Recommendations to ensure Critical Minerals for Energy Systems are available for the transformation of the UK Energy System to 2050

Over the next 40 years, analysis suggests that investment in energy innovation could reduce the cost of meeting the UK's low carbon energy goals by £600 bn[1]. These savings would reduce the upward trend in energy costs across the economy making the UK more competitive. Furthermore, energy technology development could result in UK business opportunities totalling at least £18 bn to 99 bn to 2050[2]. However, recent surveys have identified that some UK executives, particularly those in the manufacturing sector, are concerned about the availability of resource inputs and the economic impact that it may have on UK competitiveness[3] - potentially jeopardising energy goals and green growth opportunities.

The Energy Research Partnership (ERP) has undertaken a review of resources in order to assess whether resource availability will represent a significant risk for UK energy innovation and system development to 2050. This document discusses metal minerals such as platinum (i.e. excluding fuel minerals, e.g. oil, and non-metals e.g. aggregate) used in high tech and energy system applications; it was undertaken with UKERC[4]. The impacts of other resources such as water are being examined separately by the ERP.

The review has highlighted the following key issues regarding the availability of metal minerals:

- Resources concerns are not a new phenomenon. Recent concerns have been stoked by the rapid rate of growth of emerging economies and ecological impacts of resource consumption.
- Energy systems increasingly depend on metal minerals such as chromium as a result of the proliferation in the use of exotic elements and the increased mineral intensity of new energy technologies; many are essential in the development of the low carbon energy system to 2050[5]. Consideration of primary supply of minerals is important in the near term, not only because of the expansion of energy systems but also because the long lifetime of assets means that minerals are `locked-in', unavailable for recycling for many years. Recovery and recycling are likely to be critical and should be taken into account in current decisions.
- The impact of metal minerals non-availability on the UK economy has yet to be precisely quantified. The UK's response to the issue has tended to be non-interventionist though some funding of research into developing secondary sources has been undertaken. This is in contrast to proactive initiatives that some other governments are taking, particularly in the securing of upstream supply and substantial investment into demand side research. In the long run, the UK is therefore likely to be at a comparative disadvantage, and should markets remain tight, the ability to develop a high value manufacturing sector could be jeopardized and the value creation opportunities of implementing mineral security measures will be missed e.g. material efficiency via better design, re-use and recycling technology development.

The ERP review has taken a systems perspective of the minerals value chain and would like to highlight the following key messages:

- **Although there is no absolute shortage of any metal mineral resources, absolute availability is not a meaningful guide to prospective future production and market availability because of the impacts of economics and geopolitics.** The key constraints are related to the volatility of price and potential supply

[1] NPV analysis by the Energy Technologies Institute.
[2] LCICG Technological Innovation Needs Assessments for Carbon Capture and Storage, Nuclear, Offshore Wind and Transmission and Storage technologies.
[3] EEF, 2011, PWC, 2011 and The Carbon Trust, 2012
[4] UKERC's Technology Policy Assessment on Minerals availability for low carbon technologies http://www.ukerc.ac.uk/support/TPA+Overview
[5] The proportion of use of minerals ranges from 8% of Tellurium in Solar PV to 100% of Dysprosium in Permanent Magnets for EVs and large wind turbines (Graedel 2011).

disruptions. The uncertain abilities of ecological sinks to safely assimilate waste from the exploitation and processing of metal minerals are likely to present further challenges.

- In contrast to the few fuel minerals, metal minerals comprise a relatively large heterogeneous group; ***metal minerals are less fungible*** and bottlenecks more likely.
- ***The mining sector is highly heterogeneous ranging from vertically integrated mining giants to small, single mine or exploratory companies called Juniors***. The different players in the sector use a variety of business strategies to manage risk and create growth opportunities.
- ***The most market responsive part of the sector are the Juniors which are funded according to different economic drivers and by different investors from the mining giants***. They also tend to focus on minerals with smaller markets (by value and volume).
- ***The volumes traded on metal minerals markets are highly varied and substantially smaller than other mineral sectors***. For example, metal minerals extracted in 2009 totalled 2.41 Gt compared to the global aggregates market at 41.2 Gt, coal at 5.9 Gt and oil 4.2 Gt. Metal minerals market size ranges from iron ore at 2.07 Gt (95% of 2009 metal mineral production) to the 32 metals which are estimated to be produced at amounts of 32 kt or less making up 112 kt (or 0.005% of 2009 metal mineral production) in total per annum. Indeed the volumes produced for a number of minor metals are not available. Many of the metal minerals essential to the development of high tech and energy system technologies are in these smaller markets. For example, hafnium - critical for low carbon, CCGT and nuclear technologies - had a production of 25t in 2009.
- ***Markets operate imperfectly for many of these smaller minerals markets due to:*** their by-product or coupled status (produced at lower volumes with other metal minerals) which results in a ***weak market signal*** for a number of metals; the small size of the markets which allows only a handful of suppliers and therefore gives producers power; and the lack of information along their life cycle from production, refining, trade to end use.
- ***The most potentially significant metal minerals constraint risk to UK energy innovation and system development to 2050 may be posed by the volatility in price and potential disruptions to the availability of these `technology metal minerals' used in both conventional energy generation and low carbon technologies***. Supply uncertainty is the key concern. The availability of technology metal minerals at reasonable economic costs is essential to facilitate the rapid commercialisation of the low carbon system.

