

The Revised German Raw Materials Strategy in the Light of Global Political and Market Developments

Marc Schmid* 

Martin-Luther-Universität Halle-Wittenberg

Abstract

Raw material markets have proven to be challenging in recent years. The so-called critical raw materials (CRMs), which are required for green technology, have particularly high environmental and supply risks. The revised German raw materials strategy attempts to address challenges of production and supply of CRMs and other mineral-based raw materials. This contribution analyzes the motivation, measures, goals, and challenges of the German raw materials strategy in the light of global economic and political developments, applying the qualitative method GABEK®. Results show that the revised strategy is more ambitious and reaches farther than the initial strategy of 2010. Challenges that remain include the lack of willingness of the German industry to engage in mine production and the more pro-active political approaches demonstrated elsewhere. As all major economic powerhouses outside of Europe pursue a hands-on approach, it remains questionable if the revised German raw materials strategy will fundamentally be able to sustainably secure raw material supply for the German industry.

KEY WORDS: raw materials strategy, green technology, critical raw materials, supply risks, political economy, Germany

近年来原材料市场证明是具有挑战性的。绿色科技所要求的关键原材料(CRMs)尤其具有高环境风险和供应风险。近期宣布的修订版德国原材料战略试图应对CRMs和其他矿物原材料的生产和供应所带来的挑战。本文使用定性方法GABEK®,分析了全球经济和政治发展背景下德国原材料战略的动机、方法、目标和挑战。结果表明,修订后的战略比2010年最初战略更有志向,覆盖面更广。仍然存在的挑战包括德国产业在参与矿产开采方面意愿的缺乏,以及其他地区出现的更积极的政治措施。鉴于欧洲以外的所有大型经济强国追求一种实际操作的方法,还有待考究的是,修订版德国原材料战略是否将从根本上为德国产业可持续地确保原材料供应。

关键词: 原材料战略, 绿色科技, 关键原材料, 供应风险, 政治经济, 德国

Los mercados de materias primas han demostrado ser un desafío en los últimos años. Las denominadas materias primas críticas (CRM), que son necesarias para la tecnología verde, presentan riesgos medioambientales y de suministro particularmente elevados. La estrategia alemana de materias primas revisada recientemente anunciada intenta abordar los desafíos de la producción y el suministro de CRM y otras materias primas a base de minerales. Esta contribución analiza la motivación, medidas, objetivos y desafíos de la estrategia alemana de materias primas a la luz de los desarrollos económicos y políticos globales, aplicando el método cualitativo GABEK®. Los resultados muestran que la estrategia revisada es más ambiciosa y va más allá que la estrategia inicial de 2010. Los desafíos que quedan incluyen la falta de voluntad de la industria alemana para participar en la producción minera y los enfoques políticos más proactivos demostrados en otros lugares. Dado que todas las grandes potencias económicas

*Corresponding author: Marc Schmid E-mail: marc.schmid@wiwi.uni-halle.de

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fuera de Europa persiguen una evaluación práctica, sigue siendo cuestionable si la estrategia alemana revisada de materias primas podrá fundamentalmente asegurar de forma sostenible el suministro de materias primas para la industria alemana.

PALABRAS CLAVE: Estrategia de materias primas, tecnología verde, materias primas críticas, riesgos de suministro, economía política, Alemania

Introduction

The production of renewable energy as well as the development of new equipment for e-mobility on the way to a CO₂ neutral economy, thereby complying with the goals of the Paris climate accord, requires technologies that are based on critical raw materials (CRMs) (Ali et al., 2017; Sovacool et al., 2020). However, the latter's supply situation can become constrained and disrupted (de Koning et al., 2018; Nassar, Graedel, & Harper, 2015), their production is typically ecologically and socially problematic (Ali et al., 2017; Tkaczyk, Bartl, Amato, Lapkovskis, & Petranikova, 2018) and substitutes usually deliver inferior performance or are not available at all (Graedel, Harper, Nassar, & Reck, 2015). Many CRMs are subject to trade restrictions such as export tariffs and export quotas (OECD, 2019). Consequently, several CRM's have been in critically short supply and prices of rhenium, rare earths, lithium, and cobalt, for example, have spiked in recent years (Burton, 2019; Helbig, Bradshaw, Wietschel, Thorenz, & Tuma, 2018; Olivetti, Ceder, Gaustad, & Fu, 2017; Schmid, 2019a). Such price peaks and supply disruptions as well as questions concerning sustainability of raw material production has caused concern among businesses and politics.

Faced with these economic and environmental challenges, many countries worldwide have launched political programs to actively support, for example, direct access to mine production, recycling activities, substitution of CRMs and stockpiling (Barteková & Kemp, 2016; Schmid, 2020b). Germany published its first raw materials strategy in 2010 to reduce its exposure to supply and price risks (BMW, 2010). The country is particularly affected by these risks as it is the biggest economy in the European Union (EU) and one of the major users of raw materials worldwide. It is among the top three importers of many raw materials (DERA, 2019). Germany's export-oriented economy is highly dependent on a stable supply of raw materials, smooth trade flows and a functioning global free trade regime. Germany has also the highest trade deficit in raw material trade among all EU member states (Eurostat, 2016).

Since Germany's first raw materials strategy was announced in 2010, the geopolitical landscape and global raw material markets have changed (Humphreys, 2019). Decarbonization and sustainability requirements have further increased and technological progress requires an increasing amount of metals (Vidal, Goffé, & Arndt, 2013). Technological change in the fields of mobility, renewable energy, and information technology has accelerated, which also leads to mounting raw material demand (Martin, Rentsch, Höck, & Bertau, 2017; Reller et al., 2009; Ziemann, Grunwald, Schebek, Müller, & Weil, 2013). With regard to the global political landscape, growing trade disputes and a retreat from free trade can be observed (Blengini et al., 2017; Fajgelbaum, Goldberg, Kennedy, & Khandelwal, 2020; Niblett, 2017). Export

restrictions that affect the trade of minerals and metals are intensifying (Korinek, 2019).

In this changing environment, the German raw materials strategy of 2010 (BMW, 2010) seemed to be outdated and the current German administration saw the need for a revision. Its revised raw materials strategy (BMW, 2020), which was announced in mid-January 2020, is supposed to address crucial aspects of raw material supply and future challenges to the raw material markets.

The aim of this paper is to identify drivers of and motivations behind the revised raw materials strategy and to answer the following questions:

- What are the major challenges in the raw material markets identified in the strategy?
- By what measures shall these challenges be addressed?
- Are these measures able to meet the challenges?

