UK Energy & Critical Materials: Cost & Vulnerability

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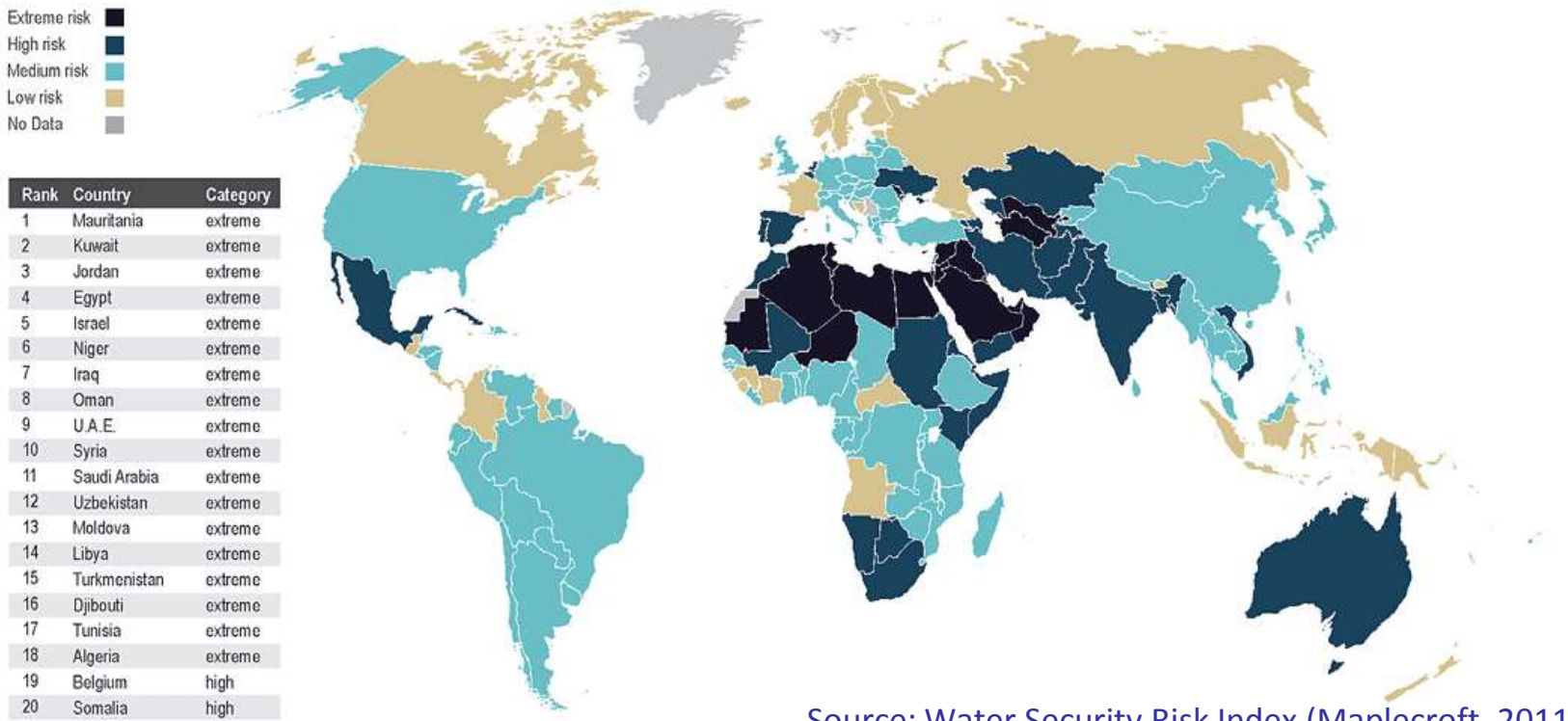
Future Conflict

