

“The Global Rare Earths Industry: A Delicate Balancing Act”

by

Professor Dudley J Kingsnorth

Centre for Research in Energy and Minerals Economics

(Curtin University, Western Australia)

and

Industrial Minerals Company of Australia Pty Ltd

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Part #1: The Issues of Balance

- The rare earths industry today.
- The “Line in the Sand”.
- The last 6-12 months.
- China.
- Present and future demand and supply.

Rare Earths: Light or Heavy?

Element	Type	Symbol	Atomic Weight
Lanthanum	'Light' or 'Ceric'	La	138.92
Cerium		Ce	140.13
Praseodymium		Pr	140.92
Neodymium		Nd	144.27
Samarium	'Medium'	Sm	150.43
Europium		Eu	152.00
Gadolinium		Gd	156.90
Terbium	'Heavy' or 'Yttric'	Tb	159.20
Dysprosium		Dy	162.46
Holmium		Ho	163.50
Erbium		Er	167.20
Thulium		Tm	169.40
Ytterbium		Yb	173.04
Lutetium		Lu	174.99
Yttrium		Y	88.92

Key Drivers of Demand

Application	Rare Earths	Demand Drivers
Magnets	Nd, Pr, Sm, Tb Dy	Drives for computers, mobile phones, mp3 players, cameras. Hybrid vehicle electric motors. Electric motors for luxury vehicles. Mag-lev trains.
LaNiH Batteries	La, Ce, Pr, Nd	Hybrid vehicle batteries. Hydrogen absorption alloys for re-chargeable batteries
Phosphors	Eu, Y, Tb, La, Dy, Ce, Pr, Gd	LCDs. PDPs. LEDs. Energy efficient fluorescent lights/lamps.
Fluid Cracking Catalysts	La, Ce, Pr, Nd	Petroleum production – greater consumption by ‘heavy’ oils and tar sands
Polishing Powders	Ce, La, Nd	Mechano-chemical polishing powders for TVs, monitors, mirrors and (in nano-particulate form) silicon chips.
Auto Catalysts	Ce, La, Nd	Tighter NO _x and SO ₂ standards – platinum is re-cycled, but for rare earths it is not economic
Glass Additive	Ce, La, Nd, Er	Cerium cuts down transmission of uv light. La increases glass refractive index for digital camera lens.
Fibre Optics	Er, Y, Tb, Eu	Signal amplification

The Rare Earths Market Today

- Estimated demand in 2011: 105ktpa, 2012: 125ktpa
- Prices: Early 2010 US\$10-15/kg; Now US\$50-100/kg REO
- China is dominant (supplying 95% and consuming 60/70% of global supply/demand)
- Constraints on Chinese production and exports are creating opportunities for non-Chinese projects.
- Two major non-Chinese rare earths projects are under construction.
- Many non-Chinese projects (>300) are being evaluated.

Global Rare Earths Demand 2011

Estimated Global Rare Earths Demand in 2011 (t REO ±15%)
 (Source: IMCOA and Rare Earths Industry Stakeholders)

Application	China	Japan & NE Asia	USA	Others	Total	Market Share
Catalysts	11,000	2,000	5,000	2,000	20,000	19%
Glass	5,500	1,000	750	750	8,000	8%
Polishing	10,500	2,000	750	750	14,000	13%
Metal Alloys	15,000	4,000	1,000	1,000	21,000	20%
Magnets	16,500	3,500	500	500	21,000	20%
Phosphors (including Pigments)	5,000	2,000	500	500	8,000	8%
Ceramics	3,000	2,000	1,500	500	7,000	7%
Other	3,500	1,500	500	500	6,000	5%
Total	70,000	18,000	10,500	6,500	105,000	100%
Market Share	68%	16%	10%	6%	100%	-

The “Line in the Sand”

- In September 2010 when China ‘*temporarily suspended shipments*’ of rare earths to Japan – to support a territorial dispute - it marked the drawing of a line in the sand.
- The Rest of the World (ROW) now recognises that it can no longer depend on China’s commitment as a long term supplier of rare earths.
- The ongoing changes to China’s rare earth export quotas present significant risks to long term businesses.