Based on a brief introduction to criticality of raw materials, this contribution analyzes the drivers behind the revised German raw materials strategy and evaluates measures, goals, and potential challenges of the revised strategy. Experiences from the former German raw materials strategy and of political measures worldwide are considered as well as current global developments, especially sustainability requirements, nationalization of resources, and global trade restrictions. The level of commitment to the revised German raw materials strategy, especially in comparison to those of Japan, the United States, and others, is also discussed.

Raw Material Markets and German Policy

Criticality and Critical Raw Materials

New, green technologies, particularly require CRMs (Grandell et al., 2016; Nansai et al., 2014). CRMs are usually defined along two dimensions: vulnerability and supply risk (European Commission, 2010, 2014, 2017b; Fortier et al., 2018; Miyamoto,

Table 1. Market Concentration of Some of the Most Critical Raw Materials (2018)

Raw Material	Major Producer	Share of World Production
Gallium	China	95%
Niobium	Brazil	88%
Magnesium (metal)	China	82%
Tungsten	China	82%
Bismuth [†]	China	81%
Beryllium	United States	74%
Rare Earths	China	71%
Antimony	China	71%
Platinum	South Africa	69%
Arsenic (arsenic trioxide)	China	69%
Graphite (natural)	China	68%
Cobalt	DR Congo	64%
Fluorspar	China	60%
Vanadium	China	55%
Rhenium	Chile	55%
Phosphate rock	China	52%

Source: USGS (2019), author's calculation; primary/mine production unless noted as refinery production (†).

Kosai, & Hashimoto, 2019). Typically, sustainability aspects of raw material production are taken into account as a third dimension (Graedel & Reck, 2016). Vulnerability captures the raw materials' relevance and the potential effects of supply disruptions. As industrialized economies, which are based on modern technologies, employ most elements of the periodic table of elements (Graedel et al., 2015; Zepf, Reller, Rennie, Ashfield, & Simmons, 2014), many raw materials have a certain degree of economic importance. The relevance of critical raw materials has been discussed with regard to different countries, industries, and technologies as well as the military (Nassar et al., 2020; Powell-Turner & Antill, 2017; Rabe, Kostka, & Stegen, 2017; Ziemann et al., 2013).

Supply risks require particular attention to identify the most critical raw materials (BGS, 2015). Supply risks are particularly high when mine production is concentrated in only few countries and the rest of the world is dependent on the imports from few players. Table 1 illustrates the market structure of some of the critical raw materials with the highest market concentration, including gallium, niobium, tungsten, rare earths, antimony, and platinum (USGS, 2019). These results are essentially in line with findings from criticality studies in recent years (DERA, 2017; European Commission, 2017b; Fortier et al., 2018).

In the case of 11 of these 16 raw materials, China is the dominant producer with a production share of more than 50% and up to 95% in the case of gallium. Increasingly, China not only dominates the mine production of many (critical) raw materials, but also farther stages along the value chain, such as refining, separation, and processing (DERA, 2019). China's strong position in raw material production has initiated leadership aspiration, downstream of the value chain, by leveraging its rich deposits to strengthen its industrial base (Biedermann, 2014; Mancheri, 2012; Rabe et al., 2017; Wübbecke, Meissner, Zenglein, Ives, & Conrad, 2016). The country increasingly aims for technological leadership and tries to build market leaders that offer tough competition to Western companies (Wübbecke et al., 2016).

China is also very restrictive in terms of trade in raw materials (Fliess, Arriola, & Liapis, 2014; Korinek & Kim, 2011) and its raw material production is typically accompanied by environmental pollution and low labor standards (Ali, 2014; Geng & Saleh, 2015; Gregory, 2010; Packey & Kingsnorth, 2016). Repeatedly, China has used its market power for its own geopolitical purposes and for strengthening its domestic industry, for example, in the territorial dispute with Japan in 2010 (Bradsher, 2010; Morrison & Tang, 2012). CRMs have also become an issue in the rivalry between the United States and China (Gulley, Nassar, & Xun, 2018), as the latter seems to be poised to use its market power in the production of rare earths as a lever in the escalating trade dispute (Schmid, 2019a, 2019b). Overall, CRMs are a focal point in the increasing nationalism and protectionist policies that can currently be observed worldwide (Fajgelbaum et al., 2020).

The German Raw Materials Policy

Germany introduced its first raw materials strategy in 2010 (BMW, 2010), to address issues of supply risks, social costs, and sustainability of raw material production. The German raw materials strategy concentrated on easier access to raw materials and transparency in the raw material markets, material efficiency, recycling and

material research, especially in substitution (BMW, 2010; Schmid, 2020b). German raw material-related activities have placed considerable focus on research funding to achieve these goals (Schmid, 2020b). The German government implemented various political programs such as the German Resource Efficiency Program (ProgRes in 2012 and ProgRes II in 2016), Research for the Provision of Raw Materials of Strategic Economic Importance (r4) in 2016 and Research for Sustainable Development (FONA3) in 2015. Concrete actions also included establishing the Helmholtz-Institute Freiberg for Resources Technology (HIF) and founding the German Raw Material Agency (DERA) (Mildner & Howald, 2013). On an international level, setting up bilateral raw material partnerships with Kazakhstan, Mongolia, and Peru were some of the more profound steps (BMW, n.a.). These raw material partnerships, however, delivered few concrete results and did not fulfill the expectations of either politicians or companies (Book, Crocoll, & Petring, 2019; Müller, 2019; personal communication). None of the countries of the partnerships have proven to be a reliable source of CRMs for German industry. In addition, more or less substantiated criticisms of the initial German raw materials strategy includes neglecting sustainability aspects of raw material production (Germanwatch, Inkota-Netzwerk, Nabu, Powershift, & WWF, 2019; NABU, 2019), little care for transparency and human rights (Mildner & Howald, 2013) and a lack of political courage and willingness to mediate market failures (Kullik, 2019). The latter is also due to the base line of the initial German raw materials strategy, which clearly stated: *“The Federal Government agrees with the business community that it is basically a matter for the companies themselves to ensure their own supply of raw materials”* (BMW, 2010, p. 8). This relatively reserved position of the German government laid the ground for all actions undertaken in the following years.

