Materials Sustainability at General Electric

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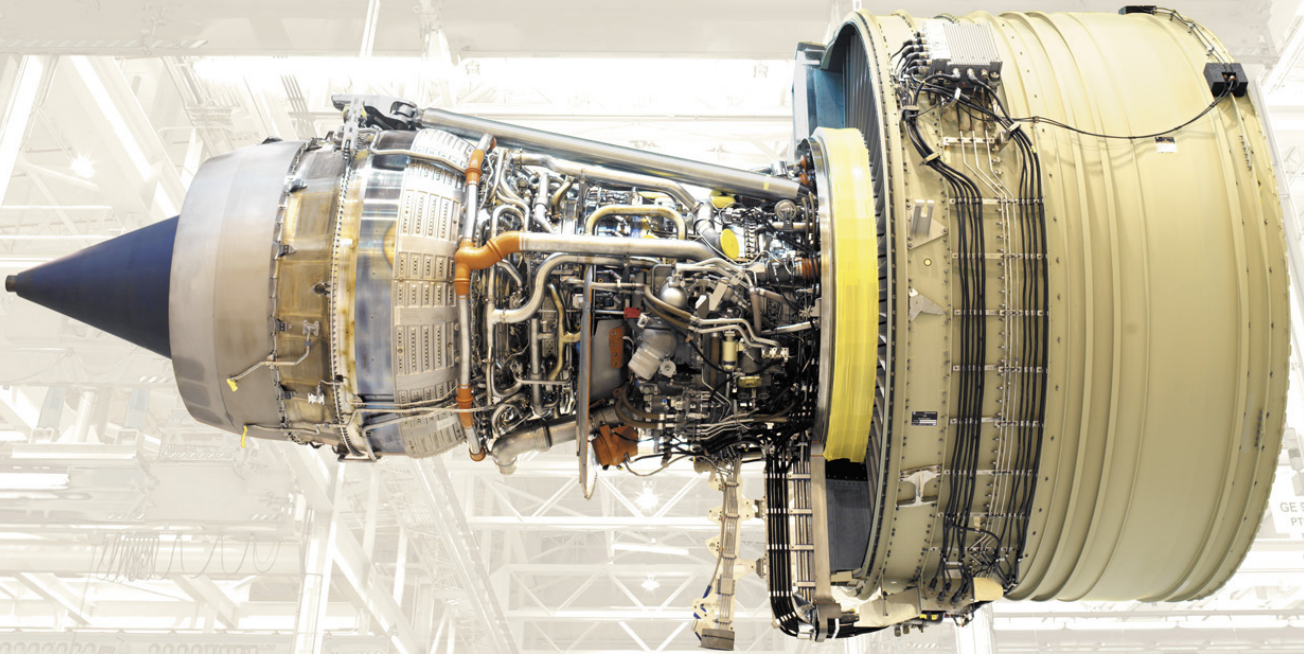
GE materials usage

- GE uses ~3 Billion lbs of material in our products annually
- For manufacturing companies, typically one-half of their Cost of Goods & Services Sold is spent on raw materials. For GE, translates to ~$35 B in 2010
- GE uses at least 70 of the first 83 elements on the periodic table



GE criticality matrix: Approach

Impact

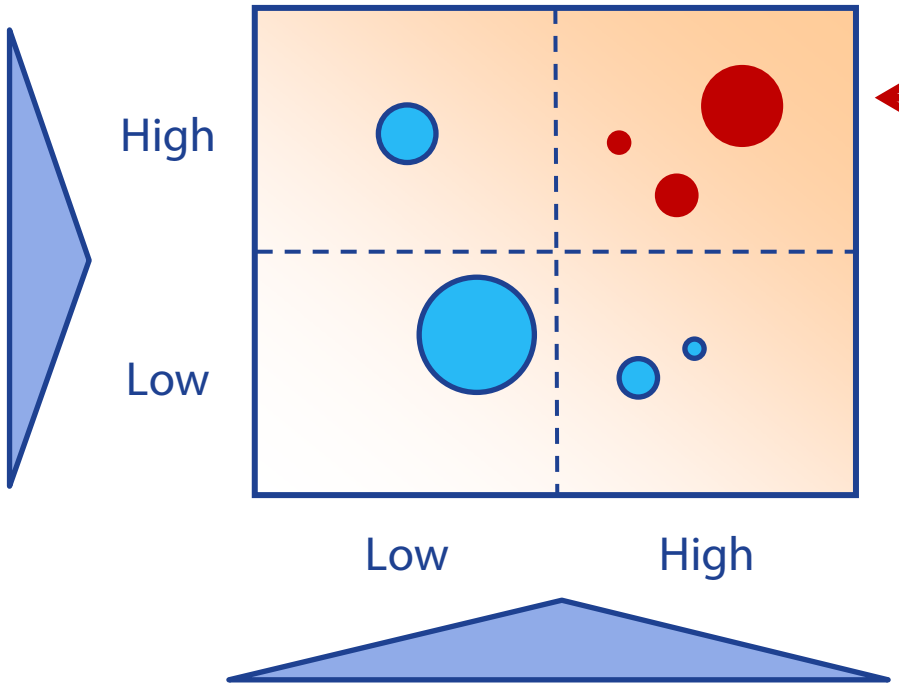
Revenue impacted

% of world's use

Substitutability (specific applications)

Cost pass-through (specific applications)

Impact score computed using: Data from business units



Highest priority elements

Methodology references

Duclos, Otto and Konitzer, Mech Eng 2010, *132*, 36.