The Opportunities

- Between 2011 and 2016 ROW rare earths production will increase tenfold – from 6ktpa REO to 60ktpa REO.
- It is forecast that between 2011 and 2016 ROW demand will grow from 35ktpa to 55ktpa.
- Forecast global demand in 2020 is 200-240ktpa REO
- Forecast ROW demand in 2020 is 70-90ktpa REO; so there is an opportunity for ROW producers to increase production between 2016 and 2020 by 50% to meet potential ROW demand.

China: RE Export Transition

- 1970s: Rare earth mineral concentrates.
- 1980s: Mixed rare earth chemical concentrates.
- Early 1990s: Separated rare earth oxides and metals.
- Late 1990s: Magnets, phosphors, polishing powders.
- 2000s: Electric motors, computers, batteries, LCDs, mobile phones.

China: Industry Constraints

- Export quotas – recent reduction of 40%.
- Production quotas – HREE reserves limited.
- Export taxes: 15-25%.
- VAT rebate on exports withdrawn.
- Industry consolidation (facilitating co-ordinated pricing).
- Environmental legislation enforced.
- Comprehensive export controls and inspections.

China: Export Quota History

Chinese Export Quota History 2005-2011 (Tonnes Product)

Year	Rare Earth Quotas				ROW Demand
	Domestic Companies	Foreign Companies	Total	Change	
2005	48,040t	17,659t	65,609t	0%	46,000t
2006	45,752t	16,069t	61,821t	-6%	50,000t
2007	43,574t	16,069t	59,643t	-4%	50,000t
2008	Actual: 34,156t Adjusted: 40,987t*	Actual: 13,293t Adjusted: 15,834t*	Actual: 47,449t Adjusted: 56,939t*	-5½%*	50,000t
2009	33,300t	16,845t	50,145t	-12%	25,000t
2010	22,512t	7,746t	30,258t	-40%	48,000t
2011	22,712t	7,472t	30,184t	0%	45-50,000t
1H2012	17,926t ²	6,978t ²	24,904t ²	Negligible	45,000t

Note: 1. Quotas adjusted to an equivalent 12 month quota as there was a change in the dates for which they were issued; so that now, they are for a calendar year 2. 1H2012 Quotas (a portion of which is provisional) which equate to about 80% of the indicated quota for the whole of 2012, i.e. it is expected that the annual will be similar to 2011.

China has Adequate Rare Earths Resources to Meet its Own Needs

- Reserves of 30-50 million tonnes REO.
- Processing capacity of 200-250ktpa REO, of which 40-50% is idle for either environmental and/or economic reasons, but 'available' for purchase.
- The SOEs charged with consolidating the industry have all announced large capital investments.
- Fujian has announced a US\$920M investment.
- China's priority is creating employment.
- **The focus should be: ROW suppliers to meet ROW demand in 2020 – lots of opportunity.**

The Last 12-18 Months

- The 'Line in the Sand'.
- Chinese export quotas reduced significantly.
- China enforcing environmental standards.
- China confirms 'heavy' rare earths resources are finite (approximately 8-12 years).
- Chinese rare earths industry consolidation.
- Mt Weld & Mountain Pass rapidly moving to 22ktpa & 40ktpa REO respectively.