In recent years, several stakeholders called for a revision of the German raw materials strategy and a paradigm shift away from the previously restrained raw materials policy for different reasons and with different motivations (AK Rohstoffe, 2019; BDI, 2015b, 2018; NABU, 2019; Germanwatch et al., 2019). Various NGOs called for a German raw materials strategy that focusses on more sustainable raw material consumption, sustainability criteria for raw material production and due diligence obligations for companies (AK Rohstoffe, 2019; NABU, 2019). The NGOs' call for more protection of human rights and of the civil society when engaging in mining activities (Germanwatch et al., 2019) also found political support (Deutscher Bundestag, 2017). The Federation of German Industries (BDI) underlined the need for political measures (of the German government) to reduce distortions of the trade and market for raw materials and called for bilateral and multilateral agreements, political partnerships, and the creation of a transparent political framework (BDI, 2015b). In 2018, the BDI (2018) renewed its call for action and made several requests, ranging from strengthening measures that enable a circular economy to more engagement in exploration activities in the deep sea and outer space. The German government itself justified the need for a revision of its raw materials strategy (BMW, 2020) by citing changed framework conditions, especially increased need for raw materials due to disruptive technologies, the increase in trade disputes, politically caused market distortions, high market concentration, and responsibility for sustainable supply chains (BMW, 2019b). The revised German raw materials strategy shall secure competitive raw material supply for future technologies, while taking into account sustainability requirements and transparency along the supply chain (BMW, 2019b). By doing so, the German raw

materials strategy is embedded into European raw materials-related policies and initiatives such as the European Commission's critical raw materials assessments (European Commission, 2010, 2014, 2017b), the raw materials initiative (European Commission, 2008), and the European Commission's plan of implementing a circular economy in the EU (European Commission, 2015). Ensuring the supply with raw materials is also crucial for the European Union's Green Deal (European Commission, 2019) and a fundamental pillar of the EU's industrial strategy (European Commission, 2020).

In recent years, few scholars have analyzed political raw materials strategies worldwide. Their studies compared policies in different world regions (Barteková & Kemp, 2016), policies on strategic and critical raw materials in China (Andersson, 2020; Biedermann, 2018; Shen, Moomy, & Eggert, 2020), the competition for raw materials of certain countries (Gulley et al., 2018; Schmid, 2019a; Vekasi, 2019), and policy measures with regard to certain CRMs, especially rare earths (Mancheri, Sprecher, Bailey, Ge, & Tukker, 2019; Wübbecke, 2013). Furthermore, some scholars focused on the analysis of corporate raw material strategies, which are often intertwined with national policies (Lapko, Trucco, & Nuur, 2016; Schmid, 2020a, 2020b). The author is not aware of a structured, qualitative analysis of raw materials strategies, in general, to date, nor of the revised German raw materials strategy (BMW, 2020) in particular.

Methods

In order to systemically analyze the revised German raw materials strategy (BMW, 2020) and to take a closer look at certain aspects of the strategy, a structured textual analysis is undertaken. The in-depth analysis is based on the GABEK® method, which was established by Josef Zelger (Zelger, 2000; Zelger & Oberprantacher, 2002). The GABEK® method enables a "holistic management of complexity."¹ It is particularly well-suited for a structured examination of textual data (Raich, Müller, & Abfalter, 2014) and is well-established as a method to analyze assessments of facts and circumstances (Rhein & Schmid, 2020), to reflect justification models and to reconstruct decision making and strategizing (Schmid, 2020a, 2020b). The data processing followed the GABEK® procedures as it is implemented by the software application WinRELAN® to maintain methodical rigor.

The procedure is as follows: First, the text is subdivided in text units. Text units are short sections consisting of one or few sentences with coherent thoughts and meaningful, comprehensive sense units (Zelger, 2004). Second, these individual sense units are coded by the researcher according to the key terms that can be found in the respective units (Zelger & Oberprantacher, 2002). Third, the coding of the individual sense units is the basis for the following analysis in the form of network graphics of codes that show close associations in the sense units with regard to the different aspects under investigation. The association graphs illustrate the codes that are connected with each other in the sense units. A connection between two codes means that they are used in the same sense unit and are, therefore, associated with each other. Typically, those connections that occur several times receive particular attention to reduce complexity in the network graphics (Zelger & Oberprantacher, 2002). In general, the closer the association of the codes, the stronger the linkage in the network graphics. The network graphics are consequently an illustration of linguistic

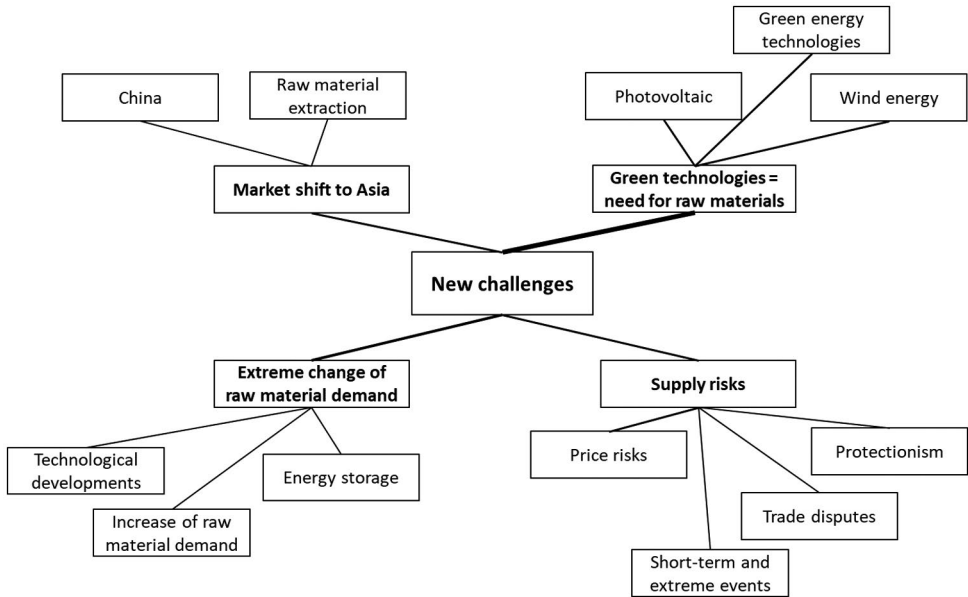


Figure 1. “New Challenges” Identified by the Federal Government in its Raw Materials Strategy

networks of associated codes. The network graphics help to navigate the associations and commonalities (Zelger, 2000).

During the entire process, the eight “big-tent” criteria introduced by Tracy (2010) are taken into account to ensure high quality standards in the qualitative research process. Additional information on the GABEK®-based coding is available in the supplementary material.

Results: The Revised German Raw Materials Strategy

Drivers and Measures of the Revised Strategy

A GABEK®-based analysis of the challenges discussed in the strategy reveals, in detail, what the German Federal Government considers to be the major issues in the raw materials sector (Figure 1). Four major challenges can be identified in the revised strategy: (i) green technologies that lead to raw material demand, for example, of renewable energy technology like photovoltaic and wind energy, (ii) supply risks, for example, due to protectionism, trade disputes, and abrupt and extreme events, (iii) extreme changes in raw material demand because of technological developments such as energy storage, and (iv) an overall shift in the raw material markets to Asia, especially to China.