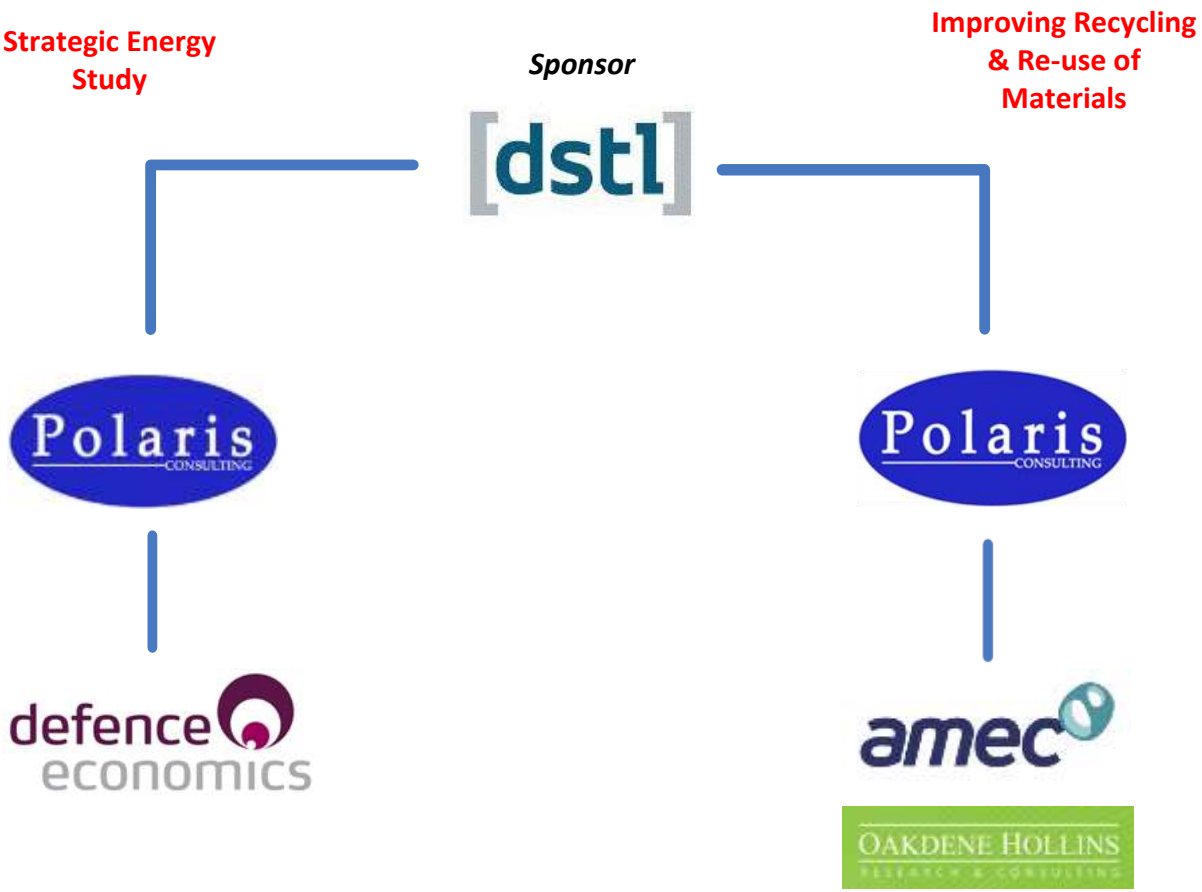
"Out to 2040, there are few convincing reasons to suggest that the world will become more peaceful. Pressure on resources, climate change, population increases and the changing distribution of power are likely to result in increased instability and the likelihood of armed conflict" - *Global Strategic Trends, DCDC*



Rank	Country	Category
1	Mauritania	extreme
2	Kuwait	extreme
3	Jordan	extreme
4	Egypt	extreme
5	Israel	extreme
6	Niger	extreme
7	Iraq	extreme
8	Oman	extreme
9	U.A.E.	extreme
10	Syria	extreme
11	Saudi Arabia	extreme
12	Uzbekistan	extreme
13	Moldova	extreme
14	Libya	extreme
15	Turkmenistan	extreme
16	Djibouti	extreme
17	Tunisia	extreme
18	Algeria	extreme
19	Belgium	high
20	Somalia	high

Source: Water Security Risk Index (Maplecroft, 2011)

Studies


Strategic Energy Study
Sponsor
dstl
Improving Recycling & Re-use of Materials
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defence economics
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Strategic Energy Study