There are a number of economic measures that may address minerals availability. They have differing response times - these are summarised in figure S1, below. With these in mind, the ERP makes the following recommendations to ensure the UK has a globally competitive energy innovation sector:

- ***The location of responsibility for the monitoring of technology metal minerals non-availability risk and opportunities should be better defined in government***.
- ***Resources risk assessments require a more holistic perspective of supply and demand side issues, on a mineral by mineral basis, in order to account for market dynamics and ensure the development of appropriate policy.***
- ***Market transparency and the needs of upstream supply actors should be a priority***. Transparency measures include the development of awareness of minerals use in energy technologies, impacts of minerals policies enacted by supplier nations, improved datasets and more open pricing mechanisms should be encouraged when there is sufficient liquidity. Primary supply initiatives include increasing the availability of risk capital for Junior miners exploration operations in unstable regions and encouraging investment and R&D in refining capacity.
- ***Investment into recycling, materials efficiency and substitution research initiatives should be improved and co-ordinated with the UK manufacturing and design sector*** - with immediate attention on design for recovery and recycling. Awareness of the impacts of the interaction of these policies needs to be researched.

Figure S1: Economic measures that may be implemented to address technology metal minerals supply constraints and their timeframes of operation.
It is noteworthy that though government can set the policy framework there is a role for business to take action and work with government to address the challenges.

Economic Countermeasures for addressing Technology Metal Minerals Constraints for Energy System Technologies	Short-Term (0 - 5 yrs)	Medium Term (6 - 19 yrs)	Long Term (20+ yrs)
Enabling			
Awareness - Integration of resource issues in energy scenarios and Materials Flow Analysis			
Data Collection and Dissemination by Producers, Refiners and Manufacturers (e.g. Bill of Materials)			
Market Transparency - Registering on exchanges, Trade Statistics and Future Options			
Co-operation through international partnerships and knowledge exchange [e.g. R30]			
Ensure mechanisms to faciliate free trade and prevention of trade restrictions by minerals producers			
Better Design and Innovation for minerals efficiency			
Supply Side - Increasing Primary Sources of Supply			
Access to Risk Capital for Junior Miners			
Risk Reduction Policies for Junior Miners operating in geopolitically challenging Locations			
Exploration and Mapping Sources of Technology Metal Minerals			
Facilitating investment environment for mining in Non-OECD nations			
Incentives to improve R&D to enhance extraction efficiencies and reduce environmental impacts			
Encouragement of skills base in geology and geoscience			
Supply Side - Increasing Refining Capacity			
Information on opportunities for producton - ores with high concentration & refining scale up			
Incentivisation of by-product and coupled production by refiners			
Encourage R&D investment to improve the efficiency of by-product and coupled refining			
Supply Side - Increase Secondary Sources of Supply through Recycling[1]			
Assess recycling capacity for different technology metal minerals			
Incentivise R&D for the improvement of recycling technologies			
Incentivise Reuse and Remanufacture			
Recycling potential for different product streams (significant range depending on length of 'in-use' phase)			
Improve recycling system - collection, sorting, link agents, design and regulation alignment			
Demand Side - Materials Efficiency[2]			
Incentivisation of Takeback Options[3], Extended Producer Responsibility, Life Cycle Ownership & RRM[4]			
Demand Side - Substitution of Material			
Map R&D work that is taking place in materials substitution and information exchange			
Align actors in metal and technology value chains to target substitution efforts - Benchmark best practice			
Demand Side - Technology Substitution			
Awareness of technology substitution trends and impact on market balance			

1. The contribution of secondary supply from the energy sector will be limited due to rapid expansion of the sector and the life span of technologies which is at least 20 years. However, the opportunity from consumer goods such as mobile phones and computers may be more rapid (2-5 years)
2. The application of materials efficiency thinking to technology minerals is likely to be limited due to the quantitaties used in devices already generally being very small.
3. Take Back Options returns the product back to the manufacturer for re-use of the materials
4. RRM - Reuse and Remanufacture is the re-engineering of technology components for re-use either in new or the same technologies.

Key
: Research / Development.
: Implementable / Realisable.
: Range of timeframe from Research to Implementation.