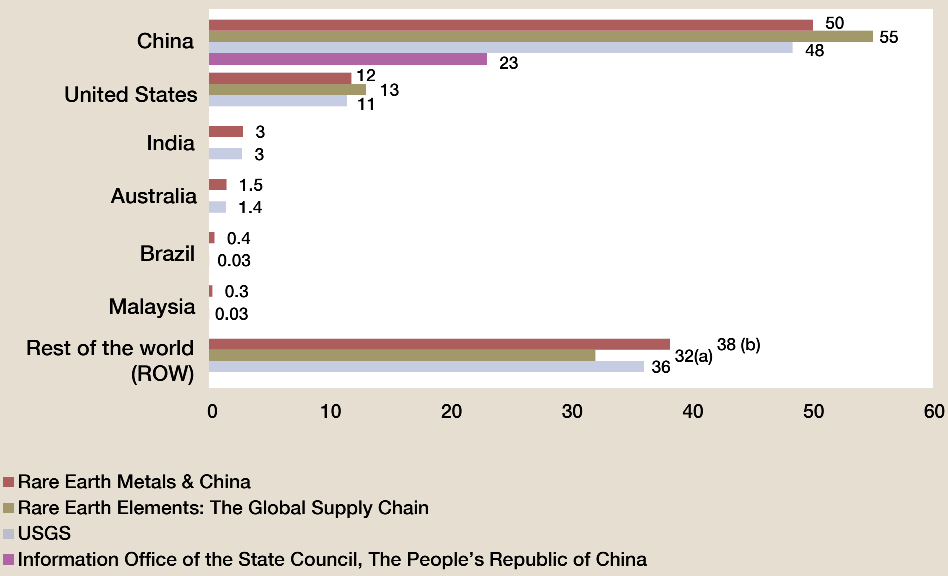
[4] Situation and Policies of China's Rare Earth Industry. Information Office of the State Council, The People's Republic of China (2012)

[5] Humphries, M. et al. (2012). Rare Earth Elements: The Global Supply Chain. Congressional Research Service

[6] *"There are about 34 countries with rare earth deposits"*. Zhanheng, C. (2011). Global rare earth resources and scenarios of future rare earth industry. Chinese Society of Rare Earths. (17 January 2011)

[7] Kato, Y. et al. (2011). "Deep-sea mud in the Pacific Ocean as a potential resource for rare-earth elements". Nature Geoscience, 4, 535-539

Figure 1. Distribution of world rare earth reserves, 2012 (per cent): different estimates



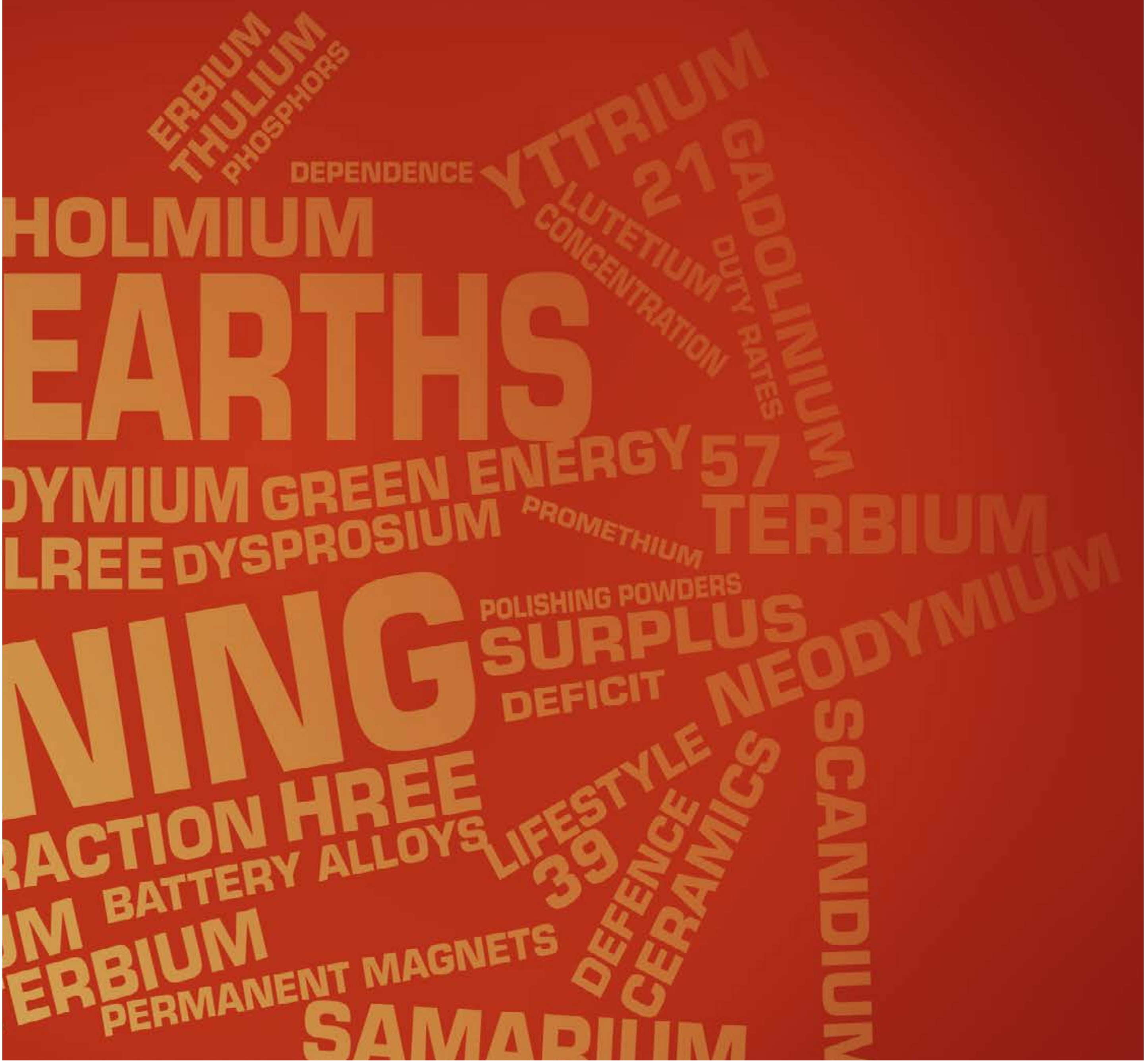
(a) Includes reserves for South Africa, Canada, Australia, Brazil, India, Russian Federation, Malaysia and Malawi.
(b) Includes 17 per cent for Commonwealth Independent States.

Source: UNCTAD Secretariat from Blakely et al., Humphries et al. (2012), USGS (2013) and the Information Office of the State Council, People's Republic of China (2012)

Southern areas). In its report, the Information Office of the State Council of the People's Republic of China [8] indicates that Chinese REE reserves account for 23 per cent of world total reserves. The share of China in world reserves has tended to decline due to intensive and sometimes uncontrolled production and processing of REEs in China in the past, as well as the discovery of new reserves elsewhere.

[8] US Geological Survey defines reserves as "that part of the reserve base which could be economically extracted or produced at the time of determination. The term reserves need not signify that extraction facilities are in place and operative. Reserves include only recoverable materials; thus, terms such as "extractable reserves" and "recoverable reserves" are redundant and are not a part of this classification system." to calculate net import reliance. Appendix C. Gambogi, J. (2013). Mineral Commodity Summaries. US Geological Survey

CHAPTER 2
RARE EARTH PRODUCTION



1. RARE EARTH PRODUCTION CYCLE

Usually, Rare Earth Elements do not exist individually in deposits but are generally associated with other metals in varying concentrations. The production chain to Rare Earth Metals (REMs) is long, complex and has to be adjusted to the specificities of production sites. The description below gives an example of the main production steps from the exploration of REEs to the production of REMs (figure 2).

The first step of any REEs production chain is the exploration or the identification of a deposit (e.g. location, size). This operation helps to determine whether, first, the deposit would be profitable,[9] and second, assesses the concentration in LREEs and HREEs as well as individual REE types it contains. In fact, REEs are often mixed together in deposits, while their concentration may largely vary from one to another. For instance, Bastnäsite and Monazite mainly contain LREEs, with a higher concentration of HREEs in Monazite than in Bastnäsite. Xenotime is the largest source of HREEs worldwide (e.g. Dysprosium, Erbium, Holmium, Yterrbium, and Yttrium).

Two main types of exploration exist, depending on whether the deposit is sought in a previously mined area or not. In the first case, the exploration is known as brownfield, while the second case is called greenfield exploration. Mining exploration is largely affected by price cycles but more so for REEs. While exploration and even mining activities were almost totally suspended in the world except in China – which supplied cheap REE exports to the world - during the period of low REE prices, large investments in exploration of new mines or the reopening of former ones have been made as a result of the price boom of the 2010-2011 period.

9 *"By convention, that portion of resources that is economic to mine is classified as a "reserve."* Long, K. et al. (2010). The Principal Rare Earth Elements Deposits of the United States - A Summary of Domestic Deposits and a Global Perspective. US Geological Survey

Figure 2. Rare Earth production process

Source: UNCTAD Secretariat

The processing of REEs can be divided in 3 successive stages:

Ores → **Concentrates**

First, the beneficiation step aims to produce concentrates and consists in the separation of the crushed ore from its gangue. There are three main separation techniques. The first two, namely magnetic and by gravity are equally used for Monazite or Xenotime separation, while the third, the separation by flotation, is mostly used to process Bastnäsite ores. This operation does not change the chemical structure of the ore. However, as concentration generates a large quantity of waste (also named tailings), this activity is generally concentrated in areas surrounding old mines in order to reduce transportation costs.

Concentrates → **Oxides**

Second, Rare Earth Oxides (REO) of individual elements are extracted from concentrates. This operation known as extraction is undertaken by hydrometallurgy (e.g. ion exchange, solvent extraction, fractional crystallization), electrometallurgy or pyrometallurgy. The first one is the most widely used by the industry. While the recovered oxides are usable and marketable as such, they are generally further refined in order to produce pure Rare Earth Metals.

Oxides → **Metals**

Third and final step: Rare Earth Oxides are refined into individual REMs using electrolysis, gaseous or metallothermic reduction techniques.

2. HISTORICAL WORLD PRODUCTION

Prior to 1960, the average rare earth production was less than 2,000 tons a year. World rare earth production increased about 2-fold between 1990 and 2000, reaching 90,000 metric tons in 2000 from about 53,000 metric tons in 1990. During the following decade (2000 to 2012), rare earth production reached a peak at 133,300 tons in 2010 before falling to 110,000 tons in 2012 (figure 3). LREEs are historically more widely produced than HREEs in quantity terms and their reserves are also larger and more widely distributed worldwide. LREEs will continue to account for an overwhelming share of the total anticipated supply by 2015 (with about 97 per cent). The smallness of HREEs plus Yttrium production and reserves compared to LREEs partly explain the price difference between both these categories, the premium price received by HREEs and Yttrium on the market as well as their higher price volatility.

Despite the large increase of the global rare earth production between 1990 and 2012, REE production remains marginal compared to some other minerals, ores or metals. For instance, the REE production was respectively 48, 124 and 152 times lower than for lead, zinc or copper in 2012.

Over the period 1966-1984, the United States was the leading REE producing country with about 64 per cent of world production (according to USGS statistics). In this period, most of the REE production was extracted from the Mountain Pass mine in California (which started in 1954). The United States recorded a maximum production of 19,900 tons in 1974, which was about 78 per cent of global REE production. However, since 1985, the share of the US production in world production has gradually dropped to an average of about a third of world production between 1985 and 1992 and finally to 5 per cent in 2002 (box 1).

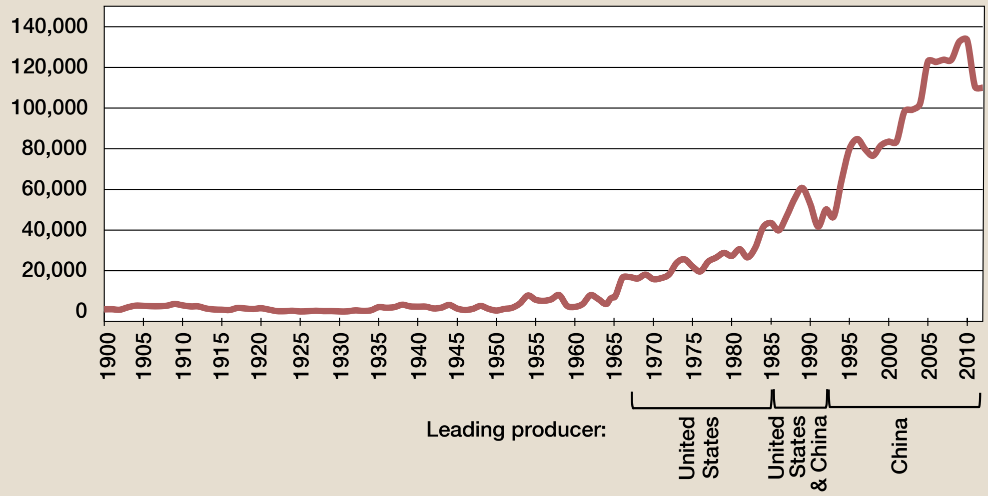
The drop of the US production has been mainly the result of the fall of US competitiveness compared to REE imported from China and resulted in the closing of the Molycorp separation and refining plants in 1998 and the consecutive drop of US production by 75 per cent between 1997 and 2000. Finally, all mining operations were suspended in the United States after 2002 with the definitive closing of the Mountain Pass mine (as reflected by USGS data statistics).

BOX 1

Approximately 20 years ago the U.S. had twelve rare earth oxide magnet factories, employing 6,000 workers and participating in a global market valued at $600 million. As of 2010, only four factories remained, with approximately 600 workers, while the global market had grown to a value of over $7 billion.

Pecht et al. (2011)

Figure 3. Long term evolution of world rare earth production, 1900-2012 (tons)



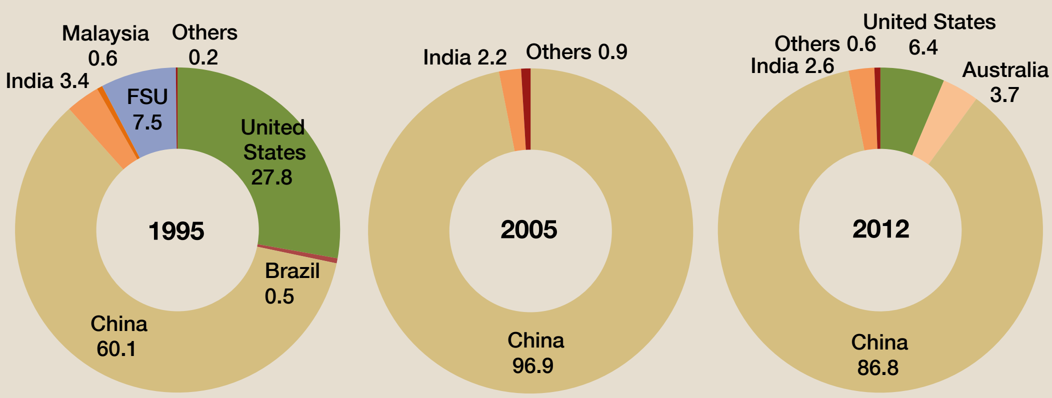
Source: UNCTAD Secretariat from the US Geological Survey
Note(s): World production data are for REO content of ores produced.

During the mid-1980s-1998 period, the Chinese government encouraged Chinese REE exports through a tax rebate policy,[10] as well as subsidized loans for the REE industry.[11] As far back as 1992, Deng Xiaoping highlighted that *"there is oil in the Middle East; there is rare earth in China"*.[12] From 21 per cent of world REE production in 1985, China reached 60 per cent of world production in 1995. During the following period from 1995 to 2012, China accounted on average for 88 per cent of world production recording its largest share from 2005 to 2010 (with around 97 per cent of world production and 126,000 tons produced, according to USGS).

