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Critical metals: risks and opportunities for Spain

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Theme

In recent years there has been a rapid expansion in the global renewable-energy and energy-efficiency technology markets. However, most low-carbon technologies require so-called 'hi-tech' or 'critical' metals, for the majority of which the EU's member states have high import dependency rates.

Summary

Today, the EU is one of the world's most important players in the international renewable-energy and energy-efficiency markets. A boost in the global demand for critical metals is expected due to the expansion of both low-carbon and high-advanced technologies. This prospect has raised widespread concern about the risks associated to the supply chain of critical metals, their impact on the national energy and climate targets and the consequences for innovation and economic growth. To address these concerns, in the last few years a number of governments have developed critical-raw-materials strategies in order to prepare for potential restrictions in the supply chain.

This policy brief focuses on the British and German national critical-raw-materials strategies as relevant examples of specific policies which are potentially transferable to third countries. The paper concludes with a brief remark on Spain's lack of political action in defining and enforcing comparable policies.

Analysis

Introduction

Since the past decade, many governments have encouraged the deployment of both renewable-energy and energy-efficiency technologies in order to diversify their energy sources and reduce their dependency on fossil-fuel imports; climate-change and environmental factors have also influenced policy-making. The resultant positive impact of the low-carbon technologies sector on job creation and economic growth at large has been widely recognised.

The EU is one of the world's most important players in the renewable energy arena, as confirmed by the 44% share of the global renewable-power capacity it reached at the end of 2011. This is the result of consistent policy-making during the last few years to develop a secure, competitive and sustainable European low-carbon economy by 2050. In terms of renewable power-generating capacity, as of the end of 2011 China and the US lead the renewable market in absolute numbers, followed by Germany, Spain and Italy, which, in turn, are the top three markets on a per capita basis. Spain has a significant presence in the wind and solar –both photovoltaic (PV) and concentrated (CSP)– power sectors, although at the end of 2011 it moved back to the fourth position on the PV capacity scale.[1]

Most low-carbon technology manufacturing processes require the so-called 'hi-tech' or 'critical metals', for which the global demand is expected to rise sharply in coming years in response to the expansion of low-carbon and other high-advanced technologies. An eventual restriction in the critical-metal supply chain has caused widespread concern.

Why 'critical metals'?

According to the EU Commission, critical raw materials are defined as 'those which display a particularly high risk of supply shortage in the next 10 years and which are particularly important for the value chain'.[2] EU member states have import dependency rates of 100% for most of these materials. Such a level of dependency generates insecurity arising from:

1) Geopolitical asymmetry: for some critical metals, exploitation projects are at present underway in only a few countries. This market concentration in countries at political and/or economic risk may disrupt trade and encourage price volatility. For instance, China, which controls around 95% of the global rare-earth elements production, established export quotas and tariffs in 2010 as part of an explicit geopolitical strategy.

2) Speculative factors: the trade volume for critical metals is comparatively small and not all critical metals trade on the London Metal Exchange (LME). The critical-metal markets are therefore less transparent than the copper, nickel, tin and zinc markets –to name a few–.

3) Technology and capital investments: many critical metals are obtained as by-products of abundant base metals; frequently, their low production rate does not compensate for the economic benefits of extracting only the base metals.

4) Geological factors: rare-earth elements are not scarce in the Earth's crust but are seldom found in ore deposits. Thus, only a reduced number of mining projects are technically viable and economically profitable.

1 REN21 (2012), *Renewables 2012 Global Status Report*, http://www.ren21.net/Portals/0/documents/Resources/%20GSR_2012%20highres.pdf.

2 European Commission (2011), *Tackling the Challenges in Commodity Markets and on Raw Materials*, COM (2011) 25 final, http://eur lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0025:FIN:EN:PDF.

5) Substitution and recycling: there are currently few replacement alternatives available for critical metals. Also, the efficiency of recycling processes is relatively low due to the complexity of scrap-metal recovering.
6) The environmental impact of mining and materials processing.

Critical metals in low carbon technologies

According to the US Department of Energy (DOE), in 2010 clean energy technologies demanded around 20% of the global consumption of critical metals.[3] This proportion is presumably due to rise in coming decades, as mentioned above.