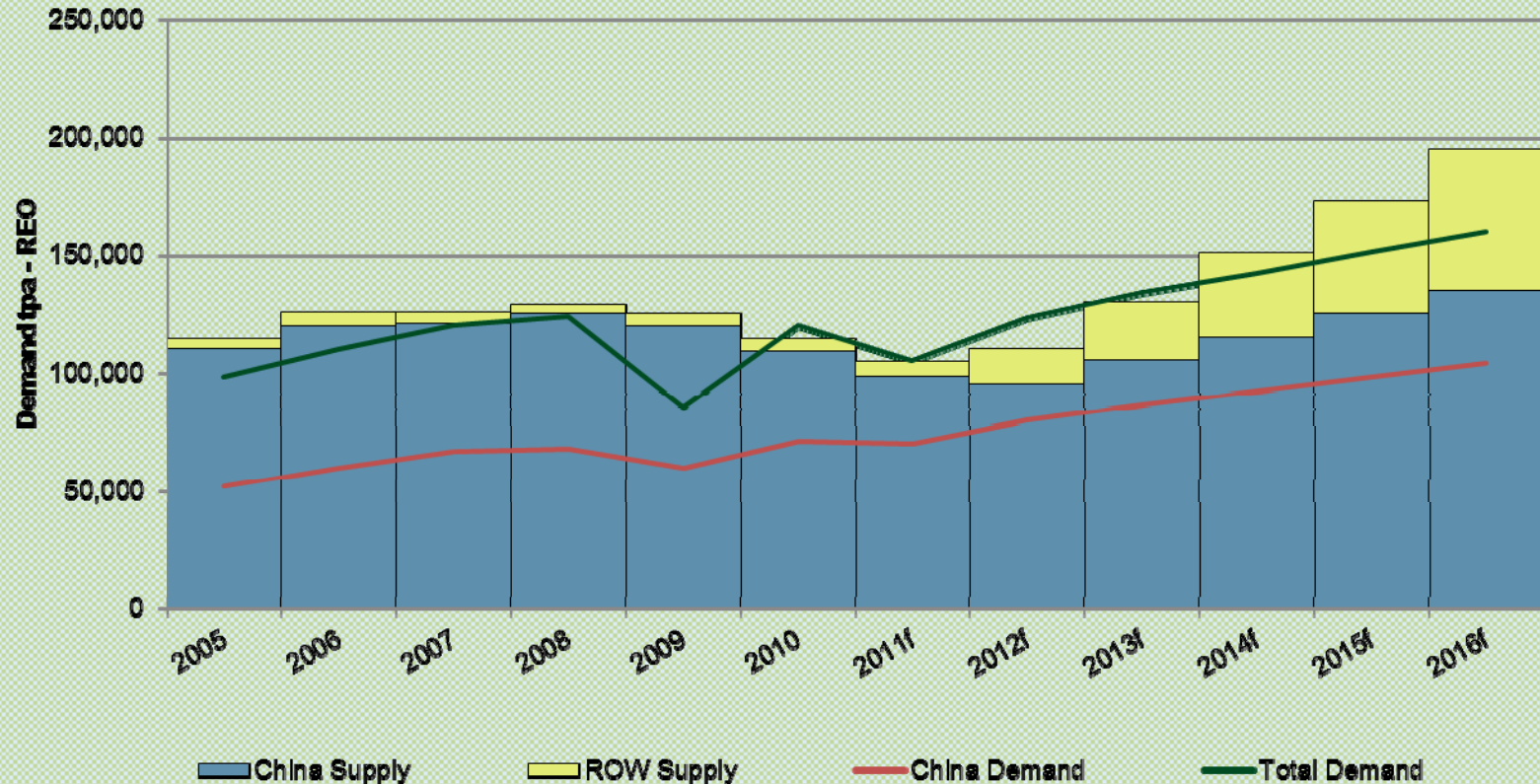
Forecast Rare Earths Sector Rates of Growth 2012-2016

Application	Growth between 2012 and 2016 with Comments
Catalysts	Modest recovery from 2011 in demand in 2012 (10%) then steady growth at 2-4%pa 2013 to 2016
Glass	Steady modest growth at 3-5%pa 2012 to 2016. There are alternatives to rare earths
Polishing	Due to high prices in 2011, a large amount of re-cycling now takes place; some recovery in 2012 (10%) then steady growth at 4-6%pa
Metal Alloys	Good recovery in 2012 (20%). But growth 2013 to 2016 constrained compared with recent years, due to adoption of Li-ion batteries on a large scale, at 4-8%pa.
Magnets	Price and availability a constraint. Forecast growth of 8-12%pa could be greater if more of the rare earths used in permanent magnets were to become available on a long term sustainable basis and at reasonable prices
Phosphors	The new lighting devices, television and computer screens use less rare earths but are getting bigger and tend to be replaced more often. Hence steady growth rate at historic at 6-8%pa
Ceramics	Steady growth at historic rates of 6-8%pa
Other	The use of cerium for water purification is included as a high growth application; leading to large increases in demand in 2012 and 2013. Other new applications are unknown but could include use of Gd in refrigeration. Growth rate of 6-10% 2014 to 2016
CAGR	Following a recovery in demand of 15-20% in 2012, IMCOA forecasts a CAGR for 2012-16 of 6-7%pa, which is relatively slow for the rare earths market; due to supply uncertainties for HREEs and the general slowdown in the growth of Global GDP.

