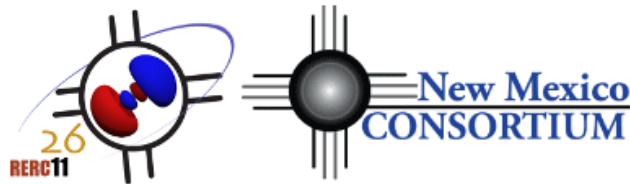
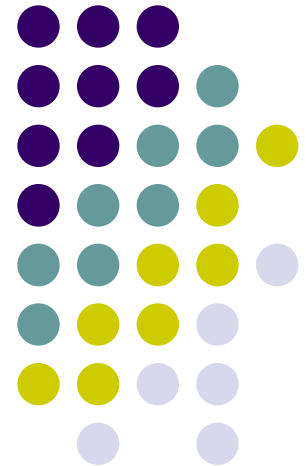


# Challenges Facing the Rare Earth Industry 2011 – 2020

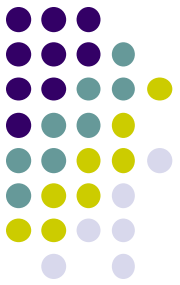
Keith A. Delaney  
Executive Director  
Rare Earth Industry and Technology Association















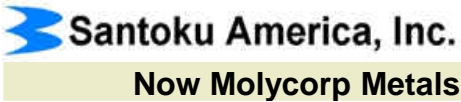






26th Rare Earth Research Conference  
June 19, 2011  
Santa Fe, NM

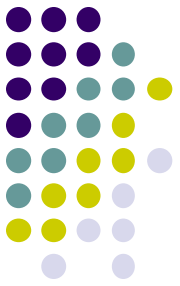


# REITA Members (as of May 31, 2011)



Industry	RE Resource Companies	Academia
 <p>imagination at work</p>		 <p>COLORADO SCHOOL OF MINES EARTH • ENERGY • ENVIRONMENT</p>
		
	 <p>MINERALS GROUP LTD OTCQX: GWMGF</p>  	
		
 <p>Now Molycorp Metals</p>		
		
		

# Presentation Overview

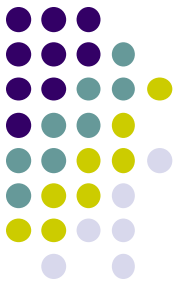


**Abridged Commercial History of RE**

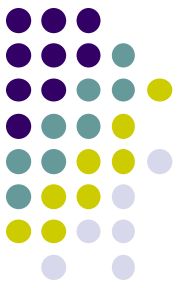
**Current Global Assessment**

**Industry Requirements Moving Forward**

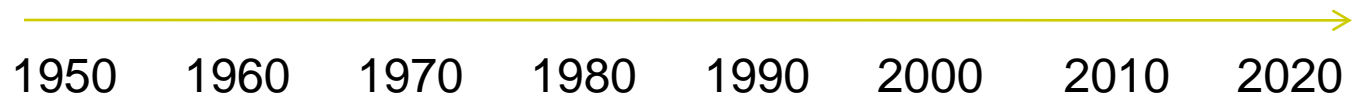
# Industry Drivers



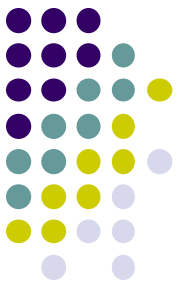
# Abridged History of Rare Earth Commercial Drivers



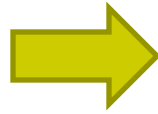
Lighter Flints 



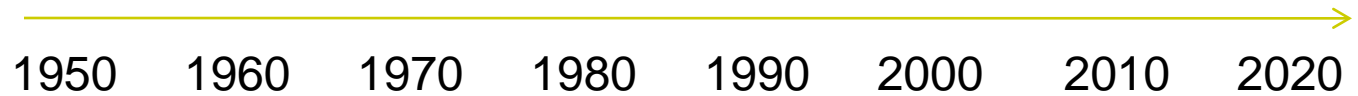
# Abridged History of Rare Earth Commercial Drivers