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- The study was commissioned by Dstl to assess the energy supply challenges to MOD:
  - How vulnerable is the MOD to interruptions in energy supply?
  - What is the likely long term price of oil and gas out to 2040?
  - How are short to medium term 'shocks' likely to affect the price of oil and gas?
- Two-thirds of MOD energy cost is fuel, so the study focused on oil, but also tackled gas pricing and wider issues of energy vulnerability
- MOD's concerns reflect the rising global demand for oil and gas, regional volatility and fears of 'peak oil'

Oil Supply is not Threatened (1)

Source: IEA (2011)

Country	Current Global Production (mb/d)	Forecast Global Production (mb/d)	Change 2010-2035
	2009	2035	
Canada	3.4	5.7	2.3
Mexico	3.0	2.5	-0.4
US	7.8	8.3	0.5
Russia	10.5	9.7	-0.8
Kazakhstan	1.6	3.9	2.3
China	4.1	2.3	-1.8
India	0.9	0.6	-0.3
Brazil	2.1	5.2	3.1
Africa	2.6	1.8	-0.7
Middle East	1.7	1.0	-0.7
Europe	4.2	1.8	-2.3
OPEC	34.4	48.7	14.3
Total Non-OPEC	48.8	47.7	-1.1
TOTAL	125.1	139.2	14.4

Globally there is sufficient oil. Much of the growth is expected to come from OPEC.

Oil Supply is not Threatened (2)

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Region	Source of UK Oil Consumption in 2010 (bpd)	% of UK Oil Consumption from Region	Regions share of world production	
			2010	2035
EU 27	13,330	0.8%		
Other Europe (Non-EU 27)**	807,881	50.5%	14.5%	14.1%
North America	5,449	0.3%	13.4%	14.5%
Other America	25,396	1.6%		
Middle East and North Africa**	104,629	6.5%	41.6%	50.5%
Sub-Saharan Africa	45,048	2.8%		
Asia and Oceania	7,206	0.5%	10.0%	5.4%
UK	590,061	36.9%	1.7%	Zero?
Total UK Consumption	1,600,000	100.0%		

Source: EIA (2011)

**Note: Production regions may differ slightly from consumption regions

UK has Good Energy Security

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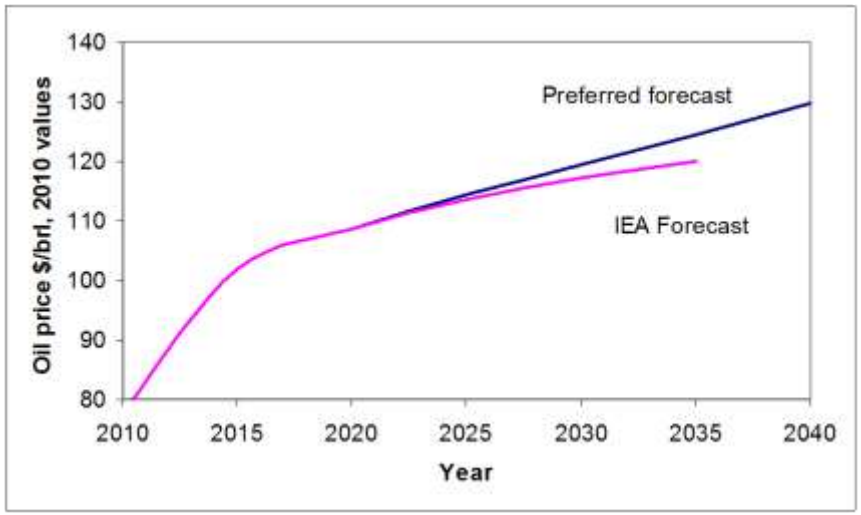
Energy security should not be confused with energy independence. The actions of the global market for oil and regional markets for gas militates against supply disruption.

1. The global oil market works through co-dependence between suppliers and consumers
2. The UK has one of the most diversified gas supplies in Western Europe
3. As the UK moves to meet its legally binding carbon emissions target of 2050, the country will be significantly less reliant on energy imports
4. Energy security can be supported through a resilient global energy market and influencing other countries

However…..

Demand increases faster than supply and this will cause an increase in prices. Long-term price will rise by 66% by 2040 (against 2010 price).