A number of reports have been published in recent years by a wide range of institutions that provide in-depth coverage of utilisation issues concerning critical metals. However, to date no definitive consensus has been reached concerning a methodology for the assessment of metal criticality and the impact of an eventual supply shortage in low-carbon technologies. In the following paragraphs several reports are introduced that briefly illustrate the issue.

The strategy documents published by the DOE in 2010 and 2011 identify criticality matrices for the short and medium term (2015-25) for photovoltaic films, wind turbines, vehicles and lighting.[4] In 2010 the Ad-hoc Working Group of Raw Materials Supply Group of the European Commission singled out 14 elements as critical for member-state industries and which are not exclusively used in low carbon technologies.[5] In 2011 the JRC Institute for Energy and Transport of the European Commission (JRC) together with the Oakdene Hollins and The Hague Centre for Strategic Studies (HCSS) released a report which focused on the impact of a hypothetical shortage of critical metals employed in six different low-carbon technologies prioritised in the European Strategy Energy Technology Plan: nuclear, solar, wind, bio-energy, carbon capture and storage, and electricity grids.[6] In 2009 the Institute for Future Studies and Technology Assessment (IZT) and the Fraunhofer Institute for Systems and Innovation Research (ISI) prepared an extensive report on the criticality of hi-tech metals based on the predicted demand for a wide spectrum of advanced technologies by 2030.[7]

Table 1 below shows a (non-exhaustive) categorisation of the most important metals required for selected low-carbon technologies.

3 US Department of Energy (2010), *Critical Materials Strategy*, December, **http://energy.gov/sites/prod/files/piprod/documents/cms_dec_17_full_web.pdf**.
4 Ibíd; US Department of Energy (2011), *Critical Materials Strategy*, December, **http://energy.gov/sites/prod/files/DOE_CMS2011_FINAL_Full.pdf**.
5 European Commission (2010), *Critical Raw Materials for the EU*, Report of the Ad-hoc Working Group on defining critical raw materials, 30/VII/2010, http://ec.europa.eu/enterprise/policies/raw-materials/files/docs/report-b_en.pdf.
6 JRC Institute for Energy and Transport, Oakdene Hills Ltd and The Hague Centre for Strategic Studies (2011), *Critical Metals in Strategic Energy Technologies*, **http://setis.ec.europa.eu/newsroom items folder/jrc report on criticalmetals in strategic energy technologies/at_download/Document**.
7 IZT & Fraunhofer ISI (2009), *Rohstoffe für Zukunftstechnologien*, 15/V/2009, **http://www.isi.fraunhofer.de/isi media/docs/n/de/publikationen/Schlussbericht_lang_20090515_final.pdf**.

Table 1. Metals used in low carbon technologies

Technology	Device	Metals
Wind	Permanent magnets in generators	Dysprosium, neodymium, praseodymium
	Steel alloys (eg, for offshore applications)	Copper, chromium, manganese, molybdenum, nickel
Solar (photovoltaic)	Crystalline silicon	Silicon, silver, tin
	Thin films	Cadmium, copper, indium, gallium, germanium, selenium, tellurium
Solar (concentrating)	Solar mirrors	Silver
Bio-fuels	Catalysts	Cobalt, palladium, platinum, ruthenium, rhodium
Nuclear energy	Reactor control rods	Cadmium, chromium, cobalt, copper, hafnium, indium, lead, molybdenum, nickel, niobium, silver, tin, tantalum, titanium, tungsten, vanadium, wolfram, yttrium, zirconium
Hybrid- and electro vehicles	Motors	Copper, dysprosium, neodymium, praseodymium
Electricity storage	Li-Ion Batteries	Cobalt, lithium, manganese, nickel
	Ni-MH Batteries	Cerium, cobalt, lanthanum, manganese, neodymium, nickel, praseodymium
Fuel Cells		Cerium, cobalt, gallium, lanthanum, manganese, nickel, iridium, palladium platinum, rhodium, ruthenium, vanadium, yttrium
High efficiency lighting	LED, halogens and fluorescent lamps	Cerium, dysprosium, europium, gallium, indium, lanthanum, niobium, scandium, terbium, yttrium
Electricity grids	Cables	Copper, lead
Carbon capture and storage (CCS)	Steel alloys	Cobalt, copper, chromium, manganese, molybdenum, nickel, niobium, vanadium

Source: US DOE Critical Materials Strategy (2010 & 2011); JRC, Oakdene Hills & HCSS (2011); IZT & Fraunhofer ISI (2009).