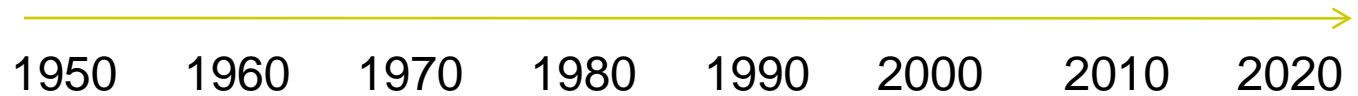
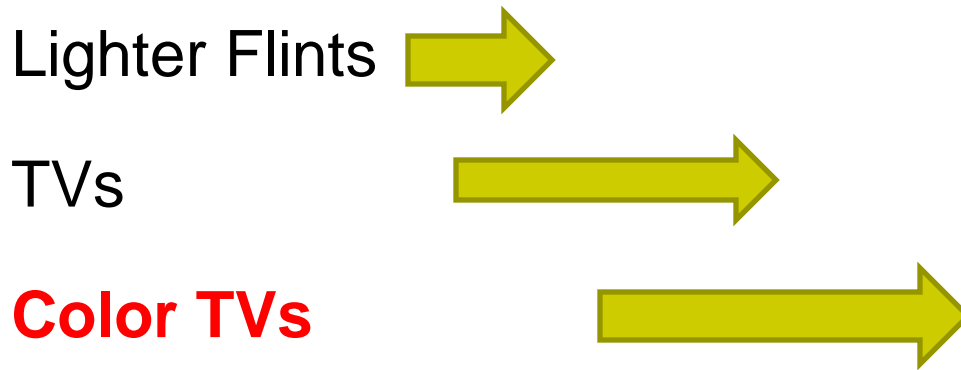
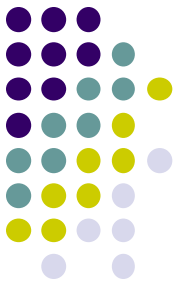
Lighter Flints



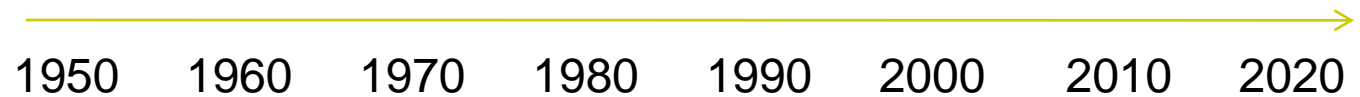
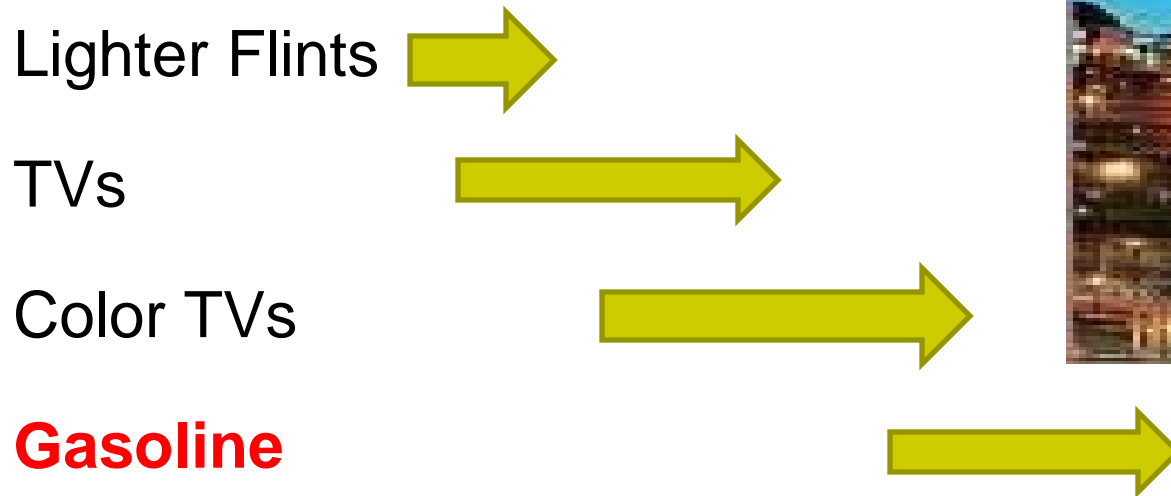
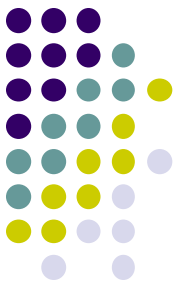
TVs