Forecast Global Rare Earths Demand 2016 (t REO ± 20%)

<u>Application</u>	<u>China</u>	<u>Japan & SE Asia</u>	<u>USA</u>	<u>Others</u>	<u>Total</u>	<u>Market Share</u>
Catalysts	15,500	2,500	5,500	1,500	25,000	16%
Glass	7,000	1,000	1,000	1,000	10,000	6%
Polishing	13,000	2,000	2,000	1,000	18,000	11%
Metal Alloys	23,000	3,000	2,000	2,000	30,000	19%
Magnets	28,000	4,500	2,000	1,500	36,000	22½%
Phosphors	8,500	2,000	750	750	12,000	7½%
Ceramics	4,000	2,500	2,250	1,250	10,000	6%
Other	5,000	4,000	8,000	2,000	19,000	12%
Total	104,000	21,500	23,500	11,000	160,000	100%
Market Share	65%	13%	15%	7%	100%	-

Rare Earths Supply & Demand



Source: IMCOA and discussions with Rare Earths Industry Stakeholders

Global Supply/Demand Balance for some Individual Rare Earths in 2016

Forecast Supply and Demand for Selected Rare Earths in 2016

<u>Rare Earth Oxide</u>	<u>Demand @</u> <u>150-170,000tpa REO</u>	<u>Supply @</u> <u>180-210,000tpa REO</u>
Cerium	60-70,000t REO	75-85,000t REO
Neodymium	25-30,000t REO	30-35,000t REO
Europium	625-725t REO	450-550t REO
Dysprosium	1,500-1800t REO	1,300-1,600 REO
Terbium	450-550t REO	300-400t REO
Yttrium	12-14,000t REO	9-11,000t REO

The Outlook to 2016

- China will not directly deny rare earths to the ROW; but it will take whatever measures are necessary to maximise 'value add' manufacturing (job retention and creation) in China.
- Chinese constraints will constrain ROW growth.
- Ongoing high prices will increase substitution, re-cycling and reduce search for new applications.
- 'Balance' will still be an issue; so prices for Eu, Dy, and Tb will remain strong.
- First of new projects will be on-stream and looking to expand.
- *Next generation* projects could be in early stages of start-up.

Supply & Demand Trends 2016-2020

- Demand in 2020: 200-240ktpa REO.
- Demand trends:
 - Greater availability of non-Chinese products.
 - Ongoing high prices will reduce growth in demand.
 - Impact of substitution , recycling and reduced research.
- Supply Trends
 - Availability of HREES will be a global issue.
 - ROW self-sufficient in LREEs.
 - Consolidation of industry in China.
 - Vertical integration.
 - Bayan Obo (falling iron ore prices).

2020 Goal: ROW to Supply 100% of ROW Demand

Reality and Imagination

- The opportunities to supply ROW rare earths demand through to 2020 are real.
- The opportunities for Australian/German mining; processing and engineering services are significant.
- Ongoing high prices will increase substitution and re-cycling.
- The project development schedules proposed by many prospective suppliers rely more upon imagination than reality.

Part #2: Rare Earths Project Requirements

- Rare earths are unique.
- Mineralogy.
- Processing options.
- Project Development Steps.
- Production in 2016.

Rare Earths – Commercial Concepts

- Rare earths are not commodities – customer specific.
- Western rare earths enterprises are single project companies (debt has to be non-recourse project funded)
- Capital intensive (>US\$50/kg REO annual capacity)
- Long start-up: limited expertise China
- Supply and demand for individual REOs is not in balance
- Used in small quantities
 - REO price has negligible impact on most applications
 - Security of supply is the real issue
 - Recent high prices have lead to recycling as a viable option