Faced with these challenges, the raw material policy aims to contribute to the companies’ stable supply of raw materials by strengthening the value chain and ensuring a competitive and sustainable raw material supply (BMW, 2019b). The Federal Government seems to be willing to address these issues in its revised raw materials strategy with a more active political approach. The strategy says: “*In the view of the German government, securing raw materials is still primarily the responsibility of companies.*”

Table 2. Overview of the 17 Measures (M) of the Revised German Raw Materials Strategy (BMWi, 2020) with Explanatory Comments by the Author

M	Aim	Field of Action	
1	“Responsible raw material extraction”: promotion of responsible mining and initiatives like the Extractive Industries Transparency Initiative (EITI)	“Domestic raw materials: indispensable pillar of the national raw materials supply”	
2	“Securing and disclosure of geological data”: Easier access to geological data at lower costs		
3	Promoting primary raw material extraction in Germany and Europe in the metals sector”: support of EU-led activities to produce raw materials for e-mobility and renewable energy in the EU		
4	“Securing raw materials”: explore domestic raw material deposits and provision of scientific and technical infrastructure	“Raw material imports: effectively increasing responsible security of supply”	
5	“Sustainable mining closure”: establish a research institute to investigate sustainable closure of mines and transformation of regions		
6	“Creating raw material awareness—strengthening acceptance for domestic raw material extraction”: Raise awareness for the importance of raw materials and increase acceptance of domestic mine production in German society		
7	“Creating a level playing field in the supply of raw materials”: Investigate further potential political measures to secure raw material supply; plus: “Reduction of trade barriers and distortion of competition” without specific measures, but a reference to the WTO		
8	“International raw materials policy and foreign trade promotion by the Federal Government”: securing funding for the six existing competence centers for mining and raw materials and establishing another center in Ghana and, potentially, one in Asia		
9	Guarantees for untied loans (“UFK guarantees”): provide loan guarantees for investments in return for long-term supply agreements for German companies		
10	“Further development of DERA (German Raw Material Agency) raw material monitoring”: Further market analysis and monitoring of raw materials and value chains based on them		
11	“Sustainable raw material management in developing and emerging countries”: Support of the World Bank for a “Climate Smart Mining”		
12	“Circular economy and secondary raw materials as a source of raw materials”: Support R&D for recycling of raw materials for future technologies and promote a resource-efficient circular economy		“Circular economy and secondary raw materials as a source of raw materials”
13	“Circular economy and secondary raw materials as a source of raw materials”: dialog with science, industry and administration to overcome challenges of a circular economy and to increase the usage of secondary raw materials		
14	“Raw material and resource efficiency”: lightweight construction strategy under consideration of life cycle assessments	“Raw Material and resource efficiency”	
15	“Corporate due diligence in supply and value chain”: initiate an international process to ensure environmental responsibility along the supply chain; also: reference to the EU-regulation on conflict minerals and to the EITI	“Sustainability and transparency in the raw materials sector”	
16	“International Cooperation”: Support to establish international sustainability standards in mining	“International Cooperation”	
17	“Cooperation with the European Commission”: Support of the measures of the European Commission and intensified exchange to coordinate measures		

*At the same time, however, numerous market developments in recent years make it clear that this market-based approach, which is based on free and fair access to raw materials, is often no longer sufficient*²² (BMWi, 2020, p. 20). With this statement the revised strategy partially resembles the initial strategy (BMWi, 2010). However, there is a clear difference with regard to whether a pure market-based approach will be able to meet the new challenges in the raw material sector. The revised strategy acknowledges that the raw material markets have increasingly become subject to state intervention and political measures as “[s]tate-controlled raw materials policy with active support in the area of securing raw materials eliminates international competition” (BMWi, 2020, p. 7). Furthermore, the strategy states: “An increasing number of export restrictions are being imposed, especially on metallic raw materials and energy sources. This approach may jeopardize growth and employment

in Germany in the medium term” (BMWi, 2020, p. 23). The German Federal Government is seemingly willing to pursue a more active approach with its revised raw materials strategy in order to ensure a stable and price competitive raw material supply, to mitigate supply risks and negative effects of trade distortions on the competitiveness of the German industry. In order to achieve these goals, the revised German raw materials strategy (BMWi, 2020) concentrates on three pillars (BMWi, 2019b):

- Increase domestic production
- Support the import of raw materials
- Increase recycling activities

These three pillars and additional aspects to address specific challenges in the mine production and in the raw material markets, are substantiated by individual political measures (Table 2). Besides measures that directly support each one of the three strategic pillars, there are ancillary fields of action, namely measures that aim to increase resource efficiency, transparency, and sustainability, and enhance international cooperation. In total, the revised strategy includes 17 specific measures (BMWi, 2020).

A closer look at the different measures shows a strong focus of the revised German raw materials strategy on domestic raw material production (6 measures) and on strengthening imports and securing raw material supply from abroad (5 measures). Securing a stable raw material supply from both domestic sources and through imports can, therefore, be considered as the main goal of the strategy as this is the aim of 11 of the 17 individual measures. In contrast, promoting a circular economy and increasing the use of secondary raw materials receives relatively little attention, with only two specific measures. This is of particular interest as the transformation to a Circular

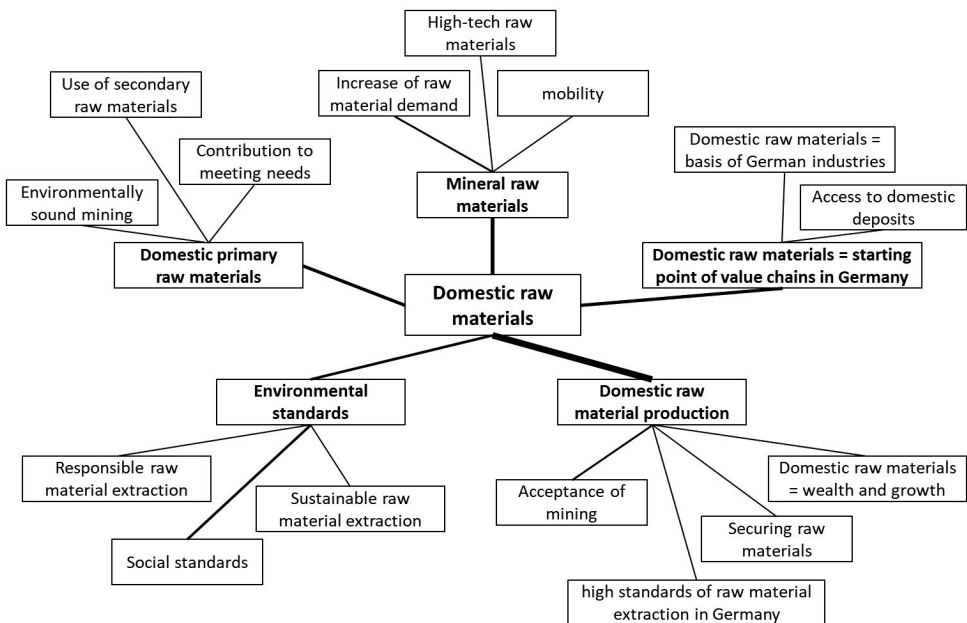


Figure 2. Associations with Domestic Raw Materials in the German Raw Materials Strategy