As a consequence of the increase of international prices since the end of 2010, the United States (via Molycorp) decided to restart the Mountain Pass mine. The first 7,000 tons of REEs were extracted in the United States in 2012. After about a decade of near insignificance in terms of production share, the United

10 Zhanheng, C. (2011). "Rare earth protection plan". China Daily. (28 May 2011) http://www.chinadaily.com.cn/opinion/2011-05/28/content_12596658.htm
11 Pecht, M. et al. (2011) "Rare Earth Materials – Insights and concerns". CALCE EPSC Press, University of Maryland, College Park
12 Rare Earth: An Introduction. Baotou National Rare-Earth High-Tech Industrial Development Zone. http://www.rev.cn/en/int.htm

Figure 4. Distribution of producing countries, 1995, 2005, 2012 (per cent)



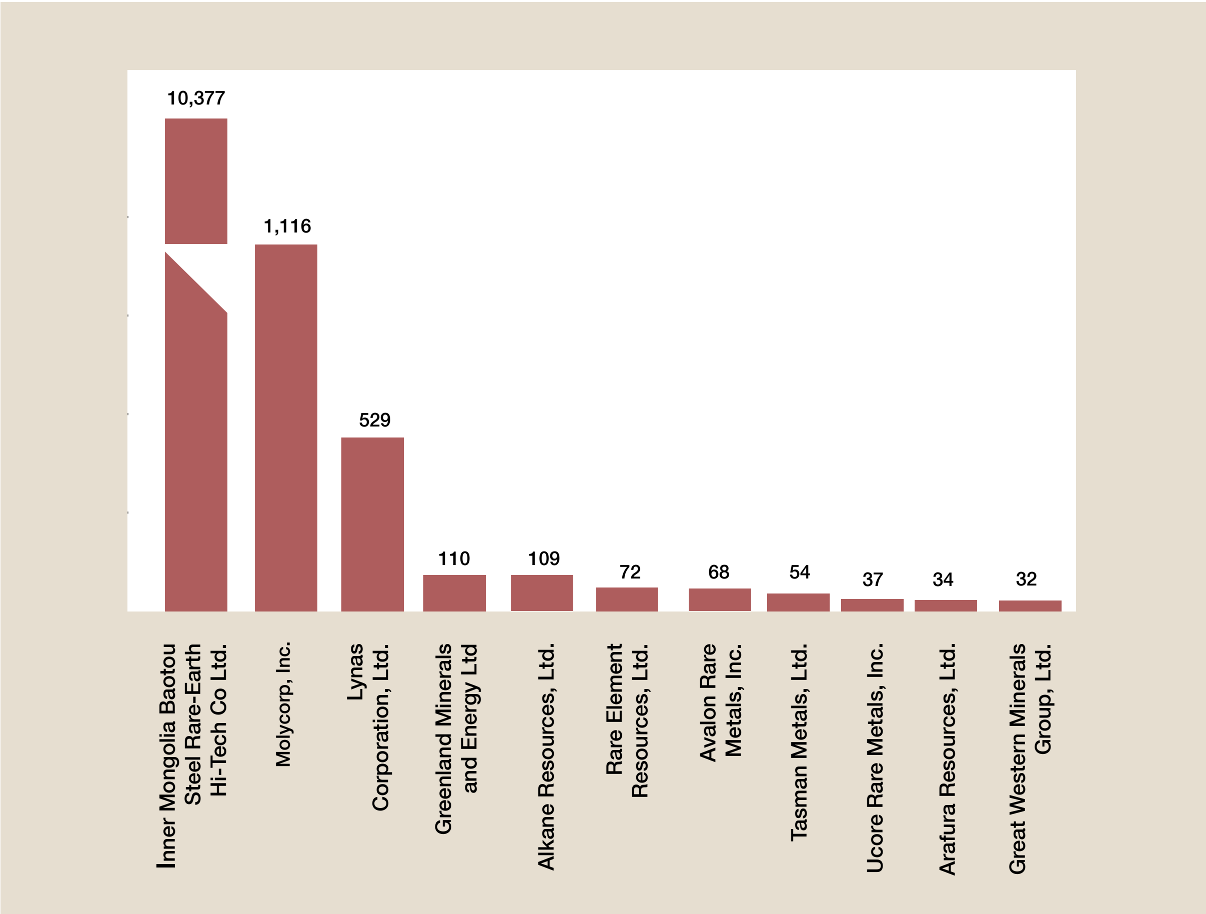
Source: UNCTAD Secretariat from Mineral Commodity Summaries (various issues), US Geological Survey

States ranked second in REE producing countries in 2012 with 6.4 per cent of world production (figure 4).

According to various reports issued by US and European sources, the expanding role of China in the world REE production and the simultaneous contraction of the share of other producing countries, United States in the lead, may be explained by the support of the Government of China to its REE sector as well as the lower labour costs and more flexible environmental regulatory framework during this period. These factors allowed China to produce REEs at a far lower cost than other producers, explaining why it was financially cheaper to import REEs from China than to produce them domestically. However, while cheap REE exports from China resulted in the contraction and sometimes the end of REE production in other countries, they also allowed companies in the US, Europe and Japan notably, to invest in Research and Development and develop new technologies as well as to produce more advanced final goods at a more competitive cost; this gave a larger share of the population access to more advanced goods and technologies by decreasing their final price.

In December 2013, six out of the ten world leading REE mining companies (outside China) in terms of market capitalization were North-American, while the four remaining ones were Australian accounting for a total market capitalization of US$ 2.3 billion. However, these companies remain small compared to the size (in market capitalisation terms) of the leading Chinese REE market player. The aggregate market capitalization of the 10 top Western companies accounted for about a fifth of the size of Inner Mongolia Baotou Steel Rare-Earth Hi-Tech Co Ltd (figure 5).

Figure 5. Chinese leading REE company and the ten world leading rare earth mining companies by market capitalization (excluding China), 2 December 2013 (million US$)



Source: UNCTAD Secretariat using data from Bloomberg (extracted on 2 December 2013 and converted using the following conversion rates: 1 CNY = 0.164087 US$, 1 AU$ = 0.914252 US$, 1 CA$ = 0.940667 US$)
Note(s): the column showing Inner Mongolia Baotou Steel Rare-Earth Hi-Tech Co Ltd had to be discontinued due to the disproportionately large size of its market capitalization compared with other companies on the graph.

For most countries utilizing REEs, the main issue remains the predominant position of China and the potential evolution of its export policy, which casts doubts about the capacity of importing countries to have access to sufficient resources to feed their industries and at a reasonable price. Furthermore, given that China is currently in a process of acquiring more advanced technologies, countries which rely upon China for their imports of REEs also worry about their future capacity to compete with China with regards to the production of REE-related goods, considering that their own production costs may largely depend upon the change in the cost of their inputs.

3. RARE EARTH PRODUCTION IN CHINA

In China, the three main producing areas are Inner Mongolia, Sichuan and Jiangxi. Taken together, these regions accounted for more than 93 per cent of total Chinese annual extraction quotas between 2007 and 2011. As mentioned by the Information Office of the State Council of China, the rare-earth industry has rapidly developed as a result of economic reforms in China starting in the late 1970s.[13] However, the domestic rare earth sector also had to face a major obstacle, which was the erratic development of producing facilities, resulting in a large number of small-size actors, some of them illegal. This situation made it difficult for Chinese authorities to monitor their REE supply chain effectively for several years, which resulted in the development of unlicensed mining as well as smuggling activities at both the production and export levels. This uncontrolled situation also partly explained the important damages that the REE activity caused to the Chinese environment as well as human health.

Since 2006, the Chinese government has implemented a new policy framework aiming to shut down illegal mines in the Provinces of Guangdong, Jiangxi and Sichuan.[14] The Chinese government also recently decided to consolidate rare earth production in China, which should result in fewer, larger and more technically advanced companies in the three main rare earth producing regions: (1) Baotou Steel Rare-Earth Hi-Tech Co Ltd in the Inner Mongolia Autonomous Region, (2) Ganzhou Rare Earth Mineral Industry Co. Ltd and (3) China Minmetals Corporation, Aluminum Corporation of China (Chinalco) and Guangdong Rising Nonferrous Metals Group Co Ltd in the Southern regions of China. This should reduce the number of companies involved in REE production to about 20[15]. Despite these recent actions, smuggling remained a recurrent issue in REE supply chain in China for a long time and at least up to 2010, according to statistics (table 3). Between 2007 and 2009, the Official Actual Extraction in China was more than 146 per cent its total extraction quota per annum. Nevertheless, a large improvement is observable in official statistics since 2010. Moreover, as indicated by the Information Office of the State

[13] Situation and Policies of China's Rare Earth Industry. Information Office of the State Council, The People's Republic of China (2012)

[14] Tse, P-K. (2011). China's rare-earth industry. US Geological Survey. http://pubs.usgs.gov/of/2011/1042/of2011-1042.pdf

[15] Zhanheng, C. (2010). Outline on the development and policies of China rare earth industry. Chinese Society of Rare Earths (7 April 2010)

Table 3. Distribution of production quotas within the various provinces of China, 2007-2011 (per cent)

Province / Region	2007	2008	2009	2010	2011
Fujian	0.3	0.4	0.9	1.7	2.1
Guangdong	0.8	1.1	1.8	2.2	2.3
Guangxi	0.2	0.2	0.2	2.2	2.7
Hunan	0.1	0.3	1.0	1.7	2.1
Inner Mongolia	52.9	52.5	55.9	56.1	53.3
Jiangxi	8.5	8.4	9.0	9.5	9.6
Shandong	1.4	1.4	1.8	1.7	1.6
Sichuan	35.6	35.4	29.2	24.7	26.0
Yunnan	0.2	0.2	0.2	0.2	0.2
Total Extraction Quota (REO tons)	**87,020**	**87,620**	**82,320**	**89,200**	**93,800**
Official Actual Extraction (REO tons)	**120,800**	**124,500**	**129,405**	**89,259**	**84,943**

Source: UNCTAD Secretariat from Rare-Earth Supply, Innovation metals. The figures for Total Extraction Quota and Official Actual Extraction were revised according to information respectively provided by China's Ministry of Land and Resources and China Rare Earth

Council, China increased the resource tax rate on its REE mining: *"the adjusted new tax rate for light rare-earth minerals (including bastnaesite and monazite) is 60 yuan per ton (US$ 9.85), and for middle and heavy rare-earth minerals (including xenotime and ion-absorption rare earths minerals) is 30 yuan per ton (US$ 4.92), much higher than the rates before the adjustment, which ranged from 0.4 yuan per ton (US$ 0.066) to 2 yuan per ton (US$ 0.33)"*[16] In 2012, Chinese authorities also decided to significantly limit the number of REE mining licenses granted in China.[17]

With regard to perspectives for REE production, different sources give different outlooks. According to the Canadian Imperial Bank of Commerce (CIBC), REE production may be limited to 100,000 tons in China in 2015.[18] However, USGS indicates that *"according to China's draft rare-earth development plan, annual rare-earth production may be limited to between 130,000 t and 140,000 t (REO) during the period from 2009 to 2015",*[19] which means 30 per cent to 40 per cent above the forecast issued by CIBC. This last estimate is confirmed by a second report issued by the Great Western Minerals Group Ltd, which indicates that Chinese supply will have increased to 140,000 tons per year by 2015.[20] At the same time, world production capacity is expected to reach 200,000 tons by 2015.

It is highly likely that China will continue to limit REE exports and notably HREEs on one hand as a result of the policies implemented to protect its environment and encourage the sustainable development of its REE sector and on the other hand to meet its domestic demand. As a consequence, the growth of the demand emanating from the rest of the world will have to begin to be met through production sources outside China by 2015. China is expected to contribute to around 70-75 per cent of world production in 2015.

REE production outside China is expected to increase in the coming years, mainly as a result of the development of the Mountain Pass mine in the United States (19,050 tons of REE per year) and the Mount Weld mine in Australia (20,000 tons REE per year) as well as other smaller projects around the world. This assumption is supported by the US Department of Energy (DoE).[21] When and if Mountain Pass and Mount Weld operate at full capacity, they would probably be able to supply about three quarters of the anticipated increase in world production by 2015. However, both these mines will almost exclusively produce LREEs – with Cerium, Lanthanum, Neodymium and Praseodymium accounting for about 95 per cent of all REE extracted from Mount Weld and more than 98 per cent from Mountain Pass. Despite the start of the Phoenix project headed by Molycorp, which is expected to process ores from the Mountain pass mine into HREE oxides, the issue of HREEs - mainly mined in China (and for which reserves are fast depleting in the country) is expected to remain pivotal up to 2015. The start of the production in few other small deposits around the world like the Bokan Mountain deposit run by Ucore Rare Earths Inc in the United States could contribute to reduce the pressure on the market after 2015.

Moreover, on 24th October 2013,[22] the Greenland parliament voted for the removal of a 25-year ban on mining radioactive materials. This decision could promote new investments in rare earths in the country, including the development of the Kvanefjeld deposit in southern Greenland. With a potential of about a quarter of the expected demand for the next five decades, this deposit is considered as one of the largest outside China. Above all, with 12 per cent of HREE content in its total resources, Kvanefjeld is expected to become a major source of HREE production in the future. However, this decision is subject to a strong opposition of environmentalists in Greenland due to the damages that such mining may cause to the Arctic region. Furthermore, the decision has to be endorsed by the Danish parliament, which could exercise its veto. As a result, it could take some time before operations start.

16 Situation and Policies of China's Rare Earth Industry. Information Office of the State Council, The People's Republic of China (2012). The figures given between parenthesis have been converted using the following exchange rate: 1 CNY = 0.164087 US$ as of 2 December 2013

17 Elmquist, S. et al. (2012). "China Cuts Rare-Earths Mine Permits 41% to Boost Control". Bloomberg. (14 September 2012) http://www.bloomberg.com/news/2012-09-14/china-cuts-rare-earths-mine-permits-41-to-boost-control-1-.html

18 Once Ignored On The Periodic Table, Don't Ignore Them Now - A Rare Earth Element Industry Overview. Canadian Imperial Bank of Commerce (2011)

19 Tse, P-K. (2011). China's rare-earth industry. US Geological Survey. http://pubs.usgs.gov/of/2011/1042/of2011-1042.pdf

20 REE Supply and Demand. Great Western Minerals Group Ltd. http://www.gwmg.ca/html/about_rare_earth_elements/key_stistics/index.cfm

21 Bauer, D. et al. (2011). Critical Materials Strategy. US Department of Energy

22 Vahl, K. et al. (2013). "Greenland votes to allow uranium, rare earths mining". Reuters. (25 October 2013). http://www.reuters.com/article/2013/10/25/us-greenland-uranium-idUSBRE99O05A20131025

CHAPTER 3
RARE EARTH DEMAND

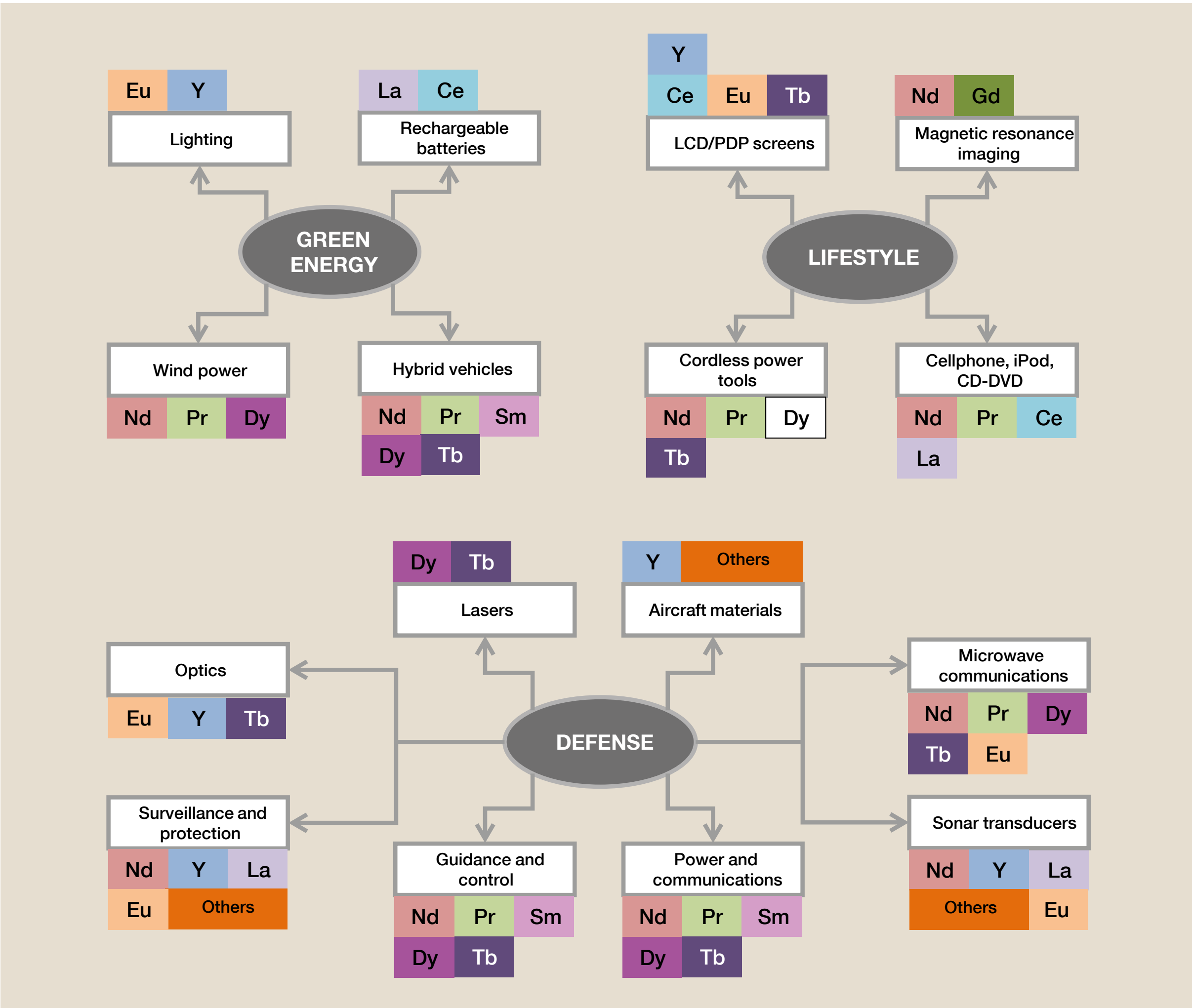
Rare earths are used in every day's activities all around the world. Thanks to their catalytic, magnetic, electrical, chemical, heat resistance and optical properties, they are considered as valuable inputs in a wide range of high-tech, high value-added and fast-growing sectors. REEs are also regarded as highly strategic due to their large utilization in military and defence applications (figure 6). When substitutes for REEs exist, they are generally less effective than originals, generating an inelastic demand for REEs. Furthermore, REEs generally account for a small share of final goods' costs of production as well as of their weight, which makes their substitution as well as Research and Development less attractive. This situation was particularly true before 2010, when REE prices were low and the market plentifully supplied.