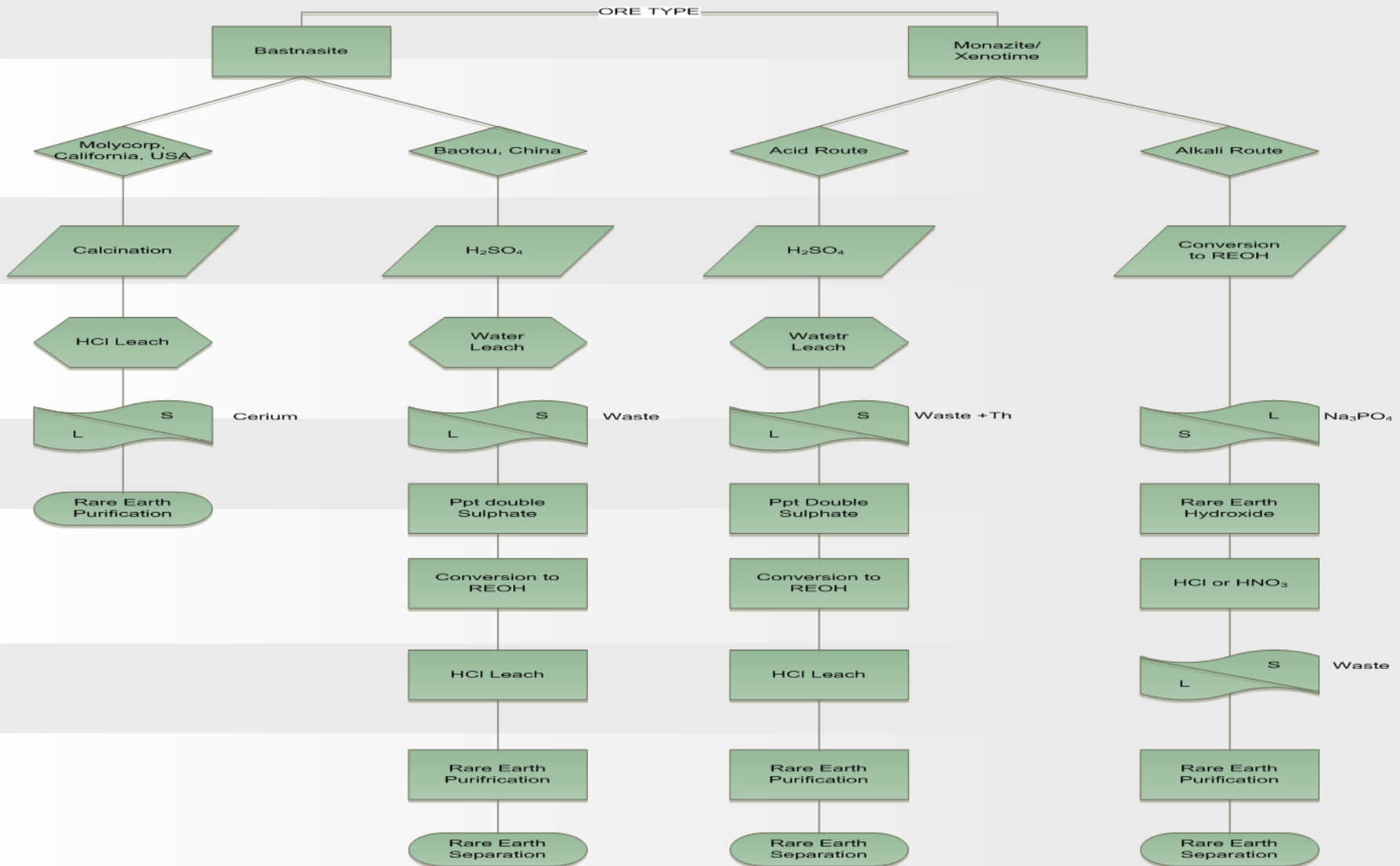
Rare Earths – Development Concepts

- Each orebody is different; so the process route is project specific.
- All rare earths orebodies have U and Th associated with them; requiring safe disposal.
- Pilot plant studies (for non-Chinese projects) essential to:
 - Demonstrate technical & economic viability
 - Generate samples for customer approval as basis for sales contracts
 - Provide data for bankable feasibility study
 - Generate data for environmental impact statement
- From Resource to BFS can take 5-12 years.