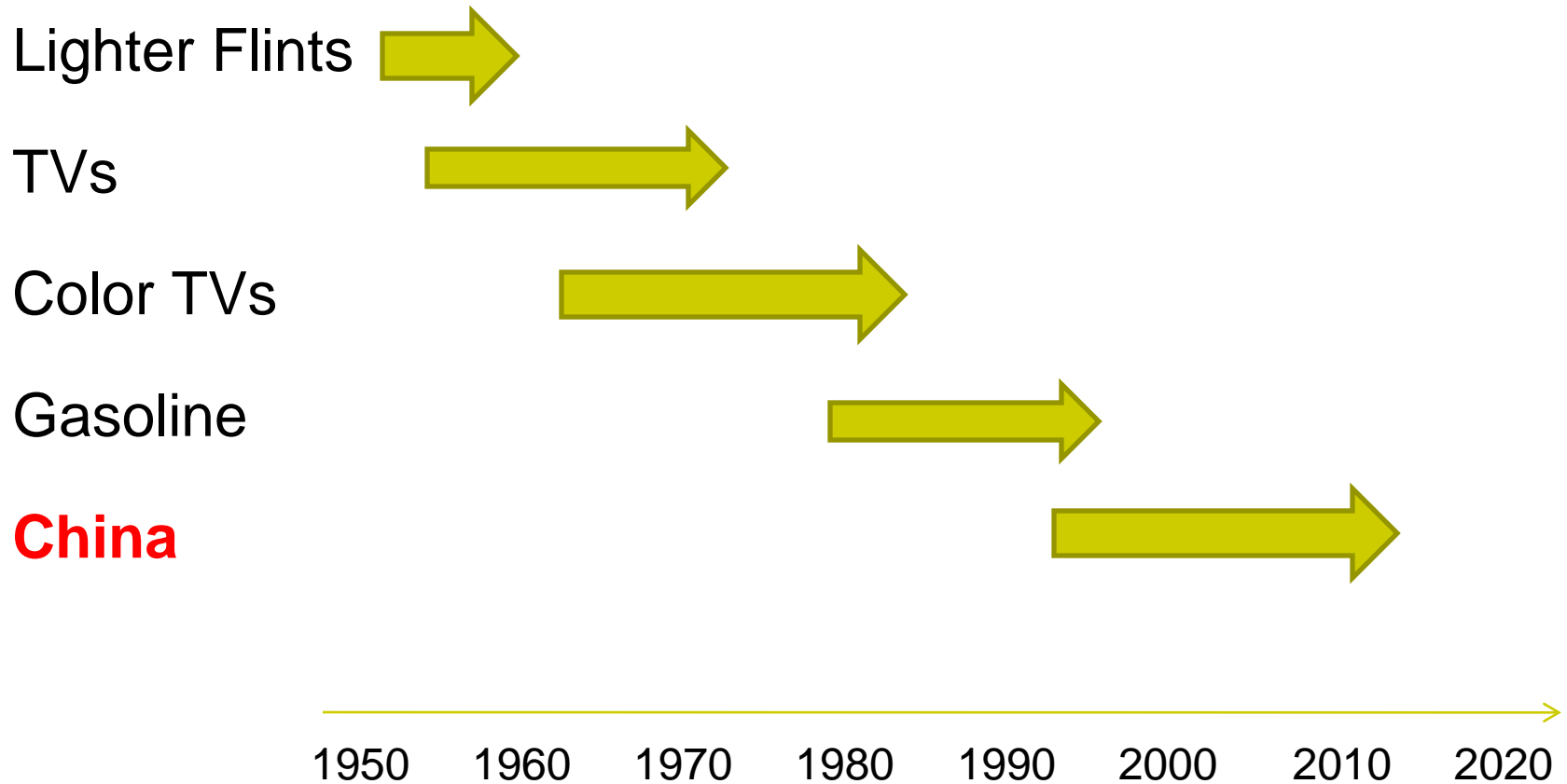
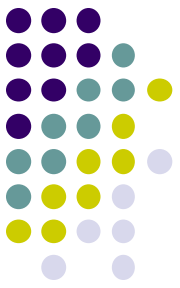
# Abridged History of Rare Earth Commercial Drivers