At that time, the development of substitutes as well as recycling methods was not seen as a priority for industries as well as governments in importing countries. A 2011 Communication by the European Commission[23] confirmed that *"no recycling or substitution processes for rare earths are currently commercially viable".* According to the European Commission, REEs substitution rate is 0.87[24]

[23] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Tackling the challenges in commodity markets and on raw materials. European Commission. (2 February 2011). See in particular the annex dealing with the Concentration of production of critical raw materials, and recycling and substitution rates.

[24] *"The substitutability index for a specific raw material is an aggregate of substitutability indices for each of its use… Four values have been given "on the basis of expert opinion" by Fraunhofer ISI to measure the various degrees of substitutability: a value of 0 would mean that substitution is possible at no cost; 0.3 means that substitution is feasible at relatively low cost; 0.7 means that substitution is possible*

Figure 6. Final sectors using rare earth materials as an input



Source: UNCTAD Secretariat from Great Western Minerals Group Ltd (comparable to the one of cobalt, but greater than the one of magnesium, for instance) and the recycling rate for REE is evaluated at 1 per cent, which ranks REEs among the less recyclable critical materials, as defined by the European Union. However, due to the price hikes of the end of 2010 and the first half of 2011, countries as well as industries have begun to seek for solutions (e.g. recycling) to reduce their dependence on REEs.

1. RARE EARTH USES

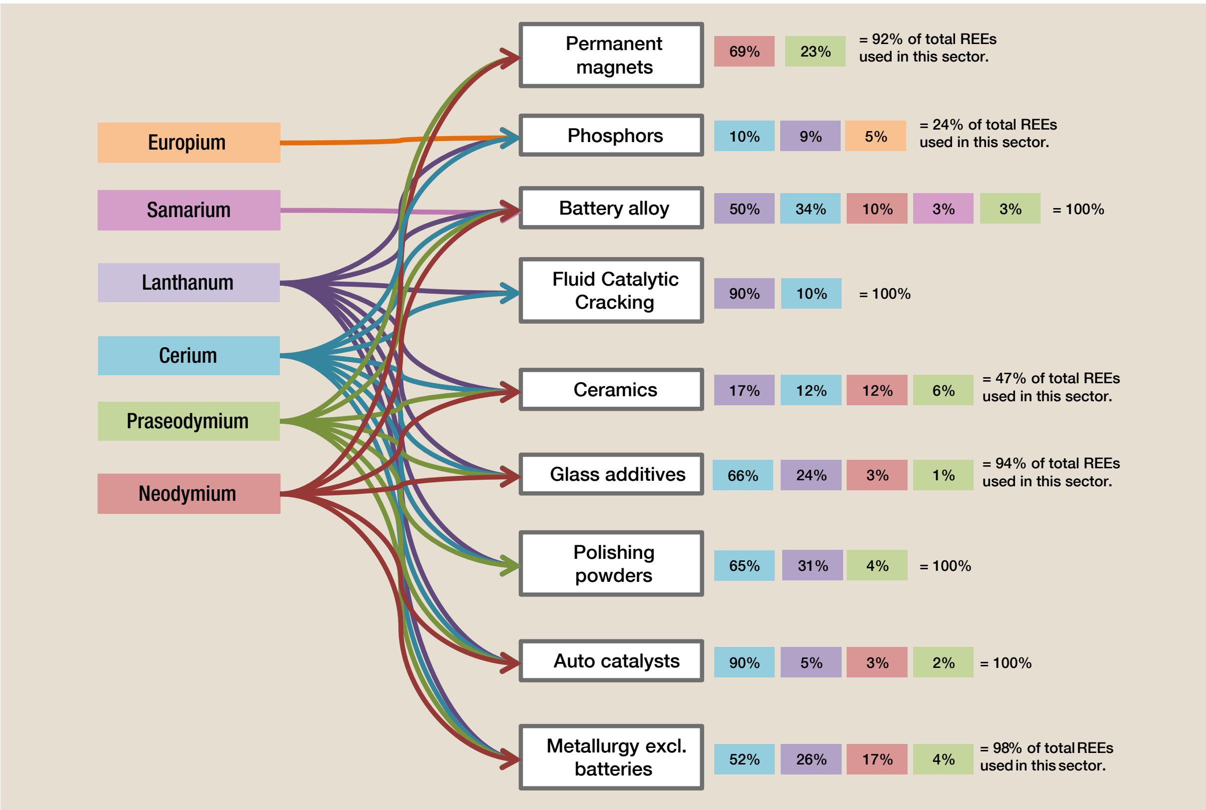
Almost all sources of information identify 9 different sectors using REEs as an input in their production process. These industries relate to permanent magnets, phosphors, battery alloys, fluid catalytic cracking, ceramics, glass additives, polishing powders, auto catalysts and metallurgy (excluding batteries). With 9 sectors requiring LREEs (figure 7) compared to 4 for HREEs, LREEs are more widely used than HREEs. In terms of the proportion of LREEs used in each sector compared to HREEs, the share of HREE is also smaller, with less than 5 per cent of total REEs used in each industry (figure 8). However, despite this low HREEs' content in semi-final products, HREEs remains pivotal in several industries.

With regards to LREEs, thanks to their versatility, Cerium and Lanthanum are used in almost all industries (8 out 9), while the use of Samarium and Europium is essentially limited to the battery alloy and phosphor industries. Finally, Yttrium plays a vital role in ceramics and phosphors production with more than half of the total REEs used in each of these sectors.

REEs demand is very difficult to estimate. In fact, as many estimates exist as sources of information,

at high cost; and 1 means that substitution is not possible or very difficult." (2010). Defining raw materials for the EU - Report of the Ad-hoc Working Group on defining critical raw materials. European Commission. (30 July 2010). https://ec.europa.eu/eip/raw-materials/en/system/files/ged/79%20report-b_en.pdf

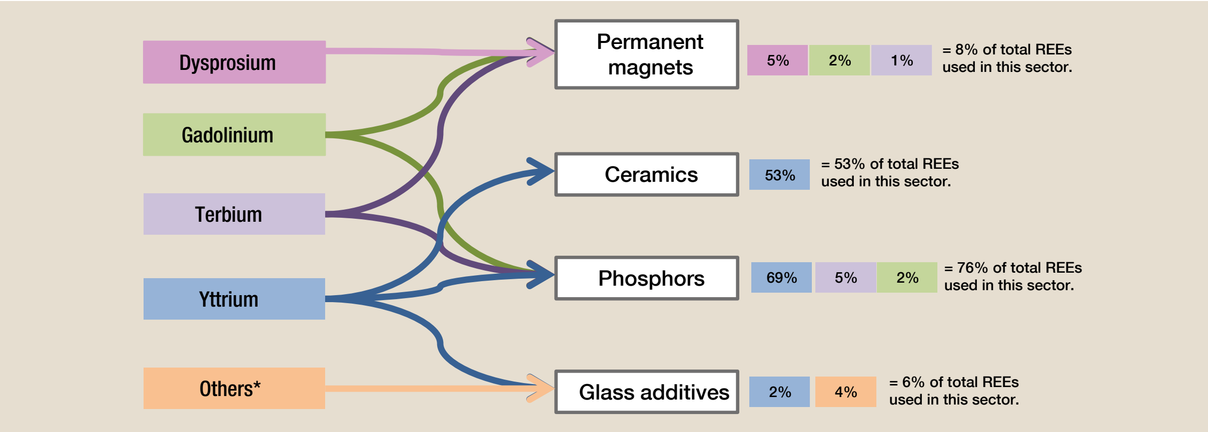
Figure 7. Main semi-final industries using Light Rare Earth Elements (LREEs) as inputs



Source: UNCTAD Secretariat using data statistics from Once Ignored On The Periodic Table, Don't Ignore Them Now - A Rare Earth Element Industry Overview. Canadian Imperial Bank of Commerce (CIBC). (6 March 2011). http://fr.slideshare.net/RareEarthsRareMetals/cibc-report

Note(s): Data given on the right-hand side of this figure are for 2011. They represent the shares of each LREE used by each industry as a percentage of the total REE used by the said industry. For instance, the basket of the permanent magnets industry was composed of 69 per cent of Neodymium and 23 per cent of Praseodymium in 2011 (and 8 per cent of HREE).

Figure 8. Main semi-final industries using Heavy Rare Earth Elements (HREEs), plus Scandium and Yttrium as inputs



Source: UNCTAD Secretariat using data statistics from Once Ignored On The Periodic Table, Don't Ignore Them Now - A Rare Earth Element Industry Overview. Canadian Imperial Bank of Commerce (CIBC). (6 March 2011). http://fr.slideshare.net/RareEarthsRareMetals/cibc-report

Note(s): Data given on the right-hand side of this figure are for 2011 and represent the shares of each HREE used by each industry as a percentage of the total REE used by the said industry. For instance, the basket of the permanent magnets industry was composed of 5 per cent of Dysprosium, 2 per cent of Gadolinium and 1 per cent of Terbium in 2011 (and 92 per cent of LREE). Promethium, Holmium, Erbium, Thulium, Ytterbium, Lutetium and Scandium are included in the «others» category.

probably given the highly strategic nature as well as the narrowness of the REE market in terms of quantity. However, it is clear that REEs demand has significantly increased since the mid-1990s with an acceleration between 2002 and 2010, reaching a maximum of about 134,000 tons in 2010. The yearly growth rate during this period was about 10 per cent. More recently, in 2011 and 2012, REE demand tended to contract slightly as a result of the very high price levels from the end of 2010 to the mid-2011 as well as limited economic growth.

From a general point of view, REE demand is expected to continue to rise in the coming years and reach 200,000-240,000 tons in 2020.[25] The growth of the world population, notably within the BRICS (Brazil, Russian Federation, India, China and South Africa) and the improvement of the standards of living in these countries, combined with factors more specific to increasing needs in end-use markets support this forecast increase.

2. COUNTRIES LIKELY TO SUPPORT RARE EARTH DEMAND

According to UN estimates, the world population is expected to reach 7.7 billion people in 2020 and further to 8.3 billion people in 2030, compared to 7 billion people in 2012. In 2030, a large majority of the world population will be living in developing countries (83 per cent) and about half of them within the BRICS.

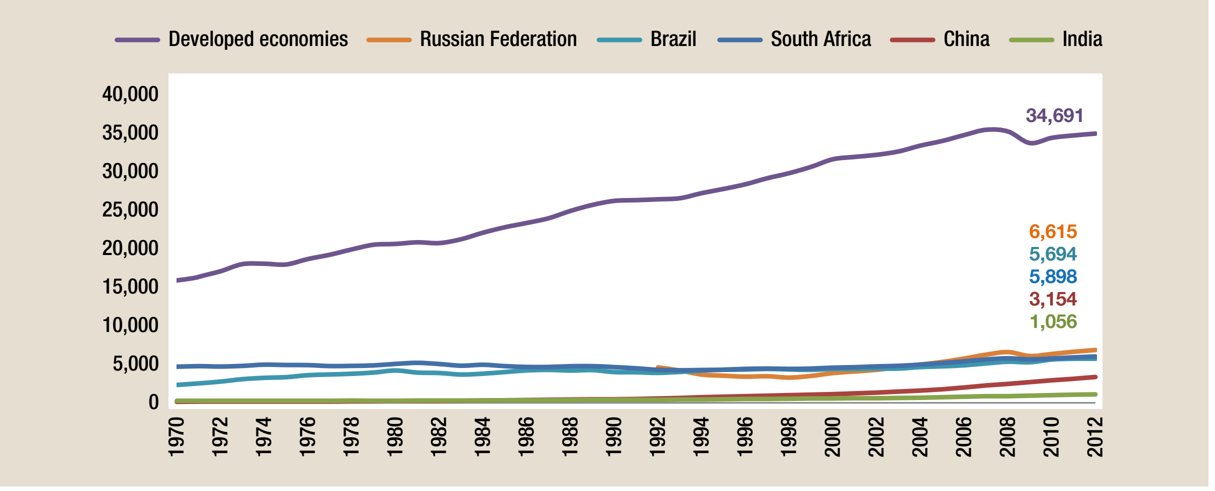
At the same time, the standard of living of the world population increased regularly since the 1970s. Over the period 2000-2012, the world GDP per capita increased by an average 2.7 per cent per year, as a result of the large growth rates recorded within the BRICS (GDP per capita increased by 109 per cent on average between 2000 and 2012 in this group of countries). More recently, over the 2010-2012 period, GDP and GDP per capita in the BRICS increased more than 50 per cent compared to their average level in the 2000s. Despite this large rise, the 2010-2012 average GDP per capita in these countries has remained low. For example, GDP per capita in the Russian Federation is about 20 per cent the one in developed countries and in India, GDP per capita is roughly 3 per cent of the one in developed countries.[26] This large gap as well as the rapid expansion of this indicator in these countries since the beginning of the 2000s give good prospects for further improvements, which could finally allow these countries to catch up with the average standard of living in developed countries (figure 9).