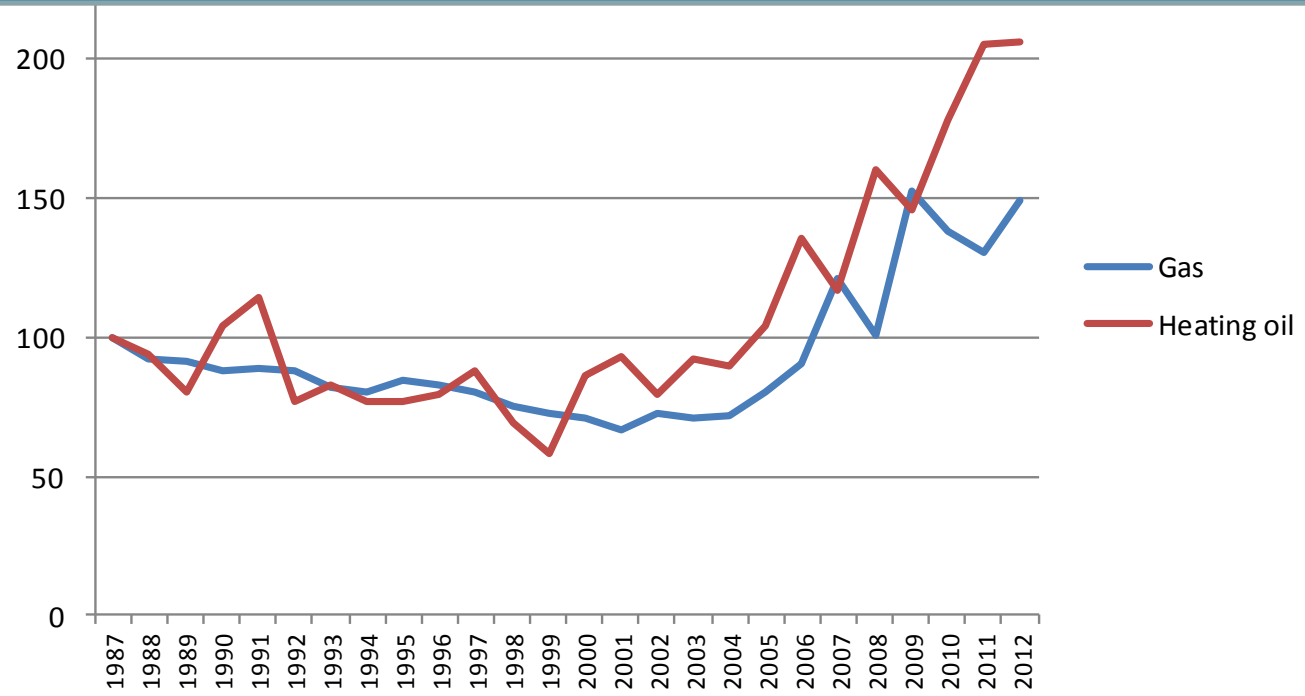
Source: IEA 2011 & Defence Economics

Country	Change in demand 2010-2040 M barrels/day
China	+6 = +67%
India	+4.1 = +124%
Rest of world	+2.6 = +3%

There is nothing UK (or MoD) can do to affect price.

With Gas as well as Oil

Close correlation in the UK between movements in oil and gas. Increased demand for gas will increase prices of gas . We forecast a 2040 price of $12 per British Thermal Unit – a real term increase of 70%