National critical raw materials strategies: Germany and the UK

Due to the dynamics of innovation associated with low-carbon technologies, it is difficult to predict the critical-metals supply and demand balance over a period of 20 years with some confidence. On the other hand, there is a consensus that this uncertainty should be managed appropriately. Several governments have reacted positively to the concerns voiced by industrial and scientific associations and have sought to anticipate, and hence minimise, the impact of potential restrictions on national economies and national energy and climate targets. This proactive approach has resulted in a number of national strategic papers being published by several governments over the past few years.

EU member states rely almost completely on imports of critical raw materials to meet the needs of their domestic industries and services. This affects EU economies in direct or indirect ways. Two main country profiles can be identified within the EU member states.

The first profile is that of countries with a strong base of hi-tech manufacturing industries and a tight reliance on metals imports. Germany, with a well-developed low-carbon and automobile industry, and to a lesser extent, France, with extensive nuclear production and automobile industry, are paradigmatic examples. For these countries, secure, competitive and sustainable access to critical raw materials is essential in order to safeguard current economic and productive patterns.

The second important profile is that of, eg, the UK and the Netherlands. In these countries, the smaller manufacturing-industry base relying directly on the critical-metal supplies lessens the impact of eventual shortages of high-tech metals. Therefore, national strategies are driven towards identifying and exploiting economic opportunities and business models associated with the efficient management and substitution of critical materials.

Germany

Germany is an interesting case study for the following reasons:

1) It has a long-standing tradition as an exporter with a strong hi-tech manufacturing industry. Maintaining Germany's global leadership in the technology and export arenas has become an essential, unquestionable political remit for all federal governments.

2) Its energy-security concept (Energiewende) relies on the successful deployment of the new green technologies in sustainable and profitable ways.

3) It has developed a mature raw-materials strategy, which encourages dialogue between subject experts from the industrial and technology areas, and comprises a wide spectrum of policy instruments –political, financial and technological– aimed at supporting German industry, particularly in the event of market failure.

In March 2005 the first Raw Materials Summit took place with the participation of the Federal Association of German Industry (BDI) and the Federal government. This event undoubtedly marked the launch of Germany's present raw-material strategy, which to date has been set forth in two main documents.[8] The core elements of this strategy are:

• The Federal government is viewed as an active player and key partner. The Federal government has undertaken the remit to establish the required political, institutional and legal framework to guarantee the reliable, competitive supply of hi-tech materials. To this end, the Federal government has empowered public agencies and shaped adequate instruments, eg, Chambers of Commerce, the German Trade and Invest (GTAI) agency and an extensive network of Federal Foreign Offices, in order to represent the interests of German national industry abroad. Further support activities are carried out by the inter-ministerial Raw Materials Committee, the Helmholtz Institute Freiberg for Resource Technology (for mineral and metalliferous raw materials) and the German Raw Material

8 Federal Ministry of Economics and Technology (2010), *Rohstoffstrategie der Bundesregierung,* **http://www.bmwi.de/DE/Mediathek/publikationen,did=365186.html**; Federal Ministry of Economics and Technology (2007), *Elemente einer Rohstoffstrategie der Bundesregierung*, **http://www.bmwi.de/BMWi/Redaktion/PDF/E/elemente rohstoffstrategie,property=pdf,bereich=bmwi,sprache=de,rwb=true.pdf**.

Agency (DERA). The DERA, under the managing umbrella of the Federal Institute for Geosciences and Natural Resources (BGR) advises the Federal government on policy-making and assists German companies in preventing failed investments and industrial failure.

• Technological development and innovation. This includes the optimisation of extractive processes for raw materials, promoting research into improved resource efficiency and materials substitution, and boosting recycling technologies.