The largest REEs consuming country has historically been China. Its share in world REE demand has been increasing since the beginning of the 2000s, from

[25] Lifton, J. (2013). "Counterpoint: Supply and Demand in the Rare-Earths Market 2015-2020". Technology Metals Research. (1 August 2013). http://www.techmetalsresearch.com/2013/08/counterpoint-supply-and-demand-in-the-rare-earths-market-2015-2020/

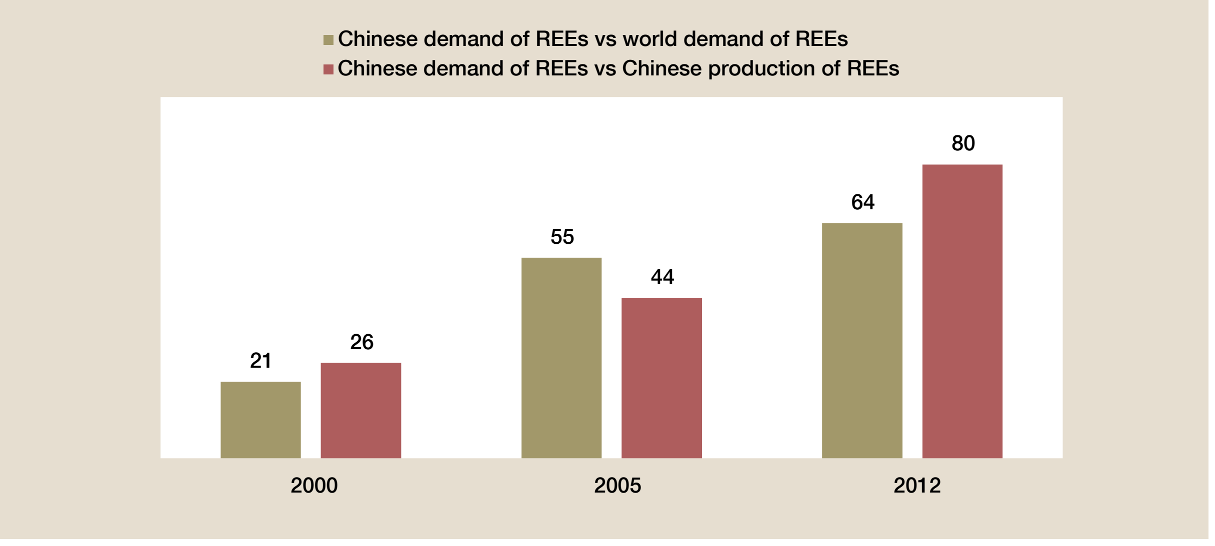
[26] Developed countries list as defined by UNCTAD, extracted November 2013

Figure 9. Evolution of the GDP per capita in the BRICS and the developed countries, 1970-2012 (US$ per capita)



Source: UNCTAD Secretariat from UNCTADstat
Note(s): data for Russian Federation are not available prior to 1992. In the graph, data indicated in colour are the averages GDP per capita in 2010-2012

Figure 10. Chinese REEs demand as a percentage of: (1) world REEs demand and (2) Chinese REEs production, 2000, 2005, 2012 (per cent)



Source: UNCTAD Secretariat

21 per cent in 2000 to 64 per cent in 2012 (figure 10). In China, the largest REE consuming sectors are permanent magnets, battery alloys, phosphors, polishing powders and catalysts. As the largest rare earth producing country as well as the leading demanding one, the ratio of its domestic demand compared to its domestic production has been growing fast from 26 per cent in 2000 to 80 per cent in 2012.

The outlook in China is optimistic with regards to rare earth demand. According to various sources of information, China's REE demand might continue to grow in the near future. Its share of the world demand should remain around 60 per cent by mid-2010s, while the rest of the world would account for the remaining 40 per cent. According to Kingsnorth,[27] *"the remaining 40% will be split half for the rest of Asia – including Japan – and the other half in the United States and Europe".*[28] Chinese demand is expected to reach

[27] Dudley Kingsnorth is an expert on rare earth matters. He is a professor at Curtin Graduate School of Business (Curtin University) and Executive Director at Industrial Minerals Company of Australia Pty Ltd (IMCOA)
[28] Bruno, A. (2013). "Kingsnorth believes Rare Earth Element demand

70 per cent of world REEs demand by 2020. This is underscored by general factors including the growth of the Chinese population (+79 million inhabitants by 2020 – about the total population of Egypt today), combined with the expected increase in its standard of living, which remains in 2012, less than 13 per cent the average of developed countries. In addition, the policies pursued by China to attract a higher share of value-added in high-tech industries within the country, and the increase of the share of green energy sources in its energy mix may contribute to the rise of the demand for rare earth by the end of the decade.

Within the framework of its energy development plan issued in January 2013, China aims to reduce CO_2 emissions and to green its economy. It plans to gradually reduce the contribution of coal (as well as other fossil fuel energy sources) in its total primary energy demand. In China, coal accounted for 68 per cent of all fuel consumed in 2012. Coal is also the main energy source in power generation in China, accounting for 79 per cent of the total in 2011, about *"as much coal as the rest of the world combined".*[29] This share is expected to contract to 65 per cent by 2017 and to 55 per cent by 2035. Renewable energies and wind power in particular are expected to benefit from that and their contribution should gradually increase up to 2035, when it could reach about 10 per cent of total power generation in China. Moreover, as a means of daily transport, two-wheel vehicles (e-bicycles, e-scooters and e-motorbikes) are widely spread throughout Asia and China in particular. As a result of the implementation of more drastic environmental policies and the development of the middle-class, the electric two-wheel vehicle market is expected to expand significantly in China. According to PikeResearch,[30] this market could increase by a compounded annual growth rate of 6.6 per cent and reach more than 65 million units by 2018. The anticipated changes in both the energy and the transportation sectors are expected to contribute to the expansion of Chinese demand of REEs in the future.

The potential increase of the Chinese demand combined with the current re-organization of its domestic supply chain raise concerns about the possibility (or not) for China to meet its internal demand through its domestic production by 2015, which may lead the country to become a net importer of rare earths in the short run instead of a net exporter, as it is today. This situation may have a direct impact on the availability of REEs on the international market as well as on international prices, especially for REE net-importing countries.

Apart from China, the other main consuming areas are Japan and the Asian region, with just less than 20 per cent of REE consumed worldwide, the United States with about 10 per cent and the rest of the world (European Union in the lead) for the difference. In these areas, where REE production was not a priority for many years due to low REE prices, the contraction of Chinese exports quotas as well as the jump of REE prices in 2010-2011 generated some threats of shortages and encouraged some countries to develop or re-start their own production and processing capacities. Australia and the United States are good examples in this regard.

3. SECTORS LIKELY TO AFFECT RARE EARTH DEMAND

With regards to the various sectors using REEs in their production process, permanent magnets, metal alloys, catalysts and polishing were the sectors with the largest demand in 2012. Together they accounted for the three quarters of world demand. REEs demand is expected to largely increase in the coming years and the composition of this demand is also expected to change. As an example, the role of permanent magnets which was the largest REEs consuming sector in 2012 is expected to be also the fastest growing one up to 2015 (figure 11). The growth in permanent magnets demand by 2015 is explained by their versatility and their use in fast-growing sectors such as high-tech devices (e.g. mobile phones, i-pod, laptops) and green energy sources (e.g. wind turbines as well as electric and hybrid cars), for instance.

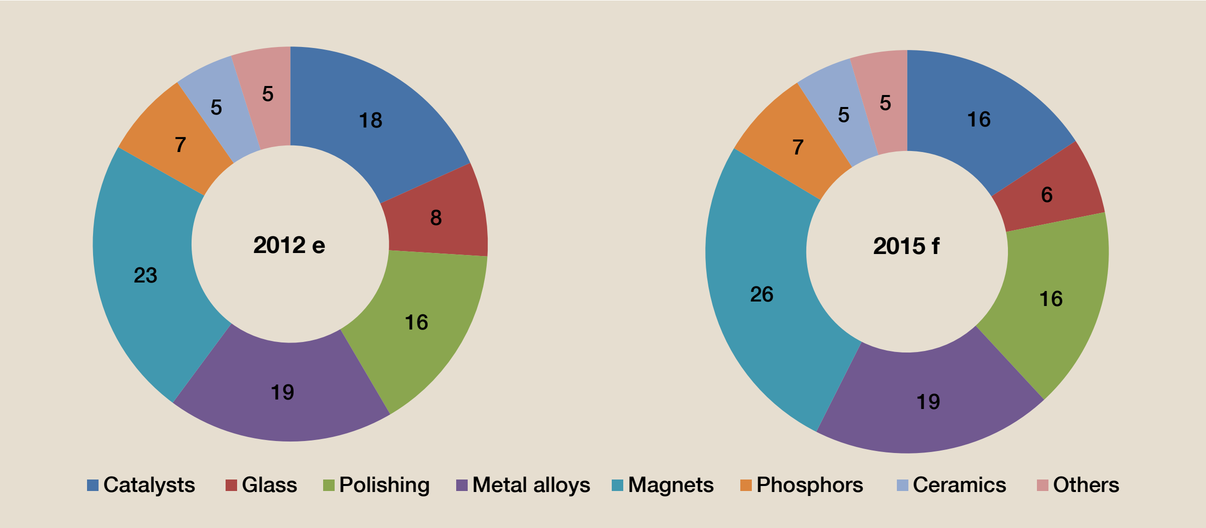
The personal technology devices sector is expected to grow significantly in the coming years notably due to the regular increase of the population within the BRICS and in their standard of living supporting the development of the middle-class, especially in China – as well as of its specific needs and wishes. The global demand for smart phones may increase fourfold by 2015 compared to its level in 2012 (figure 12). The first smart phone was launched in 1994. However, its expansion really began in 2007 and sales have largely expanded since then to finally reach more than a billion in 2012, which represents a penetration rate of 16.7 per cent of all mobile phones in the world. According to Strategy Analytics, the

and prices to increase". investorintel.com. (26 July 2013) http://investorintel.com/rare-earth-intel/dudley-kingsnorth-believes-that-ree-demand-and-prices-will-double-by-2015/

29 World Energy Outlook 2013. International Energy Agency (2013)

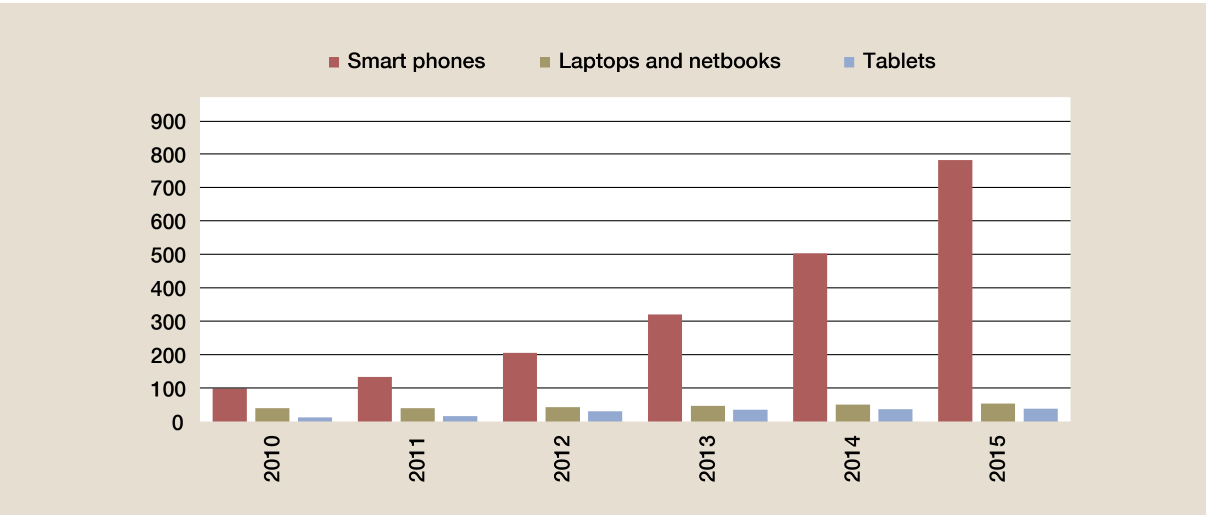
30 Bae, H. et al. (2012). Electric Two-Wheel Vehicles in Asia Pacific, Executive summary. PikeResearch

Figure 11. World rare earths demand by end-use, 2012e and 2015f (per cent)



Source: UNCTAD Secretariat estimates using the distribution of the demand by end-use in 2010 as well as the percentage change in demand for rare earths by end-use, 2010-2015, CAGR as in Chegwidden J. and Kingsnorth D. presentation "Rare earths - an evaluation of current and future supply"

Figure 12. Personal Technology Demand Outlook, 2010-2015 (million units)



Source: Canadian Imperial Bank of Commerce (2011)

next billion smart phones may be reached in the next three years.[31]

The global deployment of electric vehicles in the countries that are members of the Electric Vehicles Initiative (EVI)[32] is expected to reach 20 million in 2020 (including plug-in hybrid electric vehicles and fuel cell vehicles) compared to 180,000 in 2012.[33] In the United States, one of the stated objectives of the Obama's presidency is to reach one million electric vehicles deployed by 2015.[34] Besides this objective of

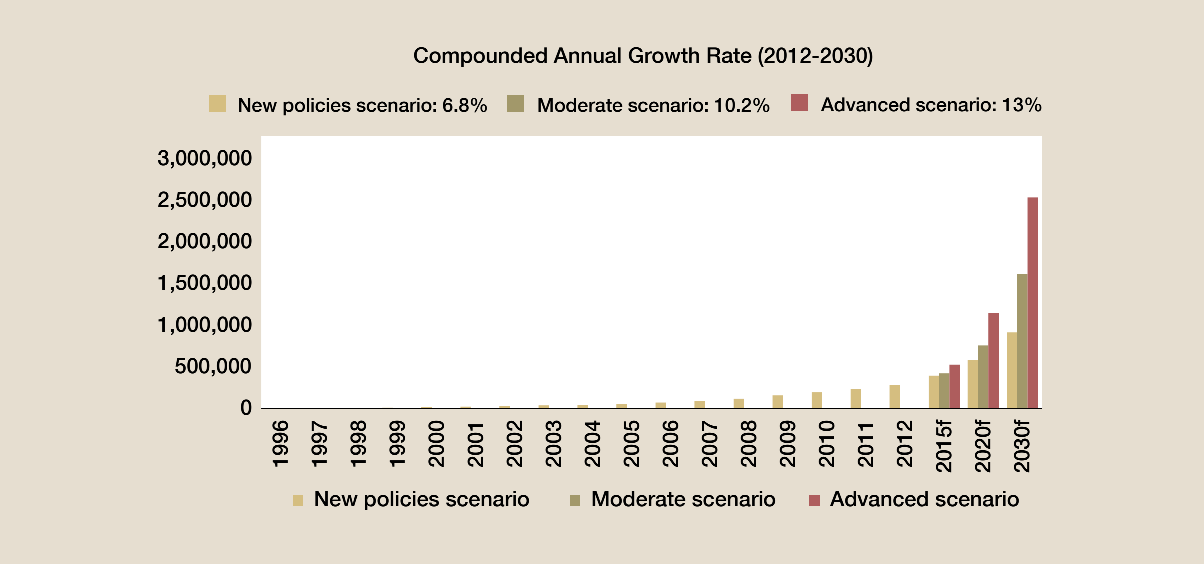
31 Global mobile statistics 2013. mobiThinking. (2013). http://mobithinking.com/mobile-marketing-tools/latest-mobile-stats

32 Countries members of the Electric Vehicles Initiative (EVI), namely China, Denmark, Finland, France, Germany, India, Italy, Japan, South Africa, Spain, Sweden, United Kingdom, United States, The Netherlands and Portugal. EVI member countries held over 90 per cent of world electric vehicle stock in 2012

33 Global EV Outlook, understanding the electric vehicle landscape to 2020 - Clean Energy Ministerial (a high-level dialogue among energy ministers from the world's major economies). Electric Vehicles Initiative, with the participation of the International Energy Agency. (2013). http://www.iea.org/publications/globalevoutlook_2013.pdf

34 One Million Electric Vehicles By 2015 - Status Report. US Department of Energy. (February 2011). http://www1.eere.energy.gov/vehiclesandfuels/pdfs/1_million_electric_vehicles_rpt.pdf

Figure 13. World cumulative wind power capacity, 1996-2030 (megawatt)



Source: UNCTAD Secretariat from the Global Wind Energy Council statistics (2012)

an increasing number of electric vehicles, the value of REE inputs in the automotive sector is also supposed to continue to rise in the future. These arguments may contribute to push demand for permanent magnets and specific REEs entering into their production process up by the end of the decade.

Wind energy is a particularly high-demanding sector of REEs. Given the importance of REEs for this sector as well as the growth anticipated for wind installations in the years to come, the demand for permanent magnets and consequently REEs is expected to grow. According to Greenpeace International and the Global Wind Energy Council[35] forecasts, wind power could contribute between 6 per cent and 12 per cent of global electricity demand in 2020 compared to 3.5 per cent in 2011. The development of this sector could reduce CO_2 emissions by 863 million tons a year to 1.7 billion tons a year.[36] The global capacity installed was 237,699MW in 2011. By 2020, this capacity may reach 586,729MW to 1,149,919MW (figure 13). In 2011, together, China, OECD North America (Canada, Mexico and the United States) and the EU-27 accounted for about 90% of the global cumulative wind capacity. This would remain unchanged in 2020, despite a potential change in their share of global capacity installed and order in the ranking (table 4). The main difference occurring among the various projections is the contraction of the share of the 3-leading areas in favour of non-OECD Asian countries or territories,[37] mainly.