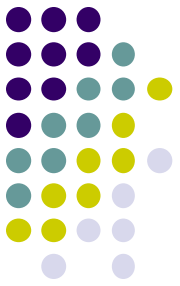
# Abridged History of Rare Earth Industry Commercial Drivers



# Abridged History of Rare Earth Commercial Drivers



# Chinese Vision Achieved



**“There is oil in the Middle East;  
there are rare earths in China.  
We must take full advantage  
of this resource.”**

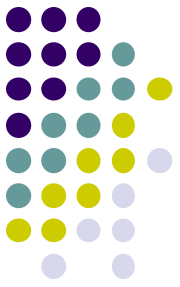
**President Deng Xiaoping 1992**

**“Improve the development and  
applications of rare earth, and  
change the resource advantage  
into economic superiority.”**

**President Jiang Zemin 1999**



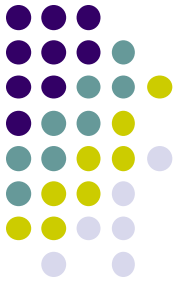
# Chinese Dominance of Rare Earth Industry



*Baotou, Inner Mongolia*



# The Case for Action



Available online at [www.sciencedirect.com](http://www.sciencedirect.com)



Journal of Operations Management 26 (2008) 222–238

**JOURNAL OF  
OPERATIONS  
MANAGEMENT**

[www.elsevier.com/locate/jom](http://www.elsevier.com/locate/jom)

## Offshoring technology innovation: A case study of rare-earth technology

Brian J. Ficarek<sup>a,\*</sup>, Francisco M. Veloso<sup>a,b,1</sup>, Cliff I. Davidson<sup>a,2</sup>

<sup>a</sup> *Carnegie Mellon University, Engineering and Public Policy, 129 Baker Hall, 5000 Forbes Avenue,  
Pittsburgh, PA 15213, United States*

<sup>b</sup> *Faculdade de Ciências Económicas e Empresariais, Universidade Católica Portuguesa, 1649-023 Lisbon, Portugal*

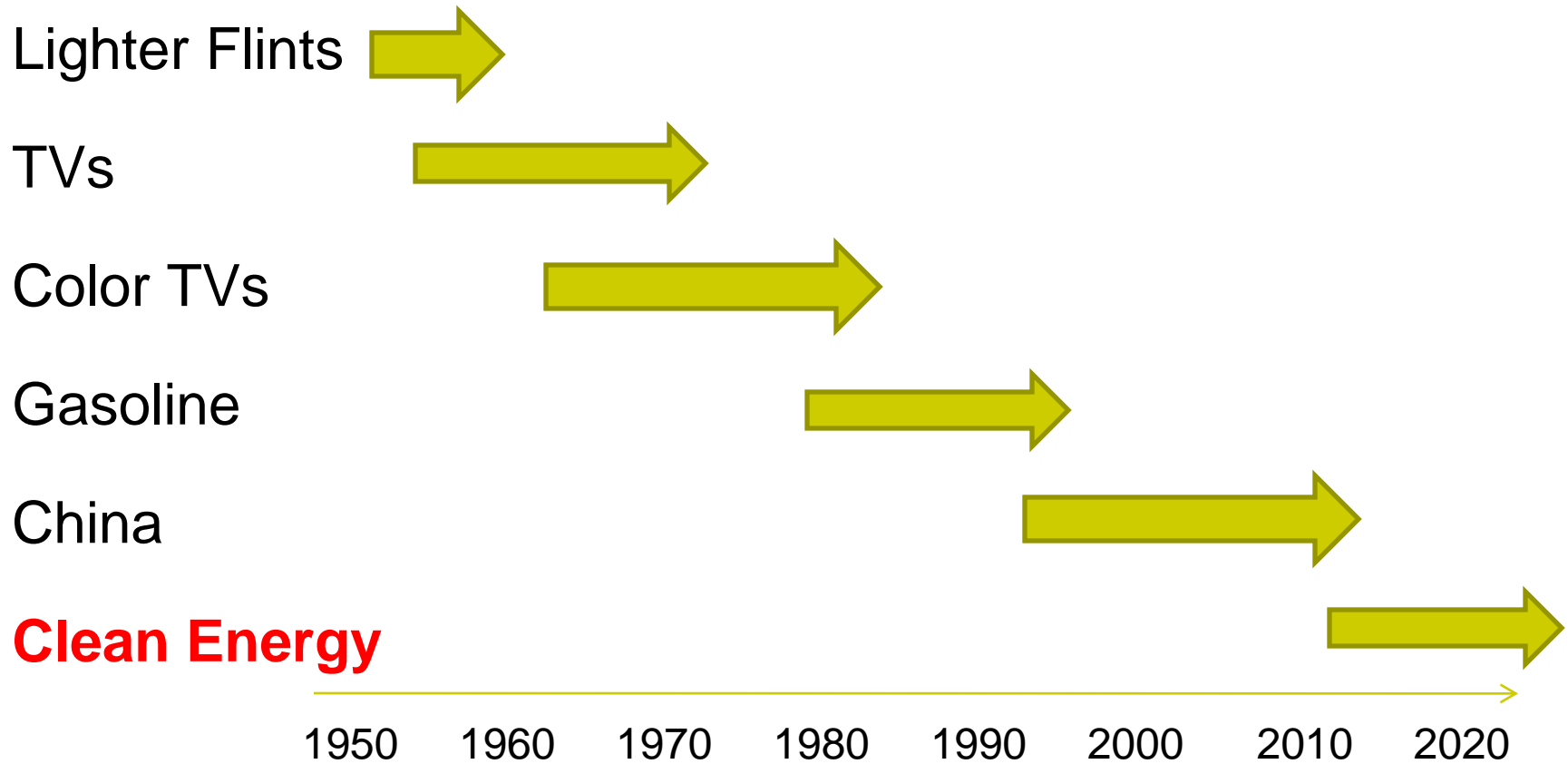
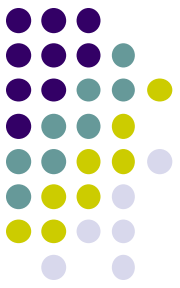
Available online 12 March 2007