• Higher education and training are both regarded as valuable instruments for the preparation of highly-qualified professionals and for promoting cooperation between professionals and scientific institutions of excellence.

• 'Raw materials diplomacy'. The Federal government has deployed a broad range of initiatives for a larger supplier diversification. The Ministry of Economics and Technology has established a number of strategic raw materials partnerships, eg, in 2012 with Kazakhstan and Mongolia, and in 2013 with Chile. Furthermore, strengthening bilateral relations with West and South African countries is an explicit intention of the government.

• Financial support for upstream activities. The capital intensity associated with exploration and exploitation activities is definitely a curbing factor, which limits the range of entrepreneurs with the capacity to undertake targeted actions. Thus, the Federal government offers a variety of instruments to help German companies manage the risks associated with fresh investments, among them: the government guarantees for untied financial loans (UFK-Garantien) for the development of raw-material projects abroad; investment guarantees against political risks; and the so-called Hermes Insurance against non-payment of foreign clients. The Explorations Support Programme, launched at the beginning of 2013, provides conditionally repayable loans for exploration projects both in Germany and abroad. The beneficiary companies, based and commercially operating in Germany, are liable to repay the loans only when their exploration activities result in profitable exploitations.

• Alignment with the EU Raw Material Initiative. It is not the intention of the German government to formulate a raw material strategy applicable to all EU member states, but to work together with the EU to back common national interests, in particular regarding technological and industrial challenges and commercial relations with producer countries.

• Multilateral cooperation. The Federal government has prompted the G8 and the G20 partners to engage with raw-materials sustainability, market transparency and good governance as a means of ensuring regional stability. It also backs international development policies to be sourced from national, EU and international programmes. An example of the latter is the Extractive Industries Transparency Initiative (EITI).

France

In 2010 the French government presented a strategic plan which stressed the importance of critical metals for the low-carbon sector.[9] Its major action points are:

• Strengthening France's strategic knowledge of the strategic metals that have the greatest impact on the French economy, in liaison with the extractive, processing and manufacturing industries.

• The intensification of targeted exploration projects through the combined efforts of coordinating public institutes and private partners, and the promotion of R&D activities in the field of extractive and processing techniques.

• The exploration of the potential resources of the ocean floor as a key objective until 2030.

• Improving the efficiency of recycling processes under the coordination of public expert agencies.

• Consolidating political support to entrepreneurial efforts with producer countries including China, Russia, Mongolia, Brazil and South Africa.

• Entering into bilateral partnerships with selected producer countries like Australia and Canada.

• Exchanging experiences with consumer countries (eg, the UK, Germany, Finland and Sweden) at the public, industrial and scientific levels.

• Fostering a coherent European policy that links security and sustainability with mining, industry, trade and development policies.

In January 2011 the French government created the Committee for Strategic Metals (COMES), an advisory body responsible for defining the directives for a strategic-metal security policy, which gathers public actors, technical bodies and entrepreneurial federations.

9 Portail du Gouvernement, *Les métaux stratégiques*, 27/IV/2010, **http://archives.gouvernement.fr/fillon_version2/gouvernement/les metaux strategiques.html**.

The UK

In March 2012 the Department for Business Innovation and Skills (BIS) and the Department for Environment Food and Rural Affairs (DEFRA) jointly published an action plan which addressed concerns previously raised by the Confederation of British Industry (CBI) and the EEF Manufacturers Organisation.[10] The plan highlights the difficulty of inferring both the economic value and future demand of critical metals and hence, to reliably assess the economic risks for British industry. On the other hand, an eventual restriction of critical metals is expected to affect the British economy less seriously than it would the economies of predominantly manufacturing countries like Germany.[11] The reason is that the bulk of British imports consist of semi-manufactured and manufactured goods, hence the global supply of critical metals affects the British economy mainly in an indirect way.

Criticality is regarded as a driver for innovative solutions which encourage the diversification of technologies and the development of new business models. In this regard, the British action plan identifies a number of potential competitive advantages centred on:

1) Research into new materials and materials substitution as a means for pioneering alternative solutions.

2) Cost saving to be gained from innovation in resource-efficiency production techniques and lifetime optimisation.