Economy is a key goal of the European Commission (European Commission, 2015; Mayer et al., 2019). There is also only one measure under the paragraph “Sustainability and transparency in the raw materials sector” that explicitly targets sustainability and transparency in the early stages of the supply chains. This does not necessarily mean that sustainability is not sufficiently considered in the strategy. Instead, the aim seems to be to take sustainability requirements into account with practically every measure. Consequently, sustainability is mentioned frequently throughout the entire strategy (the author counts “sustainable,” “sustainability” and related words 53 times in the entire document). The strategy, in particular, emphasizes the advantages of a German and European raw material production at the highest environmental and social standards: *“It is important to get back into the business of local extraction of raw materials. In this way, raw materials can be extracted and processed in Europe under the highest environmental and social standards, thus preventing problems such as “burden shifting,” the shifting of production-related environmental pollution to other countries”* (BMW, 2020, p. 16).

Finally, the revised strategy also aims for resource and raw material efficiency as well as increased international cooperation. Specific measures for the latter, however, remain vague and aim for promoting cooperation, which does not seem to be very ambitious.

Major Strategic Pillars

The revised German raw materials strategy relies on the three pillars of domestic production, raw material imports and recycling. All three pillars require a detailed analysis.

As described, these pillars, are, however, not equally weighted. A strong focus is put on raw material imports and more domestic production with the latter being indeed a novelty in comparison to the initial raw materials strategy. Figure 2 illustrates the associations in the revised strategy with regard to domestic raw materials.

According to the revised raw materials strategy, domestic raw materials shall increasingly contribute to Germany’s raw materials need and—in combination with greater use of secondary raw materials—meet a large proportion of its growing raw material demand. Domestic raw material production is associated with new demand on mineral raw materials, especially so-called high-tech raw materials, for example, for mobility applications. Domestic raw materials are also considered to be important as a starting point for German value chains and access to domestic raw materials is assumed to be crucial for several German industry branches.

In addition, the revised German raw materials strategy stresses the possibilities of environmentally friendly domestic mine production. It is argued that the environmental and social standards in Germany enable responsible raw material production from domestic deposits. At the same time, high environmental and social standards are seen as a prerequisite for the social acceptance of mine production in Germany. However, the strategy does not explicitly say how these projects could compete with projects abroad, which do not necessarily include negative externalities in their price calculations. Raw materials are commonly produced in countries with low environmental standards and only minor regulations with regard to the impact of mining on the local community and human health (Edwards et al., 2014; Schrecker, Birn, & Aguilera, 2018; Whitmore, 2006). Border adjustment measures could help increase

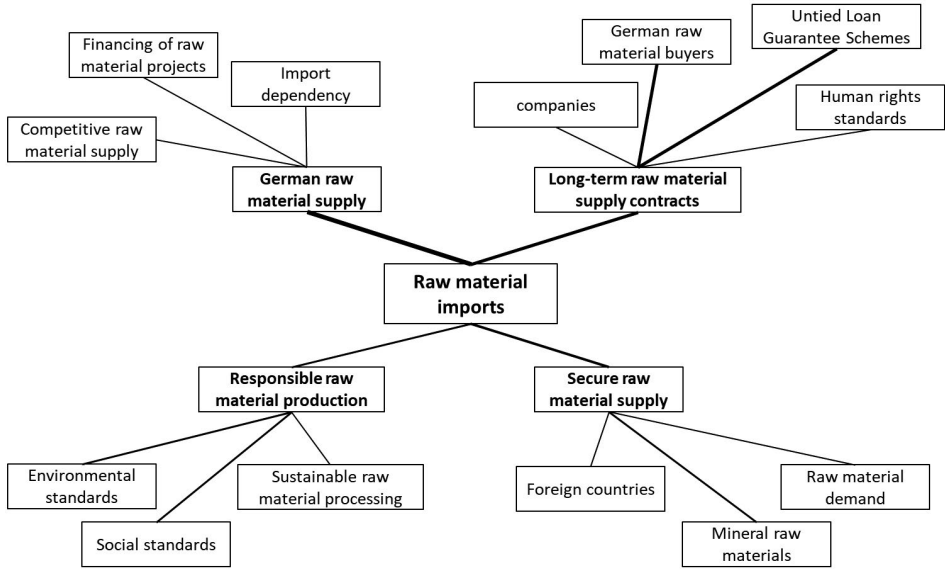


Figure 3. Associations with Raw Material Imports

price competitiveness of domestic raw material production but harbor potential for trade conflicts (Fouré, Guimbar, & Monjon, 2016; Mehling, van Asselt, Das, Droege, & Verkuijl, 2019) and could endanger competitiveness of German companies with their global rivals.

In general, a strong focus is put on domestic production of construction raw materials, which reveals some fundamental problems. Although Germany has some domestic raw material production, its main products are clay, sand, gravel, natural stones, gypsum, potash, and with regard to energy raw materials, brown coal, gas, and crude oil (BGR, 2018). Metal production is negligible, with an annual production of 63 t of copper, 6 t of silver, and 7 kg of gold (BGR, 2018). With regard to the critical raw materials listed in Table 1, there is no relevant German production besides fluorspar. However, German fluorspar production accounts for less than 1% of world production (BGR, 2018; USGS, 2019).

The strategy also acknowledges that increased domestic raw material production will not be sufficient. Import dependency will prevail. Figure 3 illustrates the associations of the revised German raw materials strategy with regard to raw material imports.

In the German raw materials strategy, the necessity of imports is directly linked to Germany’s import dependency and the need for competitive and secure supply of mineral raw materials from foreign countries. Long-term raw material supply contracts are considered an important pillar to address these challenges and to secure stable raw material imports. The strategy stresses the availability of untied loan guarantee schemes for German companies when projects are tied to long-term supply contracts and when they are in accordance with human rights standards. Overall, a special focus is put on responsible raw material production abroad under high environmental and social standards. Sustainability requirements not only concentrate on raw material extraction, but also include the processing of raw materials.