### Abstract

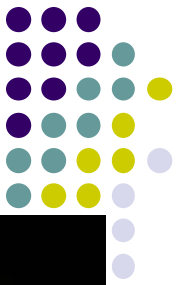
Many US firms are improving their individual competitiveness by offshoring manufacturing operations, services and, increasingly, knowledge work. Although research to date has maintained that these practices are beneficial to the offshoring firm and national economies, by reducing costs and expanding markets, little is known about the longer term effect of offshoring on the rate of innovation of home economies. This paper suggests that offshoring practices have adverse effects on innovation at the national home base. The analysis uses patents in the rare-earth element industry, a high-tech area which is among those that have evolved the furthest towards outsourcing and relocation away from the US and to developing countries. Looking at the rare-earth industry can provide insights in identifying potential long term impacts of offshoring on innovation because many other US industries are likely to adopt similar offshoring strategies.

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# Abridged History of Rare Earth Commercial Drivers



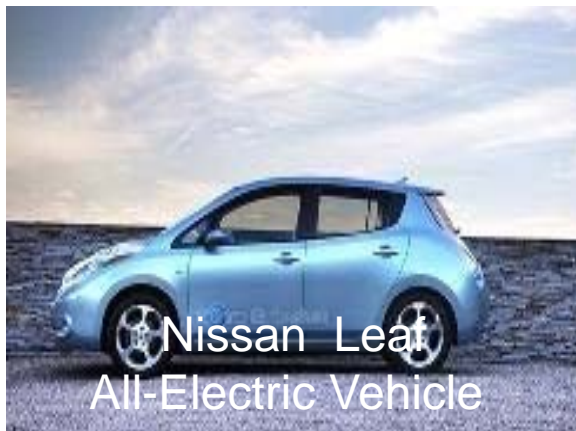
# Clean Energy



Integrated Starter Generator



4 MW Offshore  
Wind Turbine