The growth of the world population combined with the improvement of its standard of living, particularly within the BRICS, should contribute to increasing the needs of REE-based products, notably within these countries. Moreover, the intensification of international and national legislative frameworks concerning CO_2 emission limitation will encourage the strengthening of green energy sectors worldwide in the medium to long term. Combined, these factors will continue to put pressure on world REE reserves and prices. However, the potential development of substitutes, new technologies as well as recycling solutions may help to counterbalance this situation.

[35] Global Wind Energy Outlook 2012. Greenpeace International and the Global Wind Energy Council (2012)

[36] *"The Global Wind Energy Outlook paints a picture of three different futures for the wind industry, looking at scenarios out to 2020, 2030, and eventually to 2050; and then measures these scenarios against two different projections for the development of electricity demand: the first based on the International Energy Agency's World Energy Outlook, and another, more energy efficient future developed by the ECOFYS consultancy and researchers at the University of Utrecht".*

[37] Afghanistan, Bangladesh, Bhutan, Brunei, Cambodia, Chinese Taipei (Taiwan Province of China), East Timor, Fiji, Indonesia, Kiribati, Democratic People's Republic of Korea, Laos, Macao (China), Malaysia, Maldives, Mongolia, Myanmar, Nepal, Pakistan, Papua New Guinea, Philippines, Samoa, Singapore, Solomon Islands, Sri Lanka, Thailand, Tonga, Vietnam, Vanuatu, Cook Islands, French Polynesia, New Caledonia.

Table 4. Global wind power capacity installed by countries/areas, 2011, 2020 [39] megawatt and percentage)

	Global	EU27	China	OECD North America	3-leading areas
2011					
Installed capacity (MW)	237,699	93,947	62,364	52,753	209,064
Share of the total		39.5%	26.2%	22.2%	88.0%
Ranking		1	2	3	
2020, New Policies Scenario					
Installed capacity (MW)	586,729	207,246	179,498	121,238	507,982
Share of the total		35.3%	30.6%	20.7%	86.6%
Ranking		1	2	3	
2020, Moderate scenario					
Installed capacity (MW)	759,349	210,270	214,445	155,208	579,923
Share of the total		27.7%	28.2%	20.4%	76.4%
Ranking		2	1	3	
2020, Advanced scenario					
Installed capacity (MW)	1,149,919	263,220	230,912	290,805	784,937
Share of the total		22.9%	20.1%	25.3%	68.3%
Ranking		2	3	1	

Source: UNCTAD Secretariat from the Global Wind Energy Council statistics (2012)

[39] According to the three scenarios defined by Greenpeace International and the Global Wind Energy Council. The *"New Policies "scenario is based on an assessment of current directions and intentions both national and international energy and climate policy, even though they may not yet have been incorporated into formal decisions or enacted in law. The "Moderate" scenario takes into account all policy measures to support renewable energy either already enacted in the planning stages around the world, and at the same time assuming that the commitments for emissions reductions agreed by governments at Cancun will be implemented, although on the modest side. The "advanced" scenario is the most ambitious one. It explores the extent to which the wind industry could grow in a best case "wind energy vision", but still well within the capacity of the industry as it exists today and is likely to grow in the future. It assumes an unambiguous commitment in renewable energy in line with industry recommendations, the political will to commit to appropriate policies and the stamina to stick with them"*. (2012). Global Wind Energy Outlook 2012. Greenpeace International and the Global Wind Energy Council

CHAPTER 4

RARE EARTH PRICES

Rare earths are not traded or even quoted on international commodity exchanges. As a consequence, the price discovery mechanism appears to be less "transparent" as for some other commodity markets (e.g. cocoa, crude oil, copper). Furthermore, the oligopolistic nature of this market also creates uncertainties with regards to the availability of REEs as well as their future prices. Moreover, the lack of reliable international statistics on REEs' trade does not help to improve such a situation and increase the transparency of price formation.

With the purpose of enhancing the transparency of the price discovery mechanism, China planned to implement the first market place dealing with rare earth products – The Baotou Rare Earth Products Exchange – in October 2013. According to *China Daily*, this exchange is an initiative from Baotou Steel Rare-Earth Hi-Tech Co Ltd (the leading Chinese and world REE producing company) and the trading platform has been registered with 11 other major rare-earth companies with a capital standing at 120 million Yuan (US$ 19.5 million).[39] According to Gu Ming, general manager of the Baotou Rare Earth Products Exchange, the exchange aims to strengthen the links among the different REE producing regions, enhance price transparency, adjust long-term market balance and stabilize the market.[40] At the time of writing, little information about the exchange is known.[41] Furthermore, it would be interesting to know the list of products which will be traded and quoted on the market (commodities, semi-final goods, final products). The exchange is supposed to begin with spot and forward trading, but futures trading may come later.

As a disclaimer, UNCTAD would like to indicate that given that no public or private authoritative source of information exists in regard to REE prices as such, the trends given below are indicative and mainly derived from the analysis of spot prices.

As may be observed from the various sources of information, HREEs generally record higher prices than LREEs due to their higher scarcity. HREEs prices also appear to be more volatile than LREEs, for the same reason.

Historically, REE prices remained relatively unchanged from 2001 to 2009, but dramatically rose between the end of 2010 and mid-2011, notably as a result of the contraction of Chinese REE exports and the anticipation of possible market shortages. The year 2011 recorded the highest prices, historically, particularly at the beginning to mid-2011, especially with regards to HREEs. Thereafter and throughout 2012, prices declined sharply. LREEs were particularly hit during this second period. This downward move of REE prices can be explained by multiple factors. First, due to the surge of REEs prices in 2011, new supply capacities started to be developed worldwide in order to reduce dependence on Chinese exports (e.g. resumption of domestic REEs production in the United States). Second, the sluggish economic situation further dampened REE demand worldwide and was further accentuated by the reduction of activity resulting from the tsunami in Japan in March 2011. Third, REE demand also tended to contract as a result of end-users making efforts to use more efficiently available REE quantities (Box 2) and draw on their stocks.

BOX 2

"Molycorp now mixes half as much dysprosium into its magnetic powders as it did even a year ago"

"The global oil industry has similarly begun using less lanthanum, another rare earth, during oil refining. Only 1.5 per cent of the latest catalyst formulations for oil refining are now lanthanum, down from 4 or 5 per cent three years ago"

Bradsher, K. (2013)

During the first half of 2013, REE prices remained subdued. However, over the summer, prices firmed up again, partly due to a decrease of quantities available for exports as a result of the crackdown on illegal REE mines in China, the temporary shutdowns of processing plants and the actions carried out by the Chinese government against smuggling *("from 2006 to 2008, the volumes of rare earth products imported from China, according to statistics collected from foreign customs, were 35 %, 59% and 36% higher than the volumes exported").*[42] In consonance with this policy, the Chinese government initiated a 3-month campaign (15 August - 15 November 2013) aiming to *"reduce illegal exploration, production and*

[39] Juan, D. (2013). "First rare-earth products exchange to help stabilize market". China Daily. (10 August 2013). http://usa.chinadaily.com.cn/business/2013-08/10/content_16884782.htm

[40] Kosich, D. (2013). "China to begin trial run of rare earth products exchange". mineweb.com. (12 August 2013). http://www.mineweb.com/mineweb/content/en/mineweb-industrial-metals-minerals-old?oid=200612&sn=Detail

[41] "China starts trial run of rare earth products exchange". CCTV.com. (8 November 2013). http://english.cntv.cn/program/newshour/20131108/103194.shtml

[42] Situation and Policies of China's Rare Earth Industry. Information Office of the State Council, The People's Republic of China (2012)

distribution of rare earth metals and regulate rare earth recycling companies".[43] REE prices are expected to globally increase in the medium-term.

1. THE INFLUENCE OF CHINA IN RARE EARTH PRICE FORMATION

Given its scale, the jump of REE prices from the end of 2010 to mid-2011 compared to their level since the beginning of the 2000s deserves further clarification.

The rise of REE prices and HREE in particular has been underscored by global supply shortages induced by an increasing demand in advanced industries combined with the contraction of export quotas from China since 2005 and anticipations regarding potential REE shortages in the coming years. The most significant reduction of export quotas occurred between 2009 and 2010, when they dropped from 48,155 tons to 30,258 tons (-37 per cent) (figure 14). Chinese export quotas as a percentage of Chinese domestic extraction were halved between 2000 and 2012 (from 64 per cent in 2000 to 32 per cent in 2012). HREE generally account for a small part of Chinese export quotas. In 2013, HREE averaged 13 per cent of total Chinese export quotas. The size of HREE market being also narrower than the one of LREEs, HREEs prices move differently from the ones of LREEs; they usually benefit more from increases in prices and suffer less when the trend goes downward.

As early as 1990, rare earths had been defined by the Chinese government as a protected and strategic sector for the Chinese economy. This importance has been repeated in the *Guidelines for Development of National Mineral Resources 2008-2015* issued by China's Ministry of Land and Resources in 2007. Foreign investors were then prohibited to mine and process rare earths on their own, but encouraged to partner with Chinese nationals in joint ventures. The number of Chinese companies and joint ventures allowed to export rare earths from China has been gradually limited (from 59 in 2006 to 28 in 2013). On average, joint ventures accounted for less than 30 per cent of Chinese export quotas[44] allocated between 2009 and 2013 – 28 per cent in 2013 (table 5). The Ministry of Commerce (MOFCOM) is the entity in charge of the allocation of rare earth export quotas in China.[45]

Three main developments have characterized the Chinese REE value chain during recent years.

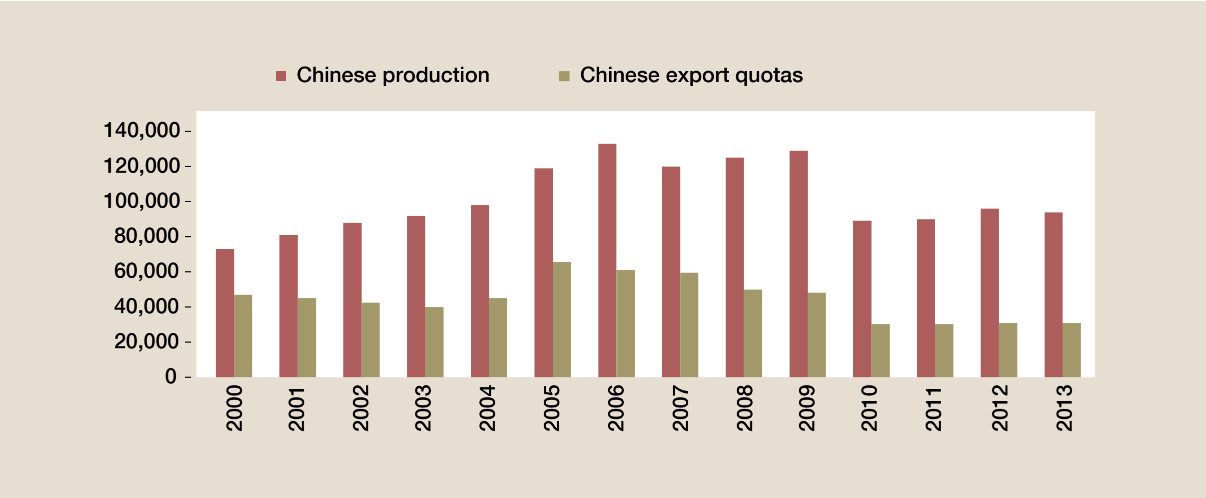
First, is the creation of domestic strategic REE stockpiles aiming to combine both state and corporate (commercial) stockpiling. While the objective of these reserves was initially to store concentrates, the guidelines issued in May 2011 expanded them to metals enabling the country to store REEs at different stages of their production process (resources and products). According to several sources of information, China started to buy and stockpile REEs

[43] Juan, D. (2013). "Rare earths on shaky ground". China Daily. (9 August 2013). http://usa.chinadaily.com.cn/business/2013-08/09/content_16881435.htm

[44] Annual Chinese quotas are released in 2 tranches.

[45] Liu, H-W. et al. (2012). "China's rare earths export quotas: out of the China-raw materials gate, but past the WTO's finish line?". Journal of International Economic Law, 15 (4), 971-1005.

Figure 14. Chinese REE production and Chinese export quotas, 2000-2013 (REO tons)



Source: UNCTAD Secretariat
Note(s): Chinese REE production for 2013 is an UNCTAD forecast. Export quota for 2013 is the official data released by the Chinese government.

Table 5. Allocations of REE export quotas in China, 2013 (tons)

	LREE	HREE	TOTAL
TOTAL ALLOCATIONS IN 2013 (tons)	**27,382**	**3,617**	**30,999**
Chinese-Owned companies	**19,703**	**2,596**	**22,299**
Gansu Rare Earth New Materials Co.	1,695	160	1,855
China Nonferrous Import-Export Co. Jiangsu Branch	1,534	303	1,837
Grirem Advanced Materials Co.	1,457	299	1,756
China Minmetals Corporation	1,380	313	1,693
Yiyang Hongyuan Rare Earth Co.	1,293	46	1,339
Ganzhou Chenguang Rare Earth New Materials Co.	1,178	125	1,303
Leshan Shenghe Rare Earth Technology Co.	1,271	125	1,396
Guangdong Rising Nonferrous Metals Group Co.	1,064	171	1,235
Xuzhou Jinshi Pengyuan Rare Earth Materials Co.	1,096	117	1,213
Ganzhou Qiandong Rare Earth Group Co.	874	195	1,069
Inner Mongolia Baotou Steel Rare Earth Hi-Tech Co.	1,028	62	1,090
Baotou Huamei Rare Earth Hi-Tech Co.	1,053	65	1,118
Sinosteel Corporation	957	98	1,055
Inner Mongolia Baotou Hefa Rare Earth Co.	865	61	926
Chalco Rare Earth (Jiangsu) Co.	786	217	1,003
Jiangxi Rare Earth & Rare Metals Tungsten Group Co.	913	11	924
Shandong Pengyu Industrial Co.	800	88	888
Ganxian Hongjin Rare Earth Co.	278	65	343
Guangdong Zhujiang Rare Earth Co.	158	75	233
Xi'an Xijun New Materials Co.	23	–	23
Joint ventures with Chinese companies	**7,679**	**1,021**	**8,700**
Baotou Rhodia Rare Earth Co.	2,110	146	2,256
Yixing Xinwei Leeshing Rare Earth Co.	1,187	223	1,410
Zibo Jiahua Advanced Material Resources Co.	1,354	43	1,397
Jiangyin Jiahua Advanced Material Resources Co.	1,062	257	1,319
Liyang Rhodia Rare Earth New Materials Co.	932	279	1,211
Baotou Tianjiao Seimi Rare Earth Polishing Powder Co.	412	20	432
Huhhot Rongxin New Metal Smelting Co.	299	30	329
Baotou Santoku Battery Materials Co.	323	23	346

Source: UNCTAD Secretariat from Technology Metals Research

with government funds since the first half of 2012[46] and quantities of REEs bought by the governement could reach 10,000 tons for the year 2013.[47]

Second, is addressing the environmental issues associated with the mining and processing of REEs in China. In order to meet this objective, the country launched a mining and production management policy in 2007. Moreover, in May 2011, China's State Council issued a new series of guidelines aiming to promote the sustainable and healthy development of the country's rare earth industry in order to address the severe environmental damages caused by past REEs mining and processing activities in China. In this regard, a white paper issued in June 2012 by the Information Office of the State Council indicates that *"China will never develop the rare earth industry at the expense of its environment".* In the same document, the Information Office draws up a dramatic picture of environmental consequences resulting from past rare earth activities in China. Besides illegal REE mining and processing activities as well as its "lax" environmental legislation,

[46] Piedra, P. (2012). Quarterly Commodity Insights Bulletin – rare earth metal. Q3-2012 & Q2-2012. KPMG. (October 2012).