Rare Earths: The Importance of Mineralogy

- Essentially only 4 rare earth minerals have been processed for rare earths over the last 50 years;
 - Monazite
 - Bastnasite
 - Xenotime
 - The Ionic Clays that are peculiar to China
- A 'new process' could take 10-15 years to develop.
- In the view of IMCOA:
 - 30%REO is the min. economic LREE mineral concentrate grade
 - 20%REO is the min. economic HREE mineral concentrate grade
- 'Finding' US\$1B for a new process will not be easy.

Rare Earths Processing Options



Rare Earths Project Development Steps 1-3

1. Resource

- Grade (and waste:ore ratio).
- REO distribution.
- Ready access to labour, power and water.

2. Mineralogy

- Identify rare earths mineral(s).
- Liberation size not too fine.
- Preference for 'known' rare earth mineral

3. Scoping Study

Rare Earths Project Development Steps 4-6

4-6. Pilot Plant (Beneficiation, Extraction, Separation)

- Demonstrate technical viability and flexibility; operated on a **continuous** and **fully integrated** basis
- 'Products' meet customer specifications.
- Data from plant for Capex and Opex estimates.
- Data for environmental management plan.

7. Environmental Approval

- EPA approval
- Community approval

Rare Earths Project Development Steps 8-10

8. Marketing Plan

- Consistent with future customer needs.
- Realistic market share/growth.
- Cognisant of 'balance' issue.

9. Definitive Feasibility Study (incl. Funding)

10. Construction and Start-up

- Schedule is realistic.
- Provide adequate training for start-up.
- Customer liaison is ongoing

2016 ROW Rare Earths Producers

- Mountain Pass (Molycorp)
- Mt Weld (Lynas)
- Indian Rare Earths (IRE & Toyota Tsusho)
- Recycling

- *Steenkampskraal (GWMG)*
- *Kazakhstan (SARECO & Sumitomo)*
- *Dubbo (Alkane)*

Note: Dubbo is the only project with a significant portion (+25%) of 'heavies'.

Potential Heavy Rare Earths Projects

(Refer: <http://www.techmetalsresearch.com/metrics-indices/tmr-advanced-rare-earth-projects-index/>)

Potential 'heavy' rare earths projects (>25% HREO)

1. JORC/NI 43-101 Resource + Proven Process (Continuous Pilot Plant)
 - Dubbo (Alkane Resources Ltd)
2. JORC/NI 43-101 Resource
 - Bokan (Ucore Rare Metals Ltd.)
 - Kipawa (Matamec Exploration Inc.)
 - Kutessay II (Stans Energy Corp.)
 - Norra Kärr (Tasman Metals Ltd.)
3. Exploration Projects
 - Browns Range & John Galt (Northern Minerals Ltd.)
 - (TUC Resources Ltd.)

Part #3: Rare Earths Issues

Some issues to discuss

Sustainability through Diversity

European Union adopts a purchasing code that requires all imported 'strategic minerals' (included in the total supply chain) for EU use are sourced so that:

- No more than 30/40% of imported 'strategic minerals' originate in any outside country outside the EU (unless a bilateral trade agreement exists).
- No stockpiles or 'picking winners'.
- It is not specific to rare earths and/or China.
- Independent verification of supply chain.
- If it is simple other entities will adopt the code.
- Allow time; effective progressively from January 2016.
- EU, Japan, USA and Australia to co-operate in the development of rare earths technologies.

Future ROW Options

- Set common standards for occupational health and environmental protection.
- Establish national Centres of Excellence; to collaborate with other overseas centres.
- Centres of Excellence to assess future security of supply for new applications.
- ‘Exchange’ of university personnel.
- Internationalise ROW training of technicians

ROW/China Co-operation

- Share and debate information on forecast demand and supply.
- Set common standards for occupational health and environmental protection – agree to international monitoring?.
- Co-operate in basic rare earths research at universities and technical institutions.
- Exchange of technical personnel

Australia Germany Co-operation

- Supply for future applications
- Re-cycling
- ???

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Sources of Reference:

- Data from Roskill’s 14th Edition “The Economics of Rare Earths” (2011).
- China Rare Earths Information Centre and other Chinese rare earths associations
 - Prices from *metal pages*©
 - Company web sites
- Private discussions with producers and consumers