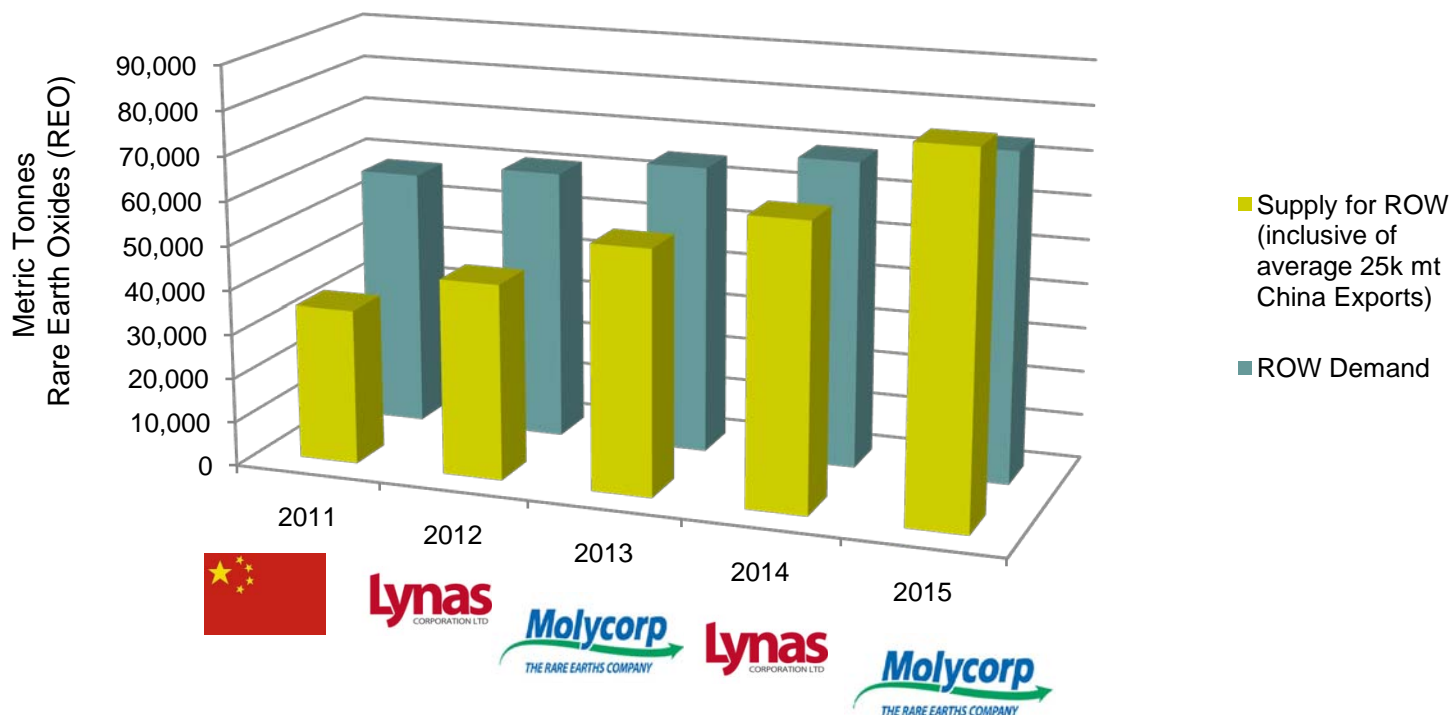
Nissan Leaf  
All-Electric Vehicle

**OEMs of Clean  
Energy  
technologies  
require reliable  
supply with  
manageable  
pricing.**



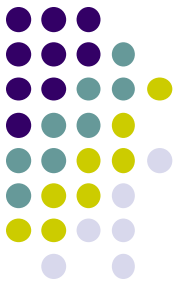
Chevy Volt

# Rest of World Demand<sup>1</sup> for REO and the Sources of Supply Increments 2011 - 2015



<sup>1</sup> Kingsnorth, Dudley, presentation to *The Hague Centre for Strategic Studies, January, 2011*

# China Overview Assessment



Observation	Consequence Related to RE Industry
<p>China realizes it has to improve the management of its RE resource with <b><i>focus on conservation, higher overall yields and environmental protection.</i></b></p>	<p>The Chinese will continue to manage its RE virtual monopoly <b><i>to induce even more downstream (value add) manufacturing to relocate to China.</i></b></p>
<p><b><i>China must create 300 million jobs</i></b> within the next 10 years</p>	<p><b><i>China has no incentive to support supply chains outside of its own borders.</i></b></p>
<p><b><i>Chinese economy will continue to grow</i></b> at or near double digit rates for the foreseeable future</p>	<p>By 2015 <b><i>China could be a net importer of RE materials</i></b> just to feed their own Clean Energy needs</p>