Source: ONS

Price Volatility

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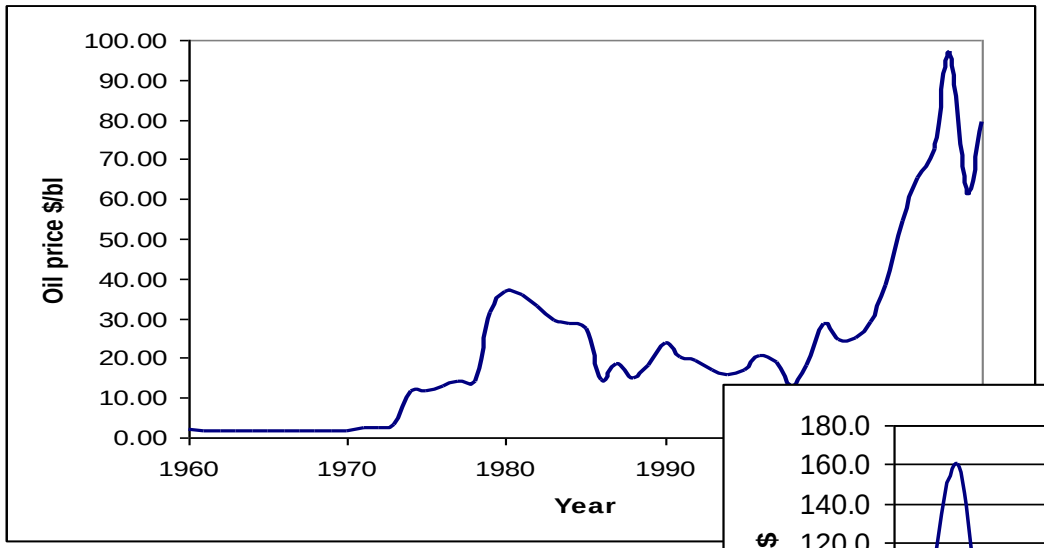
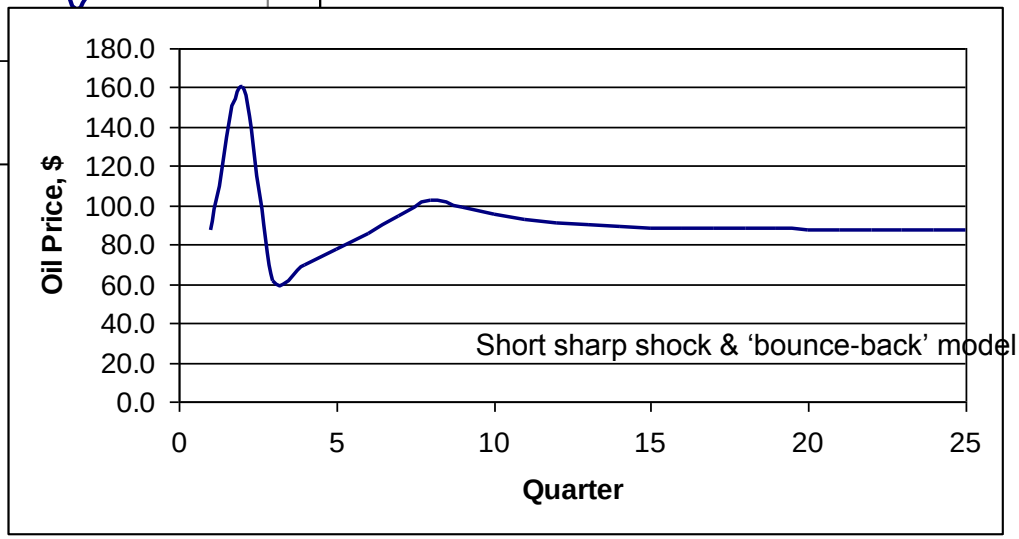
Prices affected by short term changes in actual or expected supply.





Summary of Energy Study

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Oil and gas are “fungible” products. If one country or bloc of countries threatens the UK with supply restrictions, it can be sourced elsewhere.

1. The *cost* of energy is the issue for the MOD
2. A 40% increase in oil prices will significantly impact MOD budgets
3. Platform lifespans mean that no alternative to hydrocarbon dependency exists to 2040
4. New platforms such as UAVs and changes to doctrine and training will have an impact
5. Forward buying – which MOD does – can smooth spikes in price
6. MOD has to face the reality of increasing price and plan accordingly

Recycling & Re-use Study

- Aims:
  - To understand the barriers to, and opportunities for, greater recycling in the MOD
  - To determine the viability of re-using or recycling critical materials as a mitigation strategy against them becoming unavailable in the future
- Critical materials are those of high importance to a country or organisation where there is a perceived high risk of disruption or interference with supply
- Nine exemplar materials were selected for the study, including 3 Rare Earth Elements (REEs)
- China now dominates the supply of REEs, with the potential to threaten security of supply