As a way to reduce the risks of potential supply disruptions and the resulting competitive disadvantage for the German industry, the German government aims to establish

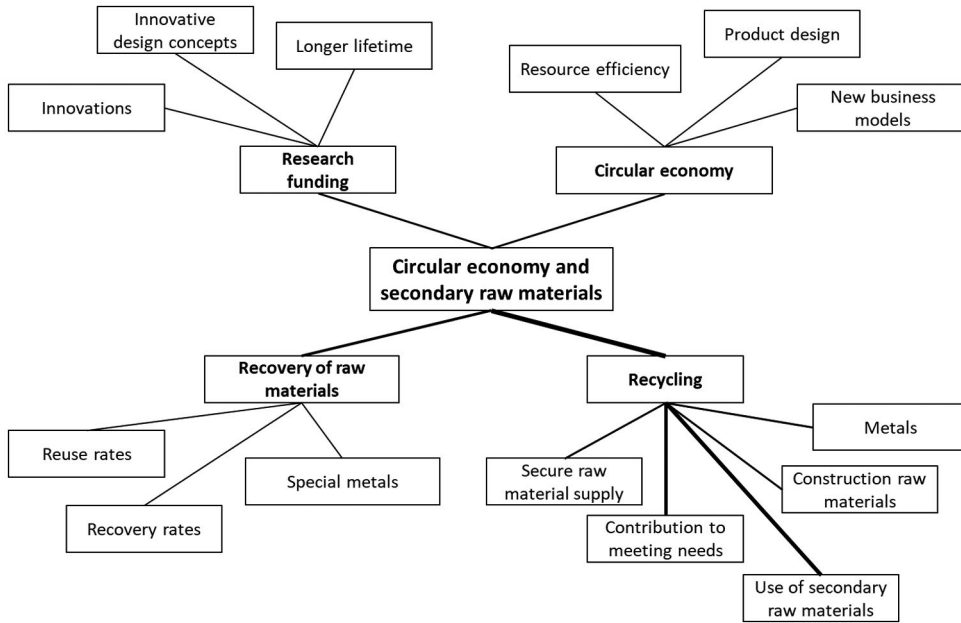


Figure 4. Associations with Circular Economy and Secondary Raw Materials

a “level-playing-field” (BMW, 2020, p. 20) and emphasizes the important role of the World Trade Organization (WTO), which enables settlement of trade disputes via its Dispute Settlement Body (DSB). However, the WTO is weakened and currently limited in its capacity to act (Brewster, 2018). The German Federal Government consequently does not rely on a single approach, but stresses instead: “*In addition, the Federal Government will in future make even more consistent use of the bilateral dialogue with countries that use trade and competition distortions to achieve a reduction in political intervention in the markets*” (BMW, 2020, p. 23).

As a third pillar, the German raw materials strategy focuses on increasing recycling rates to replace primary raw materials through secondary raw materials (Figure 4).

Extended recycling activities shall contribute to meeting raw material needs of the German economy by securing secondary (instead of primary) raw materials supply, in particular, of construction raw materials and metals. Increasing the recovery of raw materials, in the raw materials strategy, is achieved by focusing on politically set reuse and recovery rates, which have already been put in place through various legislative amendments in recent years.

The raw materials strategy, however, reaches much farther than increasing the use of secondary raw materials: it is also an attempt to support the transformation of the current linear into a circular economy. Establishing a circular economy is seen as resource efficient and shall be supported by respective product designs and new business models. The strategy will be achieved by several research funding measures to accelerate innovations, such as innovative design concepts and longer product lifetimes. The German raw materials strategy (BMW, 2020) is in line with current developments in the EU (European Commission, 2015) and addresses the negative externalities caused by mining activities—secondary raw material production requires only a small proportion of energy and emits remarkably less CO₂ than primary raw

material production (Binnemans et al., 2013; Damgaard, Larsen, & Christensen, 2009; Ekman Nilsson et al., 2017; Reck & Graedel, 2012). At the same time, recycling reduces the need for imports and, therefore, relaxes market concentration and supply dependence (Gaustad, Krystofik, Bustamante & Badami, 2018; Rademaker, Kleijn, & Yang, 2013). Many challenges remain associated with recycling, especially of CRMs: they are typically used in small amounts and are mixed with other raw materials, which makes recycling difficult and costly. However, as their recycling quota are still relatively low (Graedel et al., 2011), potential for CRM recycling is enormous. The German raw materials strategy tries to contribute to overcoming the remaining problems with the help of research funding, by setting reuse and recovery rates and by intensifying the dialog between science, industry, and administration, which seems to be rather vague. Because it proposes only two specific measures, the transformation into a “circular economy and secondary raw materials as a source of raw materials” (BMWi, 2020), however, receive only minor attention.

Discussion

Strategic Measures in the Nexus of Politics and Companies

One can acknowledge that the revised German raw materials strategy seems to follow a more pro-active approach, is less reserved and more holistic than its predecessor of 2010. Attributing a more active role to politics can be seen to be in line with an overall shift in the German political landscape in recent years, which redefines the role of politics in the market economy in Germany. This more hands-on approach fits into recent developments in German economic policy that focus more on maintaining competitiveness along the entire value chains, thereby acknowledging that competitive advantage is based on a strong position of the German industry at every step, as stated in the “National Industrial Strategy 2030” (BMWi, 2019a). The German industrial strategy also acknowledges that active state intervention may become necessary in certain situations: *“If the market forces within a country’s economy cannot maintain its innovative strength and competitiveness, then it is the responsibility and task of the state to step in”* (BMWi, 2019a, p. 2). Similar motivations can be found in the revised German raw materials strategy (BMWi, 2020).

The revised German raw materials strategy, from this perspective, seems to be a major step forward in taking action for both securing the supply of CRMs and enforcing a more sustainable raw material production. However, the bottom line remains that the German government considers the supply of raw materials as a task for industry and that politics can only support companies’ efforts. This attitude was already formulated in the original German raw materials strategy of 2010 (BMWi, 2010) and was once again stressed during the discussions concerning plans for German battery cell production (Deutscher Bundestag, 2019). Therefore, the German political approach of addressing market distortions and externalities in the production of raw materials seems to be both ambitious and reserved at the same time. German politicians seem to be trapped between their belief that companies know best how to handle individual risk and how to address global challenges, and the notion that the latter approach will not be adequate to meet the new global challenges in the raw material markets,

especially with regard to China's state capitalistic approach. The latter is based on partially or wholly state-owned companies. The politicization of decision making in the Chinese economy shall ensure long-term planning in the companies in order to establish national and global champions that compete with western companies (Lin & Milhaupt, 2013; Schweinberger, 2014). China's state capitalistic system is frequently subject to allegations such as discrimination against foreign companies that try to gain market access in China, unfair trade practices, dumping and state subsidies (Gang, 2015; He, Chakrabarty, & Eden, 2016).