# Where Will 2016 – 2020 REO Supply Increments Come From?



## Light Rare Earth Resources

## Heavy Rare Earth Resources

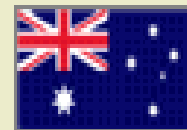


Dy for “under the hood” magnet applications

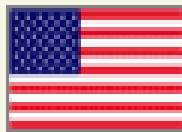
### Arafura Resources



### Alkane Resources



### Rare Element Resources



### Avalon Rare Metals



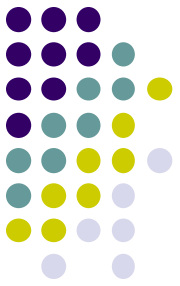
### Toyota/Sojitz/Govt. of Vietnam



### Great Western Minerals Group



# Other High Profile Heavy RE Resources



## Heavy Rare Earth Resources

**Matamec Resources**



**Mitsubishi / Neo Material Technologies**



**Quest Rare Metals**



**Sumitomo / Kazatomprom**



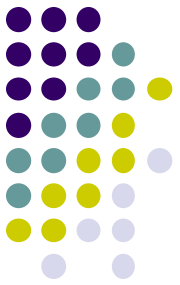
**Toyota/Indian Rare Earths JV**



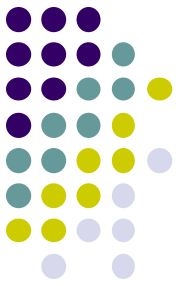
**Ucore Rare Metals**



# RE Project Companies Issues to Address for OEMs

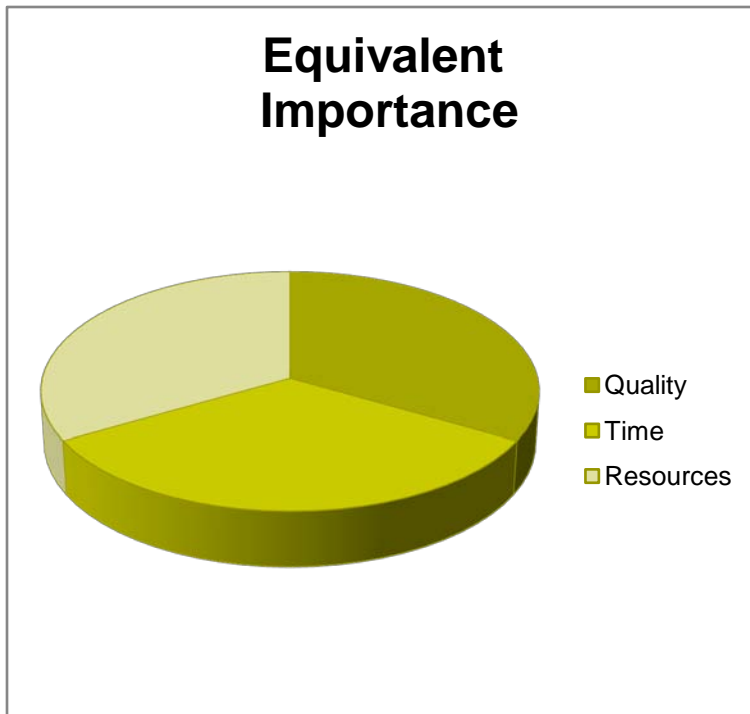


Reliable Supply	Manageable Pricing
Lack of accurate demand forecasts – <i>huge error bars</i>	Cost minimization – variable and fixed
Shortening of 5-12 year process to develop and commercialize a new RE resource	New profitable markets for Ce / La
Adequate development funding to accelerate the commercialization process	Enough RE properties in the queue so that ROW production capacity <i>gets ahead and stays ahead of ROW demand</i>

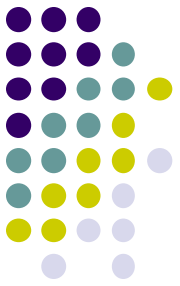


# Reducing New RE Project Timeline

## Project Management Lesson: Spend Extra Resources to Save Time While Maintaining Quality



# Reducing New RE Project Timeline When Resources are Tight

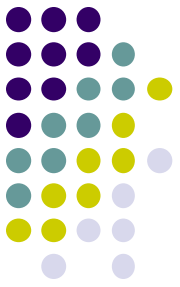


Single Project Companies with limited track records

Credit is tight in general – long payback for these investments is problematic

Technical talent scarcity?