Critical Materials

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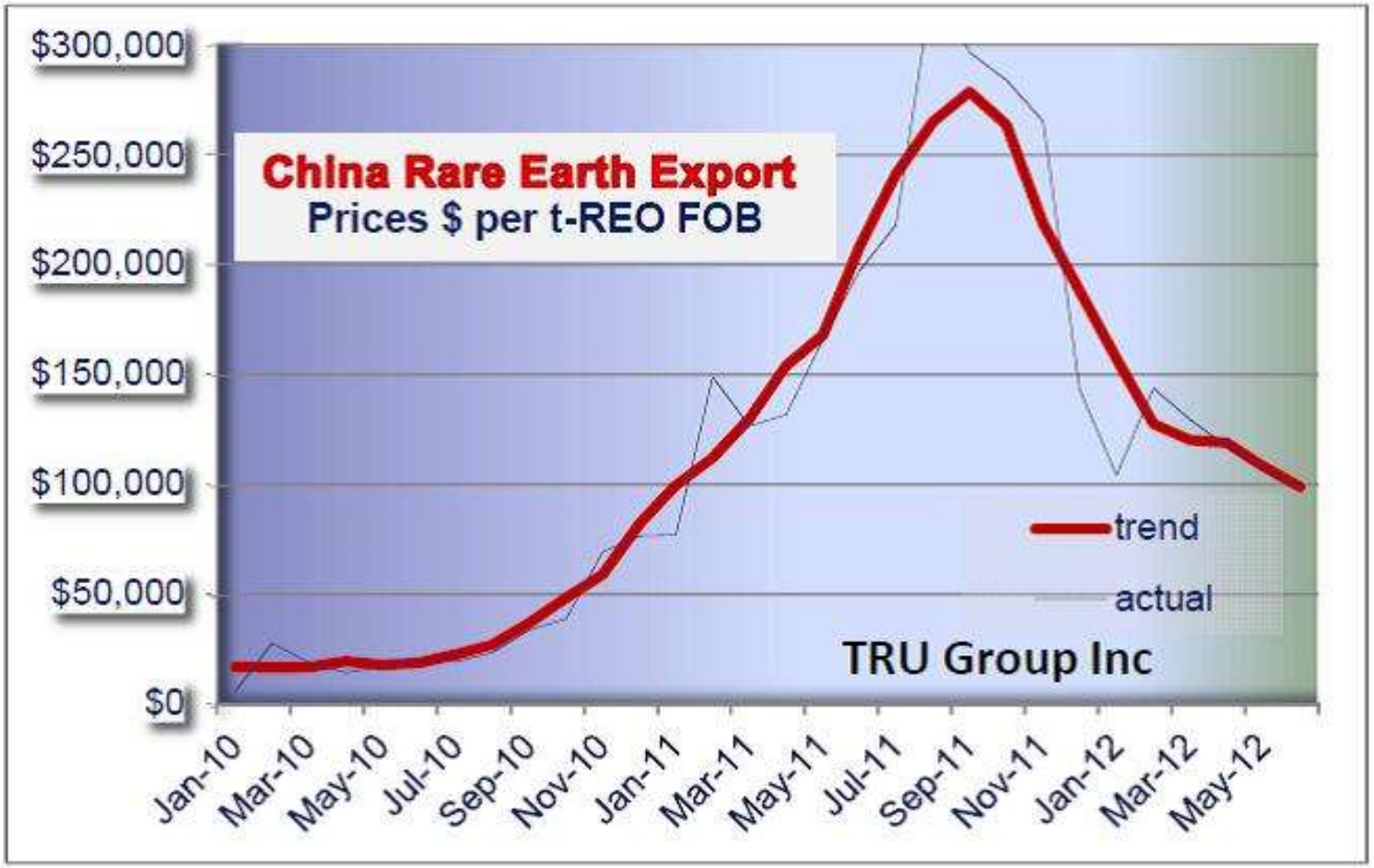
Material	World Supply, 2010 (tonnes)	Primary Producing Countries (%)	Major Applications (%)	Price – ($/kg)
Tellurium (component of CMT)	500	Japan (47 %) USA (45%) Canada (8%)	Photovoltaic cells (40%) Thermo-electric modules (30%) Metallurgy (15%)	Metal (29.11.12) $115-$130
Erbium	870	China (98%) India (2%)	Glass additives Fibre optics/lasers	Not quoted on metal markets
Indium	1,540	China (53%) South Korea (16%) Japan (11%)	Flat panel displays (74%) Other Indium tin oxide (10%) Low melting point alloys (10%)	Metal (29.11.12) $495-$530
Neodymium	21,000	China (98%) India (2%)	Magnets (76%) Metallurgy (8%) Battery alloys (5%)	Metal (06.12.12) $100-$110 Metal oxide (06.12.12) $70-$80
Tantalum	790	Brazil (23%) Mozambique (15%) Rwanda (14%)	Capacitors (60%) Cemented carbides (16%) Aerospace and automobile (14%)	Metal (29.11.12) $490-$530
Titanium	3,420,000		Paints (56%) Plastics (23%) Paper (11%)	Titanium sponge (29.11.12) $5.8-$6.4
Tungsten	94,000	China (81%) Russia (4%) Canada (3%)	Cemented carbides (60%) Fabricated products (17%) Alloy steels (13%)	Tungsten oxide (06.12.12) $31.68-$32.00
Yttrium inc. YAG	7900	China (98%) India (2%)	Phosphors (52%) Ceramics (32%) Glass additives (2%)	Metal oxide (06.12.12) $50-$60