3) Secondary (local) supply capabilities if viable recovery processes can be demonstrated.

Some of the most important measures proposed in the action plan are:

- Priority identification. To enhance knowledge on the economic value and risks to British industry of critical metals is a central issue for further policy-making.

- Keeping the industry updated on risks and alternatives. The Environmental Sustainability Knowledge Transfer Network (ES KTN) and the British Geological Survey (BGS) have created a strategic-materials resource database that will enable British industry to assess medium- and long-term business risks and to evaluate alternative action.

- Managing political support. The British government has a commitment to represent the interests of the UK's national industry abroad and to mediate where market distortions appear. Bringing together national industry and scientific

10 Department for Business Innovation and Skills and Department for Environment Food and Rural Affairs (2011), *Resource Security Action Plan: making the most of valuable materials*, March, **http://www.defra.gov.uk/publications/files/pb13719 resource security action plan.pdf**.

11 House of Commons (2011), *5th Report – Strategically important metals*, The Science and Technology Committee, 17/X/2011, **http://www.publications.parliament.uk/pa/cm201012/cmselect/cmsctech/726/726vw.pdf**.

institutions is considered a powerful instrument to help shape policy priorities at the EU and international levels. The so-called Green Alliance has opened up new channels for the exchange of information and experience between the government, the industry and other significant groups.[12]

• Supporting research and development. The British government, through the Technology Strategy Board (TSB), financially supports innovation and research for the development of new products and services. The main areas identified are: metals substitution, optimisation of resource efficiency, re-use of specific products, and recycling and recovery of components and/or metals. Eligible projects should involve partners from the scientific, industrial and metal supply-chain sectors. Furthermore, the UK is well aware of the importance of defining EU-wide research goals which are aligned to British national priorities.

• Supporting deployment effectively. In September 2011 the TSB together with the Chemistry Innovation KTN and the ES KTN launched the Materials Security Special Interest Group (SIG), an interdisciplinary cross-link network with the mission of encouraging the adoption of new business models and supply chains to boost the effective deployment of innovative marketable solutions.

• Advocating transparency and good practices in politically unstable regions. The British government promotes the implementation of global transparency standards in all countries that belong to the critical-metal supply chain. Specifically, the government supports the EITI initiative and advocates coordinated development policy-making within the EU.

The Netherlands

The Dutch economy imports mainly semi-manufactured products and has only a limited dependency on critical materials. Thus the main goals of Dutch policy concerning critical materials consist in strengthening relations with the major semi-finished goods supplier countries.

The Dutch strategy pursues: (1) to safeguard a free international trade system and enforce development cooperation for good governance, transparency and sustainability; (2) to encourage raw material 'austerity'; and (3) to foster research (eg, in urban and deep-sea mining), innovation, recycling and substitution as sources of economic and business opportunities within the cooperation frameworks set up by the EU. The Dutch government highlights the tight link that must exist between the national and EU policies.[13]

12 The Green Alliance is a think-tank which, over more than 30 years, has worked closely with business, politicians and other influential groups to achieve political solutions to environmental challenges.
13 *Policy Document on Raw Materials*, August 2011, **http://ec.europa.eu/enterprise/policies/raw materials/files/docs/mss netherlands_en.pdf**.

Which way forward for Spain?

Presently, Spain is one of the leading countries in terms of renewable power generation and has a significant base of renewable manufacturing industry. By the end of 2011, Spain had become the fourth-ranking country worldwide for installed PV capacity. Moreover, Spain leads the CSP market and it belongs to the group of the four leading countries in total wind-power capacity. In parallel, the Spanish renewable industry has evolved to be one of the most dynamic business sectors of the national economy by both operating across the entire technology value chain and due to a significant international projection; for instance, at the end of 2011 Gamesa ranked fourth in the wind-turbine market, with an 8,2% global share.[14]

In this scenario, it is quite remarkable that the Spanish government has to date adopted no comprehensive critical-metal strategy. Even though the government identifies action on climate change and resource efficiency as main research and innovation areas, it has left out any consideration of a coordinated critical-metal action plan.[15]

In this regard, the government faces two urgent tasks. It is essential to adopt measures both to enable the national renewable-technology industry to overcome potential barriers and bottlenecks in the manufacturing-metal supply, and to mitigate the widespread perception that sectoral R&D and innovation initiatives are only of marginal interest in the national political arena. Such measures can only be undertaken in a context of widespread political awareness concerning the nature and the relevance of the critical-metal sector. Specifically, raw-material policy-making demands a multidimensional approach combining economic, financial, industrial, innovation, foreign, development and environmental policies. While this requires a more in-depth analysis for the Spanish case, which exceeds the scope of this paper, several very general proposals can be made.