As a reaction, the United States under the Trump administration has put China into the center of its trade dispute (Tankersley & Bradsher, 2018) and is seemingly willing to risk an open confrontation with China (Friedberg, 2018; Kubo, 2019). Japan, historically, has had a problematic relationship with China, which has been fueled by recurring territorial disputes (He, 2007; Nakano, 2016) that have also led to aiming for independence in raw materials supply (Schmid, 2019a). In contrast, Germany has refrained from taking a confrontational position toward China under the governments led by Chancellor Merkel (Barkin, 2020). However, the Germans are less and less willing to accept China's international ambitions and its trade and investment policy and are becoming skeptical about China (Webb, 2019). A tougher stand against China is frequently called for by both politicians and companies (The Economist, 2020).

The area of tension between the belief in the market economy and company's innovative capacity and the need to address the challenges of China's state capitalism does not seem to be entirely balanced in Germany yet, which is of particular interest as an increased engagement of the German government in the raw material production and, in general, in the early stages of the value chain, can only support activities of private companies. The relatively low interest from industry to engage in raw material production has, however, been a major problem of the German raw materials strategy in the past (Book et al., 2019). Although dependency on CRMs from China is high, there is relatively little willingness on the part of German companies to secure their material demand by investments in mine projects or by making long-term commitments (Schmid, 2020a, 2020b). The German ministry of economic affairs stated that, due to the lack of interest from German industry, no substantial improvement with regard to the supply situation could have been achieved by either the exploration funding opportunities or by the international partnerships (BMWi, 2018, 2020). As the rare earth crisis has shown, willingness and capabilities of companies, affected by supply risks, to pursue long-term oriented raw materials strategies are limited (Schmid, 2020b). In its initial raw materials strategy of 2010 (BMWi, 2010), the German government offered funding support to exploration. However, that program was dismissed due to a lack of interest by German industry after only two years (BMWi, 2018). In addition, activities of the German Raw Material Alliance that was established to secure supply for the German industry, with major German manufacturers such as Volkswagen and thyssenkrupp as members (Graupner & Goebel, 2012), were terminated in 2015 (BDI, 2015a) without having made substantial investments.

Similar attitudes can be observed now. When the German industry was asked for their requirements as an input to be considered in the revised raw materials strategy, the German Ministry of Economic Affairs received little feedback and only few ideas (personal communication). Whereas German politics seems to be willing to take the

lead, companies seem unwilling to follow and instead are hesitant to take action on the supply of CRMs for the German economy. A senior government official stated that one could “[...] *hop and jump as you please. I do not believe that a German company will get involved in the extraction of raw materials*” (Book et al., 2019; author’s translation). As German companies are supposedly not interested in engaging in raw material production, the German economic ministry has even considered funding companies from outside of Germany such as France or elsewhere to, at least, establish a European raw material company when no German company is interested (Book et al., 2019).

Alerting the German industry to the criticality of raw materials and the need for action is required to change the current supply dependence, particularly on China. Changing the mindset in many companies to realize that their success and competitive edge also depends on the early stages of the value chain—mining and material production—is, however, a difficult task and there are few German companies that are relatively active in strategically securing their need for (critical) raw materials in the long-term (Book et al., 2019; Reuters, 2019b).

The German Strategy in the Light of Global Developments

At the same time, corporate measures are difficult to pursue when faced with political influence and state-controlled organizations that hinder regular market competition and actively influence the global raw material markets (Schmid, 2020a). The revised German raw materials strategy identifies this key challenge in the raw material market and many of the individual measures aim to reduce supply dependency and respective price and supply risks for the German economy. These measures can be categorized into three major strategic pillars: domestic raw material production, imports, and recycling, with a strong focus on the first two.

With regard to domestic raw material, there is no relevant production of basically any of the most critical raw materials taking place in Germany and the most promising deposits and mines are all outside Germany as Schmid (2019a) illustrates for rare earths, Farchy and Warren (2018) for cobalt, Shankleman, Biesheuvel, Ryan, and Merrill (2017) for lithium and Wilburn (2012) for platinum-group metals, to name just a few. The prerequisites for the production of most CRMs, such as deposits with ore grade raw material concentration, already existing mines in which CRMs are produced cost efficiently as a by-product (Nassar et al., 2015), mining friendly and fast regulation and social acceptance do not favor raw material production in Germany and in Europe in general (Aschenbrand, Kühne, & Weber, 2017; Badera, 2014; Millan Lombrana, Reiter, & Weiss, 2020). Increasing domestic production will, therefore, presumably not have any significant effect on supply dependence of CRMs in the near future.

Securing supply abroad has already been part of the initial German raw materials strategy. However, the direct effect of these measures remains small. Whereas these raw material partnerships were announced as a milestone in German raw material politics, little has happened in the aftermath of the agreements (Müller, 2019). Instead, other countries have been more effective in gaining access to raw material production than Germany. Japan has continued to get access to promising mining projects of some of the most critical raw materials (Schmid, 2019a) and China is—maybe more than ever—engaged in Mongolia, Kazakhstan, and Peru (Biedermann, 2018; Chen

& Fazilov, 2018; Müller, 2019). In order to critically reflect on the revised German raw materials strategy, how holistic and ambitious it actually is and to identify further policy options, a comparison with the raw materials strategies of other leading industrialized nations is consequently helpful.

Raw materials strategies comparable to those of Germany have been implemented by the United States, China, and Japan (Andersson, 2020; Hatayama & Tahara, 2015a; U.S. Department of Commerce, 2019), whereas both politics and companies in Germany have been quite reserved in recent years and seem to be unwilling to make long-term commitments and to actively engage in raw material production, others have filled the gap. Japan, China and, increasingly, the United States have been much more pro-active in securing supply of CRMs (Barteková & Kemp, 2016; Schmid, 2019a).