Erdmann and Graedel, EST 2011, *45*, 7620.

Graedel et al, EST, 2012, *46*, 1063.

Supply and Price Risk

World reserves	Political factors	Competing uses
Co-production	Human factors	Price volatility

Supply risk score computed using: Data from producers & public domain

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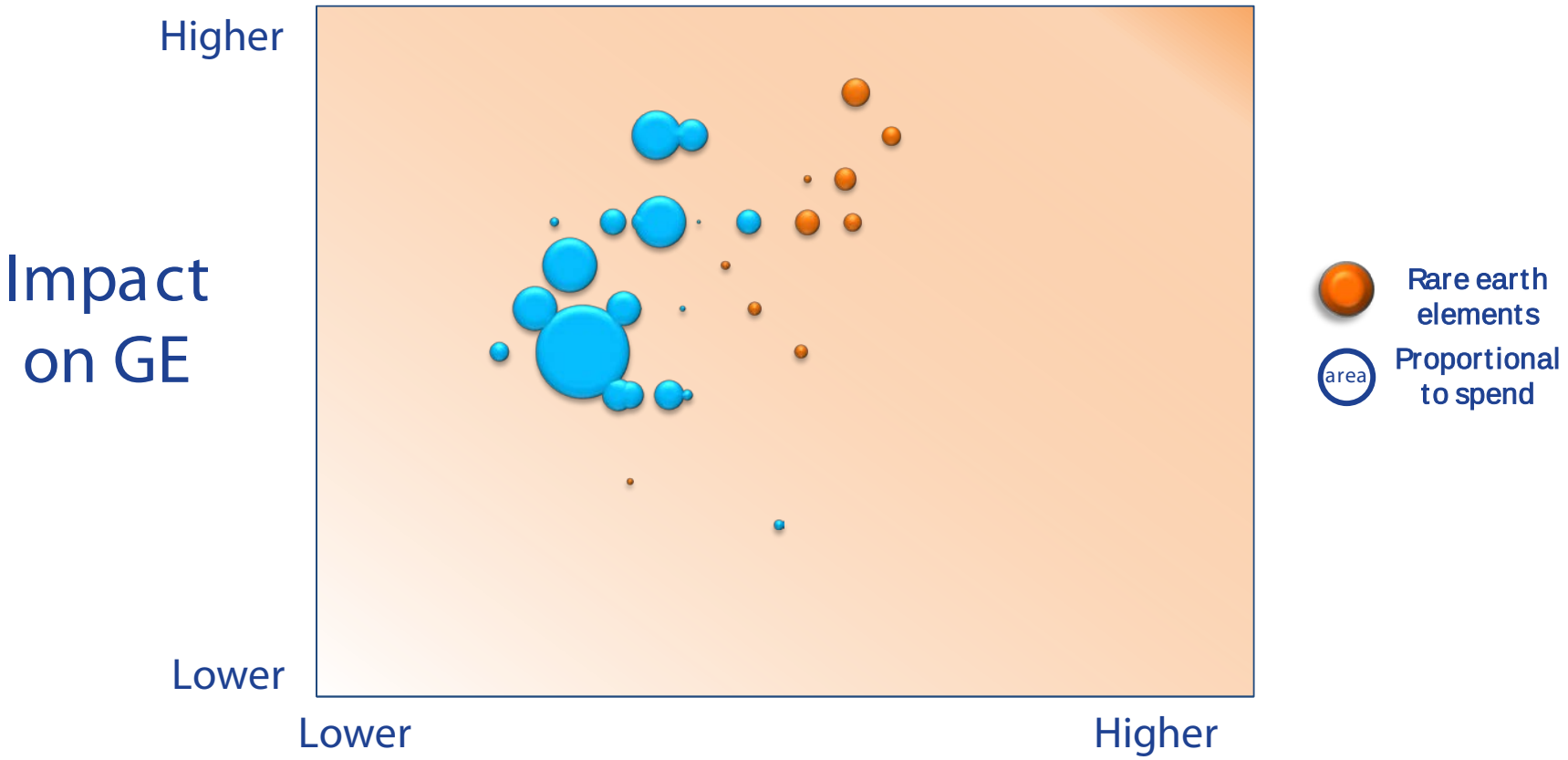
GE criticality matrix - 2012



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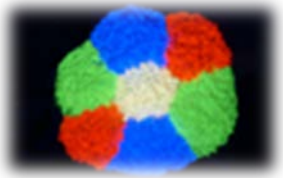
Options for responding to risk exposure

Sourcing …ensure supply through fixed price contracts, forwards, options, etc.