Price Behaviour



Critical Materials Market

- Analysts expect worldwide demand for critical materials to rise in the medium and long term
- High prices for critical materials have led to manufacturers seeking alternatives
- The extreme price reaction of this market is indicative of one with very inelastic demand, similar to the oil market
- Unlike oil, however, critical materials are a relatively small input to final price, allowing price increases to be absorbed in the supply chain
- High price will drive substitution and new sources of material in the medium term – but not the short term

Mitigation Strategies

- Restrictions in supply will lead to new sources becoming available in the medium term
- R&D can be directed towards finding alternatives and improving recycling and reuse
- In the short term bilateral arrangements (there is no established forward market for critical materials) can smooth supply
- Holding inventories of materials, which the US holds, can also smooth supply, but stockpiling is *not* UK policy
- Japan is funding research into Rare Earth Element (REE) recycling with $1.2Bn of spend, as well as seeking new supply routes and stockpiling materials

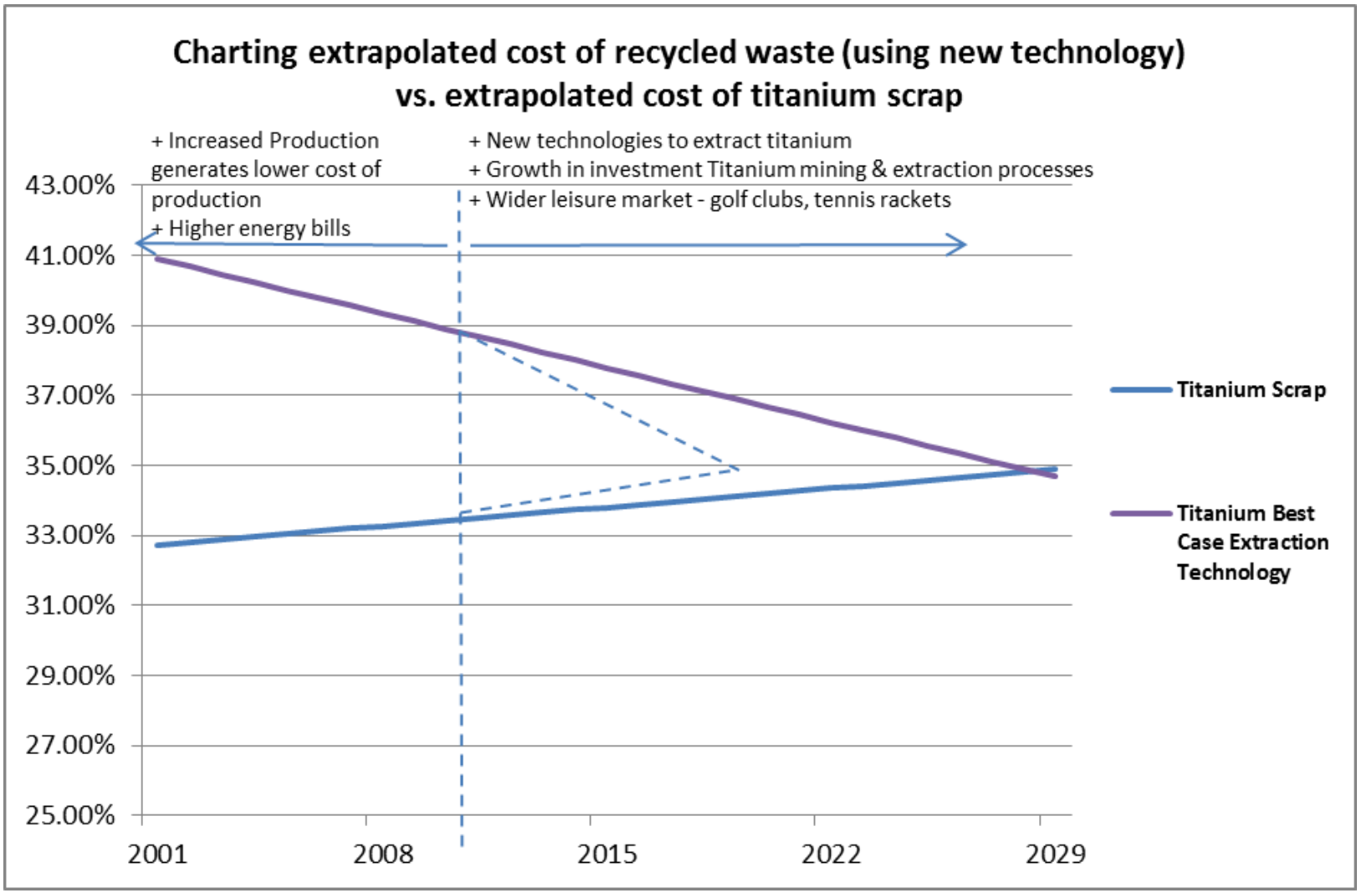
Recycling of Critical Materials

- Recycling is generally at low TRL and currently limited to specialised applications for a few elements:
  - Neodymium: magnet recycling TRL is 4; battery recycling TRL is 7
  - Yttrium: fluorescent lamp recycling TRL is 4
  - Tantalum: some limited recovery in jet alloy blades and capacitors
  - NDYAG: no facilities or research; the amounts of YAG and lifespan of lasers preclude cost-effective recycling
  - CMT: no recycling or recovery in the UK or EU
    - Telluride, however, is recycled in Belgium
  - Tungsten: well developed recycling with 35-40% of supplies from scrap
  - Titanium: recycling of scrap for some applications in the UK