On the one hand, due to its solid renewable-technology manufacturing base, Spain is in a position to implement some of the measures already adopted in other countries, including:

- Acquiring strategic knowledge of those metals which have the greatest impact on the Spanish low-carbon technology industry, in order to assess supply risks. Public bodies, professional associations, and scientific and academic circles should carry this out before implementing any specific measures.

14 REN21 (2012), *Ibíd.*

15 Ministry of Economy and Innovation (2013), *Estrategia Española de Ciencia y Tecnología y de Innovación*, February, **http://www.mineco.gob.es/stfls/mineco/prensa/ficheros/noticias/2013/Estrategia_espanola_ciencia_tecnologia_Innovacion.pdf**; Ministry of Economy and Innovation (2013), *Plan Estatal de Investigación Científica y Técnica y de Innovación 2013-1016*, February, **http://www.mineco.gob.es/stfls/mineco/prensa/ficheros/noticias/2013/Plan_Estatal_Investigacion_Cientifica_Tecnica_Innovacion.pdf**.

- Creating public advisory agencies, or empowering existing ones, with a remit to advise both the government in the adoption of adequate critical-metal supply directives, and national companies in their medium-term strategic business plans, as concerns metal availability, market evolution and efficiency. Following the German model, it is envisaged that the Geological and Mining Institute (IGME) and the Spanish National Research Council (CSIC) might play a relevant role.

- Promoting research into mineral and metalliferous resource technologies with applications for low-carbon technologies. This area of research can be linked to the current activities of the Centre for Energy, Technological and Environmental Research (CIEMAT).

- Launching a multilateral network involving governmental, professional associations and scientific and academic parties for the continued exchange of sectoral information, and for promoting training, education and standards development.

- Developing targeted raw-materials diplomacy, which on the one hand encourages bilateral relations (in particular with Latin American countries) that help diversify the range of supplier countries and, on the other, enables cooperation with the EU and other consumer countries to help identify synergies and satisfy common needs.

- Strengthening the visibility and presence of the Spanish entrepreneurial and scientific community in the European and international arenas in order to best represent national interests.

On the other hand, Spain should take advantage of its solid technological stand and ample market experience in order to maximise opportunities arising from niche innovation markets. In this regard, research into new materials, optimised resource efficiency, closed-loop recycling and re-use processes should all, in conjunction with appropriate standardisation, be strongly reinforced through the combined efforts of the Spanish government and private partners as a main prerequisite for pioneering market advantage.

As mentioned elsewhere in this paper, eventual critical-metal uncertainties bring both risks and opportunities. Therefore, the Spanish government should implement a comprehensive framework –political, legal and institutional– to anticipate any potential risks to the national renewable energy sector as well as to increase the competitive value of the national economy through innovative practical knowledge and business models.

Conclusions

The EU's renewable and energy efficiency targets could eventually be challenged by unexpected restrictions in the critical-metals supply chain, prompting the reaction of a number of governments. In this paper two relevant EU 'country profiles' have been identified as regards the exposure of the national industry and business networks to critical-metal dependency. Germany and the UK, as paradigmatic representatives of each profile, but also France and the Netherlands, have produced a portfolio of policy instruments and adopted a number of measures (as set forth in various national critical-material strategy documents) to represent and support their national industry as well as scientific interests at the EU and international levels.

At the time of writing, these issues have not yet been under discussion by the Spanish government. However, the potential impact of restrictions in the critical-metal supply chain on Spain's pre-eminent position in the renewable technologies sector requires prompt measures from the Spanish government both to anticipate such risks and to identify and exploit pioneering business models and technology solutions based on innovative practical knowledge.

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