[47] Topf, A. (2013). "Chinese Stockpiling Around the Corner". Rare Earth Investing News. (2 September 2013). http://rareearthinvestingnews.com/15348-chinese-stockpiling-around-the-corner.html. Zhuoqiong, W. (2013). "China to increase rare earth purchase". China Daily. (24 September 2013). http://usa.chinadaily.com.cn/business/2013-09/24/content_16989052.htm. "Baotou Steel Says China to Stockpile More Rare Earths; Lynas Corp Falls". MetalMiner.com. (10 September 2013). http://agmetalminer.com/2013/09/10/baotou-steel-says-china-to-stockpile-more-rare-earths-lynas-corp-falls/

China also suffered from the organization of property rights, which did not encourage companies to invest large amounts of money in order to produce using best environmental-friendly practices on fields they did not own. According to Kingsnorth, the upgrading to environmental standards equivalent to Western countries could take at least a decade in China.[48]

The ambitious strategy pursued by China regarding the protection of its environment explains why the government also decided to consolidate its REE production and more effectively monitor its domestic REE supply chain.

Third, is the increase of the local (Chinese) content of REE products. According to available data, prices along the REE value chain increase significantly from the state of commodities (concentrates) to the one of semi-final goods (e.g. permanent magnets) due to the significant costs of purification and processing REEs. The price of a kilo of permanent magnets is about 18-fold the one of a kilo of concentrates (figure 15). In order to increase the share of the value-added from REE, Chinese authorities adopted a strategy aiming to encourage the local processing of REEs in the country. The objective followed by the government was not only to re-organize its mining REE sector, but also to expand it vertically, integrating progressively the downstream stages of the value chain (e.g. renewable and high-tech industries) in order to capture a larger share of the added value generated by REEs. In 1999, President Jiang Zemin highlighted the necessity to *"improve the development and applications of rare earth, and change the resource advantage into economic superiority".*[49] Since the 1990s, China began to export processed commodities from rare earths (e.g. rare earth oxides and metals) and from the beginning of the 2000s, China began to integrate final products sectors, such as the one of mobile phones, for instance. Chinese authorities also invested in the development of recycling methods from end-use products as well as tailings for instance (box 3).

BOX 3

"China… encourages research into the application of light rare-earth elements, such as lanthanum and cerium, whose reserves are relatively abundant, and expedites the development of technology for reducing or providing substitutes for the use of scarce heavy rare-earth elements, such as europium, terbium and dysprosium".

"The state… supports the building of specialized bases for the recovery and utilization use of secondary rare-earth resources, including molten salts after pyrometallurgy, slag, waste permanent magnet materials and motors, waste NiMH nickel-metal hydride batteries, waste fluorescent lamps, dead catalysts, used polishing powder, and other waste electronic components containing rare-earth elements".

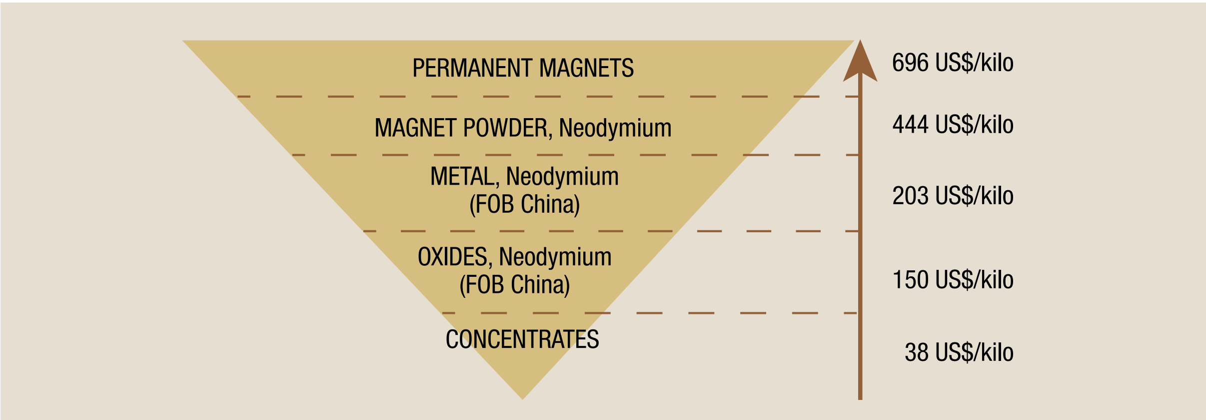
Information Office of the State Council, People's Republic of China (2012)

In addition to these measures and in order to support the local processing of REEs products, the government also sets taxes on REE exports (table 6). Individual

[48] *"I think it will be at least 10 years before China will match our standards"*, Pecht, M. et al. (2011) "Rare Earth Materials – Insights and concerns". CALCE EPSC Press, University of Maryland, College Park

[49] Rare Earth: An Introduction. Baotou National Rare-Earth High-Tech Industrial Development Zone. http://www.rev.cn/en/int.htm

Figure 15. Example of prices of rare earth and value addition along the marketing chain (US$ per kilo)



Source: UNCTAD Secretariat using data from Canadian Imperial Bank of Commerce (2011)

Table 6. China's rare earth export taxes, 2007-2011 (per cent)

	2007	2008	2009	2010	2011
Lanthanum oxide	10	15	15	15	15
Cerium oxide, hydroxide, carbonate, and others	10	15	15	15	15
Praseodymium	n.a.	n.a.	n.a.	n.a.	n.a.
Neodymium oxide	10	15	15	15	15
Neodymium (metals)	10	15	15	15	15
Promethium	n.a.	n.a.	n.a.	n.a.	n.a.
Samarium	n.a.	n.a.	n.a.	n.a.	n.a.
Europium and its oxide	10	25	25	25	25
Gadolinium	n.a.	n.a.	n.a.	n.a.	n.a.
Terbium and its oxide, chloride, and carbonate	10	25	25	25	25
Dysprosium oxide, chloride, and carbonate	10	25	25	25	25
Holmium	n.a.	n.a.	n.a.	n.a.	n.a.
Erbium	n.a.	n.a.	n.a.	n.a.	n.a.
Thulium	n.a.	n.a.	n.a.	n.a.	n.a.
Yterrbium	n.a.	n.a.	n.a.	n.a.	n.a.
Lutetium	n.a.	n.a.	n.a.	n.a.	n.a.
Yttrium oxide	10	25	25	25	25
Mixed rare-earth, yttrium, ans scandium coumpounds and metals (including battery grade)	10	25	25	25	25

Source: Tse, P-K. (2011), US Geological Survey

taxes increased between 50 per cent and 150 per cent between 2007 and 2008. According to available data, REE categories with the highest export taxes are the heavy rare earths (the scarcest REE category), plus Europium, which is a largely required REEs and a highly strategic one in the phosphor industry. This change confirms the general policy undertaken by the government to reorganize its REE sector following the implementation of the mining and production management policy as well as to develop and/or attract more advanced technologies and industries to the country. According to Silver, Chief Executive of American Elements *"there is roughly a 40 per cent difference in the cost of rare earths if you're buying on an export basis, due to the cost of the quota and the export tax… A company that moves here gets an incredible benefit"*.[50]

2. STEPS TAKEN BY CONSUMING COUNTRIES, OUTSIDE CHINA, TO ADAPT TO HIGH PRICES

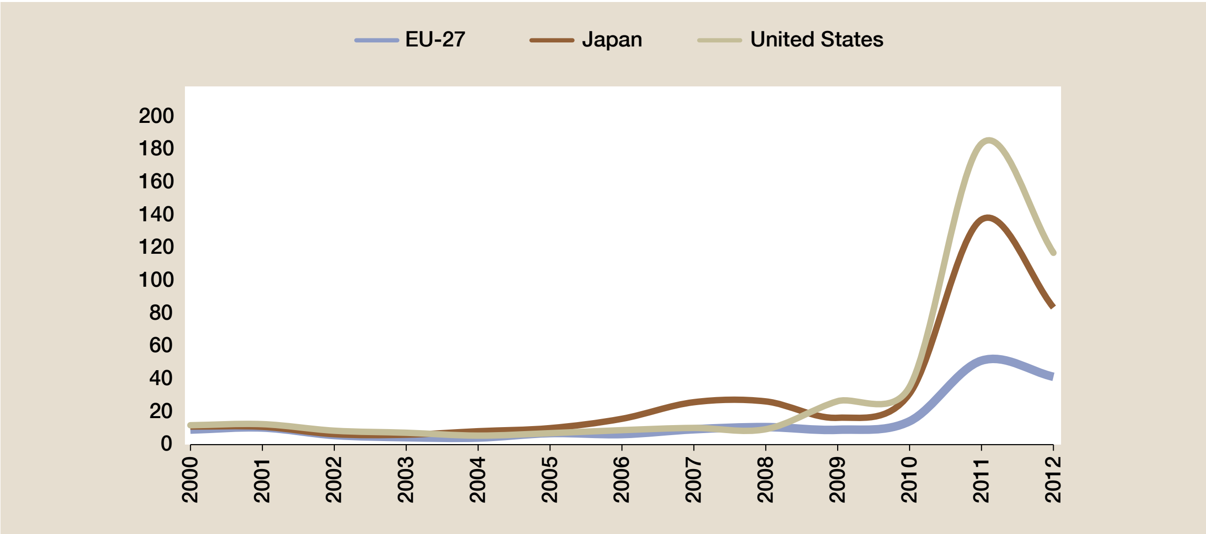
Following the trend in international prices, the unit value of imports of the three main importing areas (namely Japan, the European Union and the United States) largely increased in 2010 and 2011. They respectively increased 1.9-fold, 1.6-fold and 1.3-fold in Japan, the European Union and the United States between 2009 and 2010 and this growth was even more significant in 2011 with unit value of REE imports jumping by 3.6 times in the European Union, 4.4 times in Japan or 5.2 times in the United States compared to their level the year before (figure 16). A report issued by the Congressional Research Service assesses the situation even more dramatically.[51]

The increase of Chinese REE export taxes, combined with the reduction of Chinese REE export quotas and the large increase of international prices have generated some concerns of shortfalls and further price increases in most countries for which REE are considered as a critical element in strategic industries (the European Union, the United States and Japan in the lead). Future market shortages and associated price increases could have a direct impact on the cost of production of strategic goods manufactured in these countries as well as on the competitiveness of

[50] Pecht, M. et al. (2011) "Rare Earth Materials – Insights and concerns". CALCE EPSC Press, University of Maryland, College Park

[51] *"Prices for imported Chinese rare earths have risen significantly over the past few years. As seen in Figure 5, the average U.S customs value per metric ton of rare earth imports from China rose from $3,111 in 2002 to $76,239 in 2011, a 2,432% increase. The increases were particularly acute in 2011, when average prices jumped 723% in one year"*. Morrison, W. et al. (2012). China's Rare Earth Industry and Export Regime: Economic and Trade Implications for the United States. Congressional Research Service. (30 April 2012). http://www.fas.org/sgp/crs/row/R42510.pdf

Figure 16. Unit value of rare earth imports in Japan, EU-27 and the United States, 2000-2012 (US$ per kilo)



Source: UNCTAD Secretariat from UN COMTRADE (HS 2012: 280530)
Note(s): Code description (280530): Inorganic chemicals; organic or inorganic compounds of precious metals, of rare-earth metals, of radioactive elements or of isotopes // Alkali or alkaline-earth metals; rare-earth metals, scandium and yttrium, whether or not intermixed or interalloyed; mercury.

their companies and industries and consequently, an indirect impact on employment and their economies.

Some analysts have highlighted the consequences that the Chinese strategy may have on the transfer of know-how to this country and the loss of competitiveness of other countries through the delocalization of advanced activities of some of their companies in China in order to move closer to their supply sources. In their report entitled *"China's Rare Earth Industry and Export Regime: Economic and Trade Implications for the United States",*[52] Morrison and Tang indicated *"it is further argued that China's rare earth export policies are intended to induce foreign rare earth users to move their operations to China, and subsequently, to transfer technology to Chinese firms".*

In order to reduce their dependence on Chinese imports, several governments have initiated a series of measures. For example, the National Strategic and Critical Minerals Production Act of 2013 was adopted by the United States to *"more efficiently develop domestic sources of the minerals and materials of strategic and critical importance to U.S. economic and national security, and manufacturing competitiveness".*[53] The European Union adopted the Raw Materials Initiative in 2008 to maintain a fair and undistorted access to raw materials including REEs and Japan issued in July 2009 the *"strategy for ensuring stable supplies of rare metals".* Moreover, many countries have launched new mining and processing projects in order to increase their domestic production (table 7). Some companies are currently in a process of adopting strategies aiming to invest in upstream activities in order to secure their supplies (e.g. Toyota Tsuho).

The United States defines rare earth as critical for its economy as well as its national defence. It therefore sets a scale of criticality among the 17 individual REEs in the medium (to 2015, figure 17) to the long term (2015 to 2025, figure 18). In this matrix, Neodymium, Europium, Terbium, Yttrium and Dysprosium are highlighted by the US Department of Energy as particularly critical for green energy production. According to the Secretary of Defence of the United States, Erbium, Thulium and Scandium have to be added to the previous list drawn up by the US Department of Energy. Furthermore, within the context of the National Defence Authorization Act for FY2014, the manager of the US National Defence stockpile has been allocated a budget of 41 million US$ in order to acquire some critical materials for "military, industrial, and essential civilian needs of the United States" (Dysprosium Metal and Yttrium Oxide as far as rare earths are concerned).

[52] Morrison, W. et al. (2012). China's Rare Earth Industry and Export Regime: Economic and Trade Implications for the United States. Congressional Research Service. (30 April 2012). http://www.fas.org/sgp/crs/row/R42510.pdf

[53] Bailey Grasso, V. (2013). Rare Earth Elements in National Defense: Background, Oversight Issues, and Options for Congress. Congressional Research Service. (17 September 2013)

Table 7. State of rare earth mines and projects around the world

COUNTRY	COMPANY	PROJECT / MINE	COMMENT(S)
Australia	Alkane Resources Ltd.	Dubbo Zirconia Project	Expected output in 2016: 4,900 tons REO per year [c] (25.8% HREO) Total resource: 0,65 million tons REO [j]
	Lynas Corporation Ltd.	Mount Weld	Production: 20,000 tons REO per year (phase 1+phase 2) [h] Resource: 1.1834 million tons REO [m] (4.7% HREO)
	Arafura Resources Ltd.	Nolans Bore Mine	Target production: 20,000 tons REO per year [d], Resource: 848,400 tons REO [o] (3.1% HREO)
	Hastings Rare Metals Ltd.	Hastings deposit	Contained resource: 76,020 tons REO[s] (85.7% HREO)
Brazil	Companhia Brasileira de Metalurgia e Mineração (CBMM)	Morro Dos Seis Lagos	Resources: 11,750 tons REO [l]
Canada	Mitsubishi / Neo Materials Technologies	Pitinga	Indicated resource of 3.35 million tons (0.58% total rare earth oxides) Inferred resource: 6.48 million tons (0.60% total rare earth oxides) 34% HREO
	Great Western Minerals Group Ltd.	Hoidas Lake	Letter of intent with Star Uranium Corp. to enter into an option and joint venture [f] Resource: 62,208 tons REO [m] (3.7% HREO)
	Avalon Rare Metals Inc.	Nechalacho – Thor Lake	Production start-up: 2016-17 Estimated production: 9,286 tons REO per year [g] Resource: 4.3 million tons REO m (15.4% HREO)
	Quest Rare Minerals Ltd.	Strange Lake Rare Earth Project	Total resource: 1.15 million tons REO [j] (40.8% HREO)
	Quest Rare Minerals Ltd.	Misery Lake Rare Earth Project	n.a.
	Matamec Explorations Inc.	Zeus (Kipawa) deposit	Indicated resource: 5 to 18.7 million tons REO Inferred resource: 0.985 to 7.2 million tons REO [p] (35.8% HREO)
	Pele Mountain Resources Inc.	Pintinga	Indicated Resource: 56,380 tons REO Inferred Resource: 41,660 tons REO [i]
	Pele Mountain Resources Inc.	Eco Ridge deposit	Contained resource: 66,402 tons REO [s] (7.9% HREO)
	Commerce Resources Corp	Eldor rare earth project	Contained resource: 2,041,716 tons REO [s] (5.1% HREO)
China	Baogang Rare Earth	Bayan Obo deposit	Estimates are very different from one source to another 30-50 million tons REO. This mine is the largest around the world with around 42% of world production in 2010. [m]
	HEFA rare earths	Baotou, Inner Mongolia	n.a.
	Various	Jiangxi Province	n.a.
	Various	Sichuan Province	n.a.
	Various	Guangdong Province	n.a.
	Fujian Province has announced a US$ 905 million project based on its heavy rare earths reserves		
India	Indian Rare Earths Ltd.	Orissa Sand Complex	n.a.
Kazakhstan	Summit Atom Rare Earth Company (SARECO), joint-venture between Sumitomo and Kazatomprom		
Kyrgyzstan	Stans Energy Corp.	Kutessay II	Total resource: 0.05 million tons REO [j] (53.4% HREO)
Malawi	Lynas Corporation Ltd.	Kangankunde deposit	Contained resource: 107,019 tons REO [s] (0.7% HREO)
Mongolia			
Namibia	Namibia Rare Earth Inc.	Lofdal Rare Earths Project	Indicated Resource: 0.9 million tons REO Inferred Resource: 0.75 million tons REO [o]
Russian Federation		Lovozero deposit	Russian Federation plans to invest US$1 billion in the extraction of rare earths