Manufacturing efficiency …reduced waste, recycled waste, advanced manufacturing (i.e. additive)

Recycling …manufacturing shrinkage and end-of-life products, repair, re-manufacturing



Material re-design or substitution …reduce or eliminate at-risk element, use alternate material

System substitution …use an alternate technology to satisfy a customer's need

Longer -- Timing -- Shorter

Broaden material sources

Optimize usage

Redesign materials & systems

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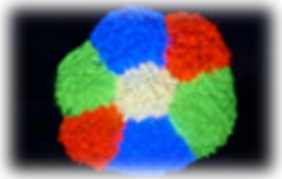
Material sustainability at GE

Sourcing

Manufacturing efficiency

Recycling



Material re-design or substitution

System substitution

Rhenium	Rare Earths
✓	✓
✓	
✓	✓
✓	✓
	✓

Each element and each application will use a unique mix of options

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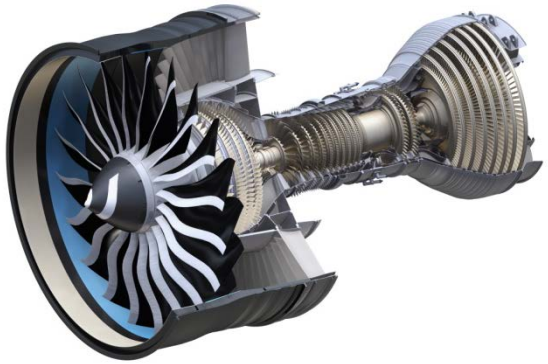
Example – Rhenium in superalloys

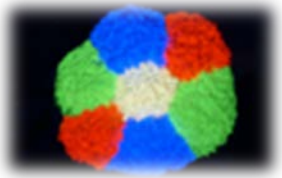
- Used in turbines: Aviation, Gas, Oil & Gas hot sections
- Rarest of elements: 1 oz Re per 120 Tons of Cu ore
- 2006: prices up 6X, sufficient availability uncertain



Sourcing …developed suppliers and worked with suppliers for better recovery of revert of Re containing materials

Manufacturing efficiency …improved handling of Re waste stream and developed chemical processes to recover Re from this waste

Recycle …developed process to reclaim, clean, and re-use Re containing alloys from end-of-life turbine blades



Material re-design or substitution …developed and certified N515 alloy with ½ as much Re for CFM56 HPT blades and N500 with no Re as CFM56 shrouds

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Metal recycling by GE Aviation

End of life parts
- 110,000 lbs '09 (<1% of '09 usage)

SCS Metals

Recycler
- Clean off coating
- Identifies metal

PCC Precision Castparts Corp.

Casting
- Uses part in heat
- Lower cost cast

New Part

KLM Royal Dutch Airlines — GE Customers

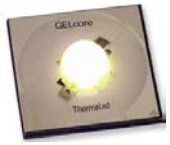
GE Service Shops

GE Aviation

Rare earth elements used in GE products

Y, Ce, Tb
La, Eu

Fluorescent lamp phosphors



Y, Ce,
Tb, Eu

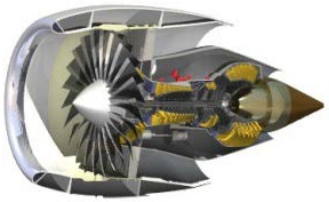
White LED phosphors

Nd

Reveal lamps

Nd, Dy, Tb

Industrial motors



Y

Thermal barrier coatings for aircraft engines

Y

Thermal barrier coatings for gas turbines

Nd, Dy, Tb

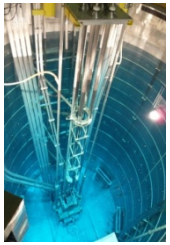
Generators for 1.5MW+ wind turbines

Y, Ce, Tb
Gd, Eu, Lu

Scintillators for CT & PET imaging

Gd

MR contrast agents



Gd

Neutron moderation for GE Nuclear

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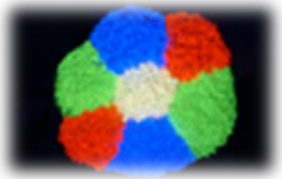
Example – Rare earths

- 97% produced in China – industry consolidation with production and export quotas
- Prices peaked at 10-20X in mid-2011
- Certain of the rare earths expected to be in short supply through 2015

Sourcing …working with global mines and separators to broaden sources

Recycle …developing recycling strategies for fluorescent lamp phosphors, including phosphor rejuvenation for end-of-life lamps



Material re-design or substitution …developing alternate phosphor systems to reduce the rare earth content. Using nano processing to reduce rare earth content in permanent magnets

System substitution …LEDs for Lighting