Case Study

- **Will it ever be cost effective to separate Titanium from Non-ferrous Waste?**
- Current ‘recycling’ involves the use of ‘scrap’ – generated through manufacturing in the form of clippings, stampings and turnings
- A cost model was developed to examine when it would be economical to recycle Titanium from non-ferrous waste
- This was a proof of principle model which could be applied to different critical materials
- The model was derived by analogy, using aluminium recycling cost data, projected energy costs and Titanium scrap prices

Case Study Conclusions



Summary of Critical Materials

- Critical material recycling is dependent upon the commercial market, making it difficult to identify cost-effective interventions
- There is a need to maintain a watch on critical materials due to the current monopoly on supply and risk of price rises
- In the medium term the commercial market is likely to create opportunities for new raw material sources or recycling
- The market is complex and the MOD is a small, niche customer in global terms
- Technology watch and the promotion of greater awareness by suppliers are to be encouraged.

Conclusions

There is nothing MOD can do to influence the future price of oil, gas or critical materials. They key is to be forewarned of the risks and to the information to manage them.

1. Supply of oil and gas is not threatened out to 2040
2. Supply of (some) critical materials might be threatened, especially in the short term
3. The long term price of all of them will increase
4. MOD needs to plan for oil and gas price increases
5. MOD needs to inform its supply chain of the risks of critical material unavailability and potential price rises
6. MOD needs to be aware of its vulnerabilities to critical material unavailability and manage its supply chain appropriately

Thank you

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