COUNTRY	COMPANY	PROJECT / MINE	COMMENT(S)
South Africa	Great Western Minerals Group Ltd. (Rare Earth Extraction Co. Ltd.)	Steenkampskraal	Indicated Resource: 176,000 tons REO Inferred Resource: 278,000 tons REO, (7.7% HREO) Estimated production 32-42,000 tons REO per year [e]
	Frontier Rare Earths Ltd. Korea Resources Corporation (10%) [b]	Zandkopsdrift rare earth project	Indicated Resource: 532,000 tons REO Inferred Resource: 415,000 tons REO [b] (7.4% HREO)
Sweden	Tasman Metals Ltd	Norra Kärr	Total resource: 0.41 million tons REO [j] (0.33 million tons REO) [m] (52.7% HREO)
Tanzania	Montero Mining and Exploration	Wigu Hi	Inferred Resource: 3.3 million tons REO [n]
United States	Molycorp Minerals Inc.	Mountain Pass	Planned annual run rate of 19,050 tons REO by mid-2013 [a] Resource: 1.84 million tons REO [m] (0.5% HREO)
	Rare Element Resources Ltd.	Bear Lodge	Potential start-up: January 2016 Resource: 398,860 tons REO [m] (2.6% HREO)
	Ucore Rare Earths Inc.	Bokan Mountain	Total resource: 0.03 million tons REO [j] (38.3% HREO)
	Ucore Rare Earths Inc.	Ray Mountains	n.a.
Vietnam	Lai Chau - Vimico Rare Earth Co	Dong Pao mine	n.a. (partnering with Toyota Tsusho and Sojitz)[q]
Greenland	Greenland Minerals and Energy Ltd.	Kvanefjeld	Indicated Resource: 4.77 million tons REO Inferred Resource: 5.56 million tons REO [i] (12% HREO)
	Hudson Resources Inc.	Sarfartoq deposit	Contained resource: 216,946 tons REO [s] (2.6% HREO)

Source: UNCTAD Secretariat as of August 2013. All data dealing with the share of HREO content have been extracted from AustralianRareEarths.com

Note(s): (1) UNCTAD tried to collect the largest and most consistent information with regards to rare earth mine production in the world. However, this table cannot be considered as exhaustive. Most of the REE mines exploited worldwide are open pit mines.

(a) *"… Although the modernization and expansion of our Molycorp Mountain Pass facility was planned to allow an expanded run rate of up to 40,000 mt of REO per year, we will not expand production beyond the initial planned run rate unless market demand, product pricing, capital availability and financial returns justify such production." (2012). Annual report. Molycorp Minerals Inc*

(b) *Frontier Rare Earths. http://www.frontierrareearths.com/*

(c) *Alkane Resources Ltd. http://www.alkane.com.au/*

(d) *Arafura Resources Ltd. http://www.arafuraresources.com.au/*

(e) *Annual report. Great Western Minerals Group Ltd. (2012). http://www.gwmg.ca/index.cfm*

(f) *Great Western Minerals Announces Letter of Intent with Star Uranium for Option and Joint Venture on Hoidas Lake Project. Great Western Minerals Group Ltd. (4 June 2013). http://www.prnewswire.com/news-releases/great-western-minerals-announces-letter-of-intent-with-star-uranium-for-option-and-joint-venture-on-hoidas-lake-project-210131051.html*

(g) *Project Fact Sheet - Nechalacho, Thor Lake. Avalon Rare Metals Inc. (16 April 2013). http://avalonraremetals.com/_resources/project_sheet.pdf*

(h) *Fact sheet: rare earths. Lynas Corporation. (Undated). http://www.lynascorp.com/SiteCollectionDocuments/Fact%20Sheets/Rare_Earths.pdf*

(i) *Fact sheet. Greenland Minerals and Energy Ltd. (2012). http://www.ggg.gl/docs/fact-sheets/GMEL_Fact_Sheet_2012.pdf*

(j) *Corporate Presentation. Quest Rare Minerals Ltd. (July 2013). http://www.questrareminerals.com/*

(k) *Yang, K-F., Fan, H-R., Santosh, M., Hu, F-F., Wang, K-Y. (2011). "Mesoproterozoic carbonatitic magmatism in the Bayan Obo deposit, Inner Mongolia, North China: Constraints for the mechanism of super accumulation of rare earth elements". Ore Geology Reviews, 40. 122–131*

(l) *Various sources*

(m) *Once Ignored On The Periodic Table, Don't Ignore Them Now - A Rare Earth Element Industry Overview. Canadian Imperial Bank of Commerce (6 March 2011)*

(n) *Wigu Hill Rare Earth Element Project, Eastern Tanzania, NI 43-101 Technical Report. Montero Mining and Exploration. (25 August 2011)*

(o) *The Rare Earth Playing Field Why the Lofdal Discovery in Namibia Can compete. Namibia Rare Earths Inc. (January 2013). http://academyfinance.ch/gri/companies/Namibia-Rare-Earths-Inc.pdf*

(p) *Saucier, G., Roy, A., Casgrain, P., Côté, Ph., Thomassin, Y., Bilodeau, M., Cannus, Y., Hayden, A. (2012). NI 43-101 report - Preliminary Economic Assessment, study for Kipawa project. Matamec Explorations Inc. (14 March 2012). http://www.matamec.com/vns-site/uploads/documents/Rep_Matamec-Fin-PEA-000-20120314-SEDAR-Com.pdf*

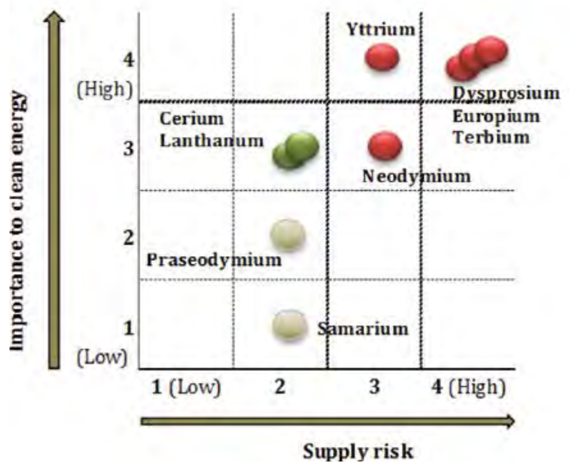
(q) *Humphries, M., (2012). Rare Earth Elements: The Global Supply Chain. Congressional Research Service. (8 June 2012)*

(r) *AMR Mineral Metal Inc. http://www.amrmineralmetal.com/*

(s) *Australian Rare Earth. http://www.australianrareearths.com/*

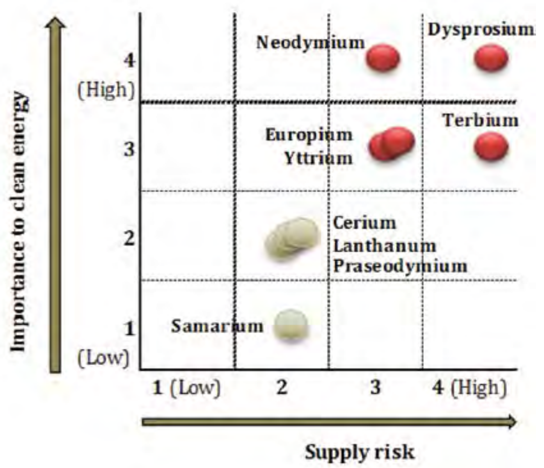
(t) *Matamec Explorations Inc. http://www.matamec.com/vns-site/index.php*

Figure 17. Rare earth criticality matrix, short-term (to 2015)



Source: UNCTAD Secretariat from Bauer et al., (2011) US DoE

Figure 18. Rare earth criticality matrix, medium-term (2015-2025)



Countries as well as private companies involved in the REE business also investigate the opportunities offered by recycling (also known as *urban mining)*. For instance, in early 2013, the United States granted US$ 120 million to the Ames Laboratory to pursue its research about recycling REE from magnets[54] and the Japanese government invested US$ 1.2 billion for research in *"recycling, as well as opening new supply routes and the stockpiling of REEs"*.[55] With regards to recycling, the Mobile Phone Working Group of the Basel Convention revised the Mobile Phone Partnership Initiative in June 2010.[56] This guidance document proposes environmental-friendly guidelines and best practices to collect used and end-of-life mobile phones as well as refurbish, recover materials and recycle them. With regards to private companies, the Japanese car manufacturer, Honda, began recycling 80 per cent of NiMH nickel hydride batteries.[57] However, REE recycling remains at early stages.[58]

Source: fotolia.fr

Apart from all measures taken at the national or regional level, some consultations have been called between China and its main trading partners as regards REE (namely, the United States, the European Union and Japan) under the auspices of the WTO.

The recent dispute settlement cases 431, 432 and 433 (covering REE, notably) follow on from the ones on *the measures related to the exportation of various raw materials (DS 394, DS 395 and DS 398)* [59] initiated by the United States, the European Union and Mexico in 2009 concerning various forms of bauxite, coke,

54 Gerleman Lucchesi, B. "Rare-earth recycling". The Ames Laboratory (United States). https://www.ameslab.gov/news/inquiry/rare-earth-recycling

55 Messenger, B. Recycling: Rarely so Critical. Waste Management World. http://www.waste-management-world.com/articles/print/volume-12/issue-5/features/recycling-rarely-so-critical.html

56 Mobile Phone Working Group. (2010). Mobile Phone Partnership Initiative, Basel Convention. (30 June 2010). http://archive.basel.int/industry/mppi/gdfd30Jun2010.pdf

57 Komnenic, A. (2013). "Rare earths recycling on the rise". Mining.com. (29 August 2013). http://www.mining.com/rare-earths-recycling-on-the-rise-82348/

58 For more examples regarding recycling, you may consult: Reisman, D. et al. (2012). Rare Earth Elements: A Review of Production, Processing, Recycling, and Associated Environmental Issues. United States Environmental Protection Agency. (December 2012). http://nepis.epa.gov/Adobe/PDF/P100EUBC.pdf

59 Dispute settlements: DS 394, DS 395, and DS 398. China - Measures Related to the Exportation of Various Raw Materials. Consulted on 18 December 2013
DS 394, http://www.wto.org/english/tratop_e/dispu_e/cases_e/ds394_e.htm
DS 395, http://www.wto.org/english/tratop_e/dispu_e/cases_e/ds395_e.htm
DS 398, http://www.wto.org/english/tratop_e/dispu_e/cases_e/ds398_e.htm

fluorspar, magnesium, manganese, silicon carbide, silicon metal, yellow phosphorus and zinc.

Based on the decision taken by the appellate body concerning DS 394, DS 395 and DS 398, and faced with the importance of REEs for a large set of industries in the United States, the European Union and Japan, joint consultations were called by these 3 entities with China with respect to China's restrictions on the export of various forms of rare earths, tungsten and molybdenum (these disputes settlements are known under the symbols DS 431, DS 432 and DS 433).[60]

The formulations used by the US[61] and the European[62] authorities (box 4) demonstrate the great importance as well as strategic and political implications of the REE sector for them as well as for their national (regional) economies, industries and population.

On 27 June 2012, the establishment of a panel was requested by the United States, the European Union and Japan. The panel was formed by the Director-General of WTO on 24 September 2012 and a set of 19 WTO members reserved their third party rights (namely: Argentina, Australia, Brazil, Canada, Chinese Taipei (Taiwan Province of China), Colombia, European Union, India, Indonesia, Japan, Republic of Korea, Norway, Oman, Peru, Russian Federation, Saudi Arabia, Turkey, United States, Viet Nam;).[63] The panel took its decision at the end of 2013 and the report circulated to the parties. However, at the time of writing, the content of this report remains confidential. The decision would probably be officially known by the end of the first quarter 2014.

Based on the potential developments of the REE markets in the years to come, projected price trends show different patterns (figure 19).

HREE demand is expected to be particularly strong in the years to come. Moreover, the pessimistic outlook regarding Chinese HREE reserves, which may be depleted within two decades and the low HREE content in other REE mines worldwide (e.g. 0.3 per cent for Mountain Pass in the United States and 1.3 per cent for Mount Weld in Australia) may lead to market deficits in HREEs and have a direct and general upward effect on their prices. Limiting factors to this growth would be the implementation of recycling solutions for goods containing REEs and tailings, as well as the development of substitutes or the reduction of the REE content in final goods.

BOX 4

"Being able to manufacture advanced batteries and hybrid cars in America is too important for us to stand by and do nothing. We've got to take control of our energy future, and we can't let that energy industry take root in some other country because they were allowed to break the rules." Remarks by the President (Barack Obama) on Fair Trade, The White House, 13 March 2012.

"China's restrictions on rare earths and other products violate international trade rules and must be removed. These measures hurt our producers and consumers in the EU and across the world, including manufacturers of pioneering hi-tech and 'green' business applications", EU Trade Commissioner Karel De Gucht, 13 March 2012.

Due to the abundance of LREEs around the world market conditions should be less tight for this category (figure 20).

Despite a wide range of applications, Lanthanum and Cerium are expected to display a production surplus in 2015 thanks to their abundance and large scale production. As a consequence, prices for Lanthanum and Cerium are expected to decrease in the coming years and their volatility more limited than for other REEs as there are no real threats of market deficits or tensions in the coming years in regard to both there REEs. (figure 21)

One LREE (Neodymium) and three HREEs (Terbium, Dysprosium and Erbium), plus Yttrium may record a production deficit by 2015. Some experts add Europium to this list.[64] In fact, Europium could be among the wider REEs used in the coming years.