# New RE Project Funding / Support Sources



**Lending Markets**

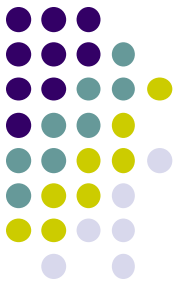
**Capital Markets**

**Trading Companies** – Sumitomo example

**OEMs** – Toyota, Sojitz and Mitsubishi

**Government** – JOGMEC example

# What Should OEMs Be Doing?

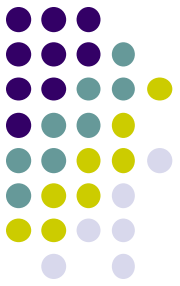


**Understand the vulnerabilities within its individual supply chains. Address vulnerabilities and plan for diversification of supply.**

**Engage in conversations with RE property developers and the rest of its downstream supply chain.**

**Use transparency and frankness in communicating forecasted RE requirements**

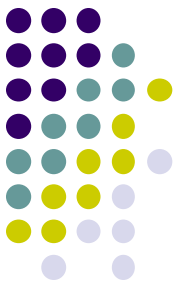
# What Should OEMs Be Doing?



## Demonstrate Commercial Commitment (Demand Pull)

- LOIs
- Off-take agreements
- Loans
- JVs

# Cost Minimization Challenges for New RE Properties

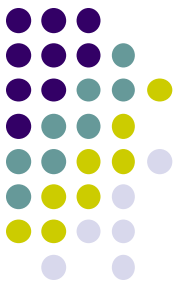


Variable Costs	Fixed Costs
<p>Molycorp setting a high standard in terms of yields, costs and environmental excellence</p>	<p>For a \$1 billion investment amortized over 10 years, fixed costs are <b>\$10 per kg</b> for a 10k mt per annum plant</p>
<p>New producers need to be at least competitive with the Chinese at <b>\$14 – 20 per kg REO<sup>2</sup></b></p>	<p>Fixed cost allocations <b>will at least double</b> if this same producer has no customers for La and Ce</p>

<sup>2</sup> Kingsnorth, Dudley, personal correspondence May 2011

# The Process Yield Opportunity

(best means for sustaining  
global RE resources)



	Unit Op 1	Unit Op 2	Unit Op 3	Overall Yield
Chemical Industry Standard	90%	90%	90%	73%
Not Untypical	62%	70%	65%	28%

# RE Unit Op Yield Improvements - Key to Variable and Fixed Cost Minimization



Such as:

Milling

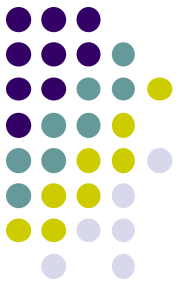
Extraction

Separation

Refining



# Areas Ripe for Global Collaboration to the Benefit of All Stakeholders



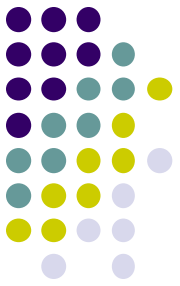
**Rebuild Intellectual Infrastructures**

**New high yield processes to extract, separate and refine RE**

**Manufacturing efficiencies and reduced waste of raw materials downstream of RE processing and recycling of end-of-life products - technologies needed**

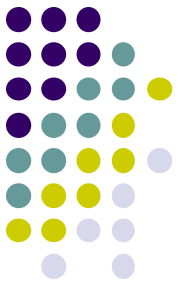
**Industry is eager for collaborations**

# Areas Ripe for Global Collaboration to the Benefit of All Stakeholders



**Means to maintain RE Permanent Magnet coercivity with minimal or no Dy**

**Continued long term fundamental research on RE properties and chemistries**



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# REITA

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Rare Earth  
Industry and  
Technology  
Association

*Tomorrow's Technology Today*

<http://www.reitausa.org>