60 Dispute settlements: DS 431, DS 432, and DS 433. China — Measures Related to the Exportation of Rare Earths, Tungsten and Molybdenum. Consulted on 18 December 2013
DS 431, http://www.wto.org/english/tratop_e/dispu_e/cases_e/ds431_e.htm
DS 432, http://www.wto.org/english/tratop_e/dispu_e/cases_e/ds432_e.htm
DS 433, http://www.wto.org/english/tratop_e/dispu_e/cases_e/ds433_e.htm

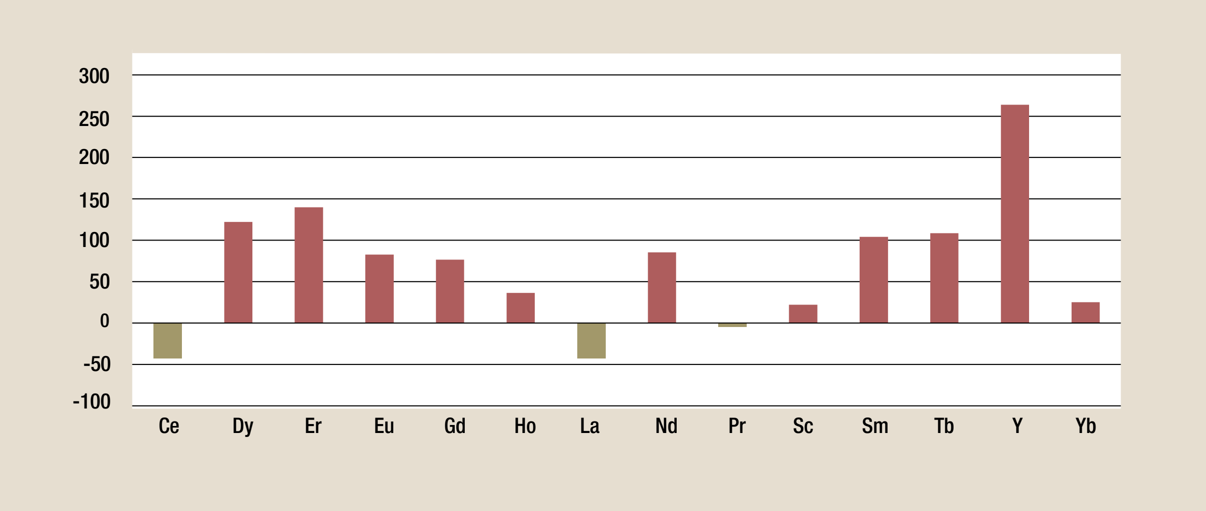
61 "Remarks by the President on Fair Trade". The White House. (13 March 2012). http://www.whitehouse.gov/the-press-office/2012/03/13/remarks-president-fair-trade

62 "EU challenges China's rare earth export restrictions", European Commission. (13 March 2012). http://europa.eu/rapid/press-release_IP-12-239_en.htm

63 European Union and Japan are third parties in DS 431. http://www.wto.org/english/tratop_e/dispu_e/cases_e/ds431_e.htm; Japan and United States are third parties in DS 432. http://www.wto.org/english/tratop_e/dispu_e/cases_e/ds432_e.htm; European Union and United States are third parties in DS 433. http://www.wto.org/english/tratop_e/dispu_e/cases_e/ds433_e.htm

64 And the list may also differ country (region) by country (region) with respect to their own political/economic orientations and they can also change with years and the evolution of alternative solutions to REEs

Figure 19. Percentage change of selected rare earth oxide prices, 2012-2014 (per cent)

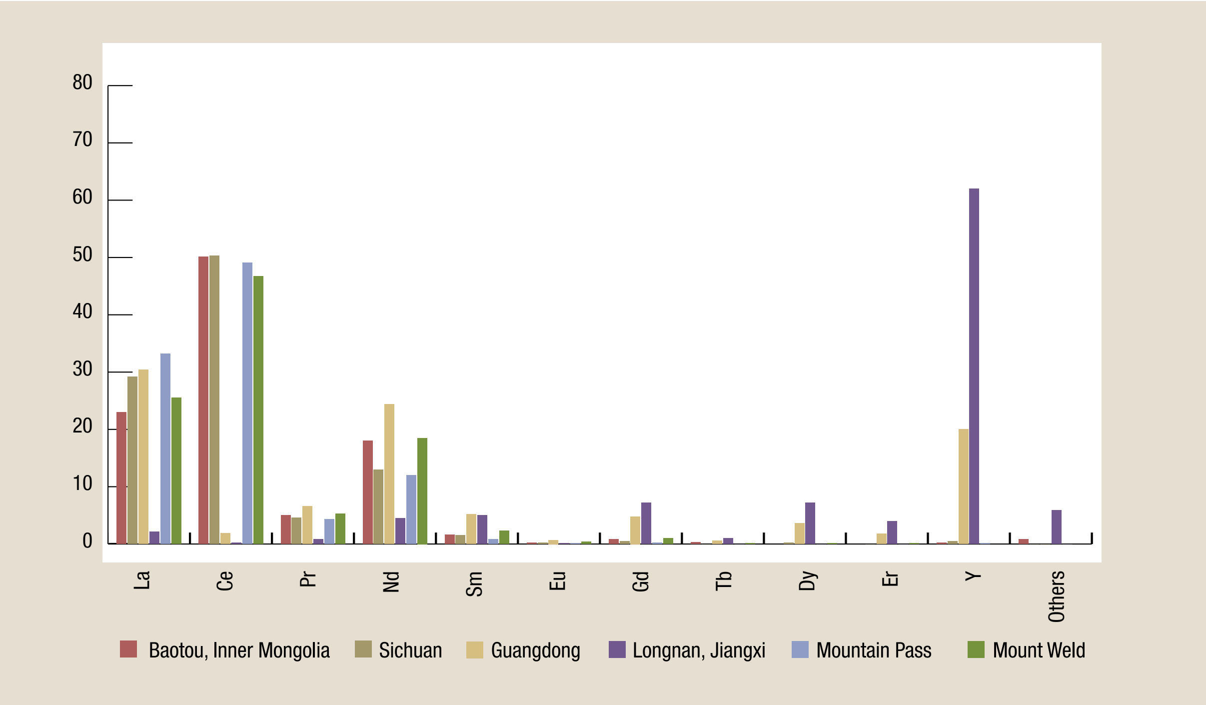


Source: Rare Earth Industry Assessment and Price Forecast, Tantalus Rare Earths AG (2012)

The large set of its applications in fast growing sectors (lighting, LCD/PDP screens and defence applications), combined with small shares in the main producing mines (0.3 per cent of all REE extracted) should encourage market participants to monitor this market carefully, as well as the evolution of its prices.

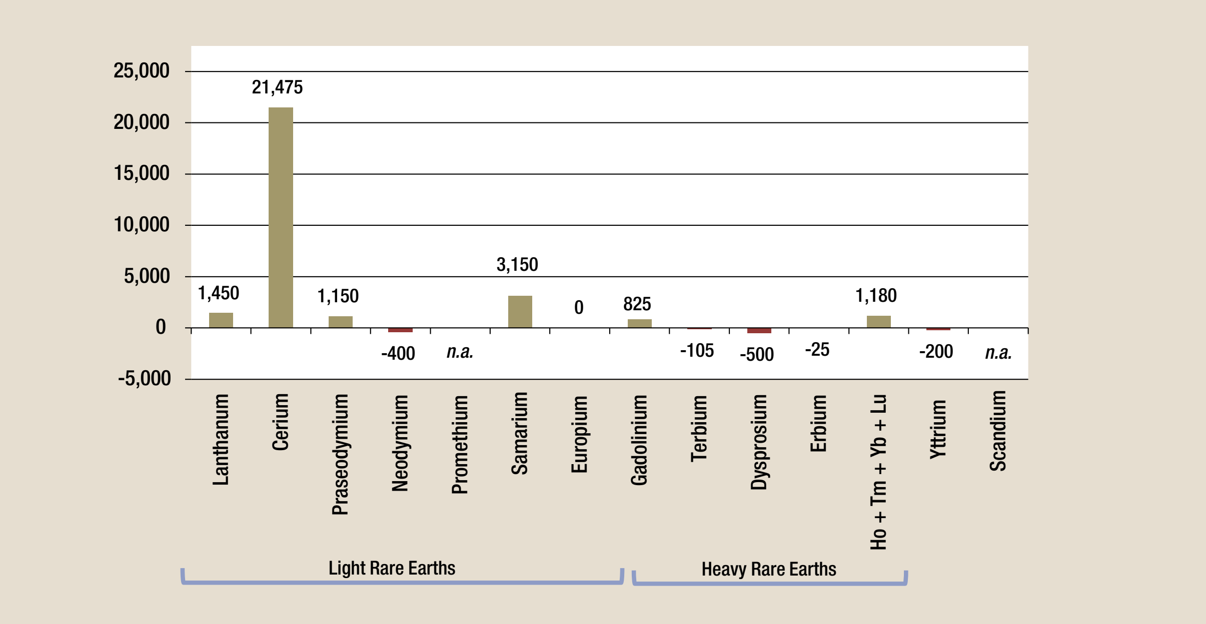
The combination of Neodymium versatility in terms of applications (e.g. wind power, personal technology and defence applications) and of its large-scale mining – Neodymium was the third largest extracted REE worldwide in 2013 - may reduce its availability on the market, pushing its prices up as well.

Figure 20. Percentage of individual rare earth element extracted from the main REE producing areas, 2013 (per cent)



Source: Technical report on the Aksu Diamas Rare Earth Element and Minor Metals, Isparta District, Soutwest Turkey, NI 43-101 Report, Roscoe Postle Associates Inc, (16 May 2013)
Note(s) "Others" stands for Holmium, Thulium, Yterrbium and Lutetium

Figure 21. Forecasts of production surplus and deficit situation for selected rare earth elements, 2015 (tons)



Source: Gowing, M. (2011)
Note(s) Ho + Tm + Yb + Lu stands for Holmium, Thulium, Yterrbium and Lutetium

On the basis of figure 20, Jiangxi and Guangdong (China) are the areas with the highest shares of HREE[65] extracted (almost 20 per cent for the first one and 11 per cent for the second one). According to Mackie Research Capital Corporation, *"China's heavy rare earths supply could be depleted in the next 15-20 years",*[66] which may rise concerns about HREE availability and prices in the coming years.

Due to the rising demand for rare earth-based products, there is some room for new mine and processing facility projects to be developed. However, entry barriers are huge in the sector due to the high development, processing and operating costs. Furthermore, the period of time between the discovery of a deposit and it coming on-stream is uncertain and may take 10 to 15 years (on average). As a consequence, recycling processes or substitutes may have potentially been developed in the meantime and/or the proliferation of production projects worldwide may also result in production surpluses and a resulting fall of REE prices.[67]

Finally, the predominant role played by China in the REE sector as well as its current concerns about the impacts of REE production on its environment and the implementation of legislation aiming to promote a sustainable and healthy development of its industry, could lead to a general rise of REE prices in the future through a general increase of production costs. China being in a process of rationalization of its value chain as well, it could move from the position of net exporting to net importing country in the near future, which could also worsen the situation on the market until new supply sources to come on-stream and have a general impact on REE prices worldwide.

65 Sum of Gadolinium, Terbium, Dysprosium and Erbium
66 Gowing, M. (2011). 2011 Rare Earth Industry Update: We remain Bullish. Mackie Research Capital Corporation. (8 February 2011). http://www.ggg.gl/userfiles/file/Broker_Research_Reports/Rare_Earth_Mackie_Industry_Update.pdf
67 While this last option does not seem to be highly likely, given the potentially fast growth in the demand from end-use sectors

CONCLUSION

The issue of rare earth elements discussed in this report is complex and sensitive. The main difficulty is the lack of systematic and authoritative information. The main sources of information used are reports issued by national or intergovernmental authorities (e.g. China, European Union, United States) and by a number of private companies involved in the rare earth sector, from extraction to financing and trading. Research publications also provide valuable information. The challenge is how best to combine this disparate information in order to produce an objective analysis of this delicate issue. This report is the result of a balancing act.

The lack of accurate historical statistics has also been a major challenge. In fact, while some sources of statistics are relatively coherent, most sources show significant contradictions, even within the same country. As a result, efforts were put into data collection in order to provide the reader with the most accurate and reliable statistical information are gleaned from all these sources. This situation is partly due to the lack of structure, organization and monitoring of the value chain, the strategic nature of REEs and the political sensitivity associated with their extraction and trading. The limited size of REEs market helps to explain why no international commodity exchange traded and quoted their prices until the end of 2013. The implementation of the Baotou Rare Earth Products Exchange in China could contribute to addressing this issue in the future depending on which products will be traded and the modalities governing their trading on the market place.

Despite the common denomination of “rare earths” and some common characteristics, such as the predominant role played by China for about two decades in terms of reserves, production, demand and exports, the 17 rare earth elements have individual markets governed by specific sectoral demand patterns and display various market outlooks. For instance, the evolution of the use of green energies in the world energy mix or the expansion of advanced technologies using REEs in regions where their penetration rate is currently low, but opportunities are high, would likely affect the demand for specific rare earths, their prices and depletion rates in the years to come. In this regard, three out of the eight HREEs (namely, Terbium, Dysprosium and Erbium), plus Yttrium could be in deficit by 2015, exerting upward pressure on prices. On the other hand, the combination of the current reorganization and consolidation of the REE value chain in China and the expansion of extraction and processing facilities around the world could give consuming countries more opportunities to diversify their sources of imports. Together with the development of recycling solutions and availability of substitutes, diversification would contribute to reducing countries’ dependence on rare earth imports, easing pressure on prices.

Global interest with regards to the rare earth issue arose quite recently in the media and in the international agenda, mainly as a result of the price boom of the end of 2010 to the first half of 2011. Given its increasing importance, as discussed in this report, it would be important to monitor this market more carefully. In this regard, international cooperation is probably needed to ensure that data and information on REEs are consistent and reliable. This would contribute to enhancing market transparency and encouraging a more sustainable approach to the extraction and processing of REEs.

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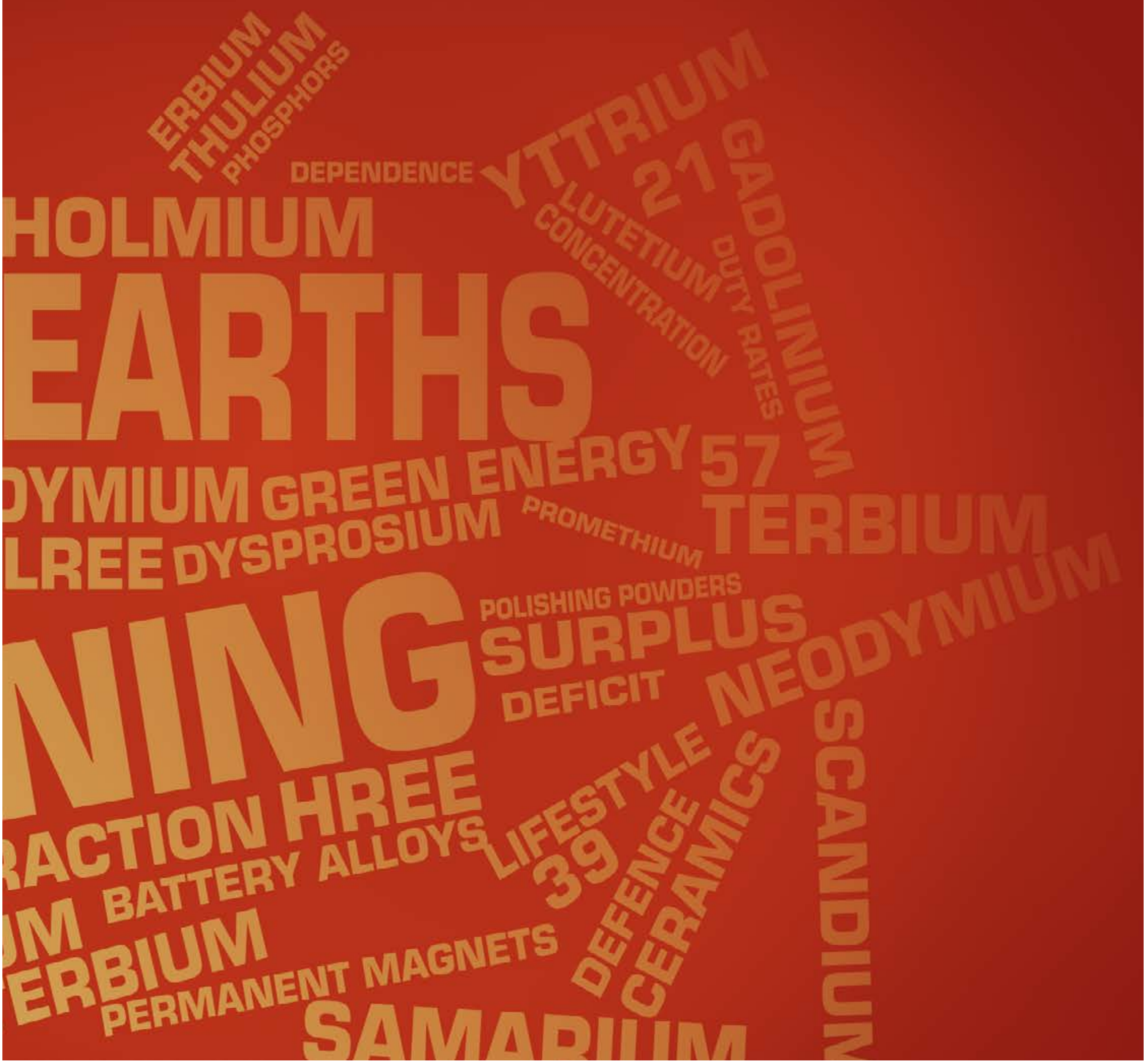

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Printed at United Nations, Geneva – GE.14-50515 – May 2014 – 984 – UNCTAD/SUC/2014/1