- Japan is actively engaged in CRM (mine) production and depends on its well-established Japan Oil, Gas and Metals National Corporation (JOGMEC) for this purpose. JOGMEC provides loans and equity to many projects for the production of several CRMs worldwide (JOGMEC, 2016). Furthermore, there is a stockpiling program for critical raw materials and both companies and politics seem to be willing to stockpile critical raw materials (JOGMEC, n.a.). Japan has pursued its pro-active approach for many years. Both companies and politics are highly organized and have well-established structures, processes, and strategies to secure the country's raw material supply. Both the Japanese government and companies aim to acquire mineral interests in mining projects worldwide to increase the supply security for Japan's industries (Hatayama & Tahara, 2015b). Japan's awareness of supply risks and respective mitigation activities have further increased since the rare earth crisis (Schmid, 2019a). In 2019, the Japanese automotive industry announced plans to set up a joint venture to cooperatively secure its supply of cobalt, which is urgently needed for the growing number of EVs produced worldwide. Most Japanese car manufacturers consider joining the consortium, which is backed by Japan's Economy, Trade and Industry Ministry (The Japan Times, 2019). In addition, Japan is engaged in exploring the potentials of raw material supply from deep-sea mud (Kato et al., 2011).
- In China, many raw materials are considered a strategic asset and, therefore, their production is often politically controlled (Andersson, 2020) and the development of the respective industries follows a long-term plan to gain economic advantages (Shen et al., 2020). China took the lead years before and has become a dominant producer, refiner, and importer of many CRMs (DERA, 2019; Rabe et al., 2017). Not only has the country developed its domestic raw material industry, but has also secured supply through investments in many CRM projects worldwide, including the production of some of the most critical raw materials like rare earths (Biedermann, 2014, 2018; Schmid, 2019a; Zeuthen, 2017). Based on its strong position in upstream industries, China has increasingly strengthened its downstream industries and aims to become a technology leader in key industries (Wübbecke et al., 2016).
- In recent years, the United States has also intensified its activities under the Trump administration. Whereas the United States traditionally runs a—primarily

militarily driven—strategic stockpiling program (National Research Council, 2008), the current U.S. administration seems to be willing to actively engage also in CRM production (Schmid, 2019b). The country is working on securing supply and decreasing dependency from imports, especially from China. Based on the U.S. President’s Executive Order 13817 (The White House, 2017), the U.S. Geological Survey (USGS) conducted its first criticality assessment in decades (Schulz, DeYoung, Seal, & Bradley, 2017) and, furthermore, investigated the supply risk to the United States (Fortier et al., 2018). The U.S. Department of Commerce (2019) released the “Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals” in June 2019. Current legislation puts an extensive focus on strengthening the supply chain of some of the most critical raw materials (Scheyder, 2019b). The United States has also re-started its domestic rare earth production (Schmid, 2019b) and already is an important producer of some CRMs like beryllium (Lederer, Foley, Jaskula, & Ayuso, 2016). The U.S. government’s Overseas Private Investment Corporation (OPIC) recently investigated possibilities of investing in United Kingdom’s TechMet, a mining business company, and in a Tanzanian rare earth project (Chowdhury, 2019; Peak Resources, 2019). Those activities are flanked by political agreements worldwide to ensure access to critical raw materials for the U.S. economy and military (Reuters, 2019a; Stringer, 2019). However, establishing a downstream industry (processing, refining, and so forth) for the individual (critical) raw materials has proven to be even more challenging than (re-)opening domestic mines and getting access to mine projects abroad. Taking the case of rare earths, the United States currently has no domestic separation and processing capacity and capability and, further downstream, there is no domestic production of sintered neodymium-iron-boron (NdFeB) magnets, the major application of rare earths (U.S. Department of Energy, 2020). Competencies along the entire value chain have also been lost in recent years due to the loss of intellectual capital outside of China (Gschneidner, 2012). The efforts now being made in the United States to close these gaps in the value chain are substantial, but it will be years before results are achieved.

Faced with this global competition for raw material supply, it is doubtful if the revised German raw materials strategy is sufficient to meet the challenges in a world that increasingly requires CRMs for the production of high technology, where a retreat of free trade can be observed (Fajgelbaum et al., 2020) and where the biggest economies are actively securing their own raw material supply. The measures taken in Japan, China, and the United States could, however, be a starting point for German politicians to derive lessons learned from policymakers elsewhere in industrialized countries. The questions that need to be addressed include whether both government and German industry should get involved in CRM projects worldwide and whether a German raw materials strategy that stretches farther downstream of the value chain, from mining to processing to the materials sector, would be a more appropriate answer to the challenges and political influences in the raw material markets. In fact, bottlenecks along the value chain not only include raw material mining, processing, and separation, but also comprise mid- and downstream industries that produce (sub-) components (Mroueh et al., 2014). A holistic raw materials strategy

should consequently include downstream industries as well and would, therefore, also contain aspects of an industrial strategy that reaches beyond mining.

The impact expected from the revised German raw materials strategy, thus far, seems to be rather small—and this is also true with regard to the financial policy instruments. Under the past raw materials strategy, the budget for raw material-related partnerships accounted to €100 mio. (Book et al., 2019), which is negligible in comparison to investments in mine projects worldwide in recent years by other countries, for example China (Book et al., 2019; OECD, 2018), which has invested around U.S. \$ 50 billion in raw material (metals)-related projects worldwide between 2015 and 2019 (American Enterprise Institute & The Heritage Foundation, n.a.). Japan's JOGMEC, together with Sojitz, provided U.S. \$ 250 mio. in loan and equity for a single rare earth project (Sojitz & JOGMEC, 2011) to secure Japan's supply of these critical raw materials and remains committed to further investments (Hanafusa, 2020). There is no organization in Germany that is comparable to the JOGMEC—and the German government refrains from the establishment of such an agency also in the revised raw materials strategy. A European raw materials organization similar to the Japanese JOGMEC as proposed years ago (ERECON, 2015) would be a profound step toward a more strategic European raw materials policy. The larger impact and financial possibilities of a European organization, comprising major member states, to engage in securing supply of CRMs for Europe, would seem to be more feasible and with great potential for success. Establishing such an organization that could be actively involved in exploration activities, mine development, primary and secondary raw material production, financing of industry-driven initiatives, and stockpiling CRMs would effectively change the landscape of the global markets for CRMs. Although the EU is seemingly not averse to such an organization, it has no mandate to establish one and, therefore, no organizational structure to directly invest in mine projects: historically, the EU's member states tend to focus on their national raw materials strategies (Houses of Parliament, 2019). However, the EU would most likely be the more suitable level to establish such an organization as the influence of the individual member states on the global raw materials markets tends to be limited, especially in comparison to the biggest players in the fields like China, the United States, and Japan. It, therefore, seems to be more promising for German politicians to support concerted activities on the EU level rather than trying to pursue them on a national level.

The EU is also more likely to exert influence in the field of international politics to reduce market distortions, for example, caused by Chinese state intervention and to ensure an international level playing field for European companies when faced with competition from Chinese state-supported companies. Based on raw materials diplomacy and free trade agreements with resource rich countries, the EU could also enable access to raw material supply for European industries at the highest social and environmental standards.

Besides securing supply with primary raw materials, the EU would also be the more suitable level to promote the use of secondary raw materials and the transformation from the current linear to a circular economy. A more ambitious European circularity strategy could help to effectively close the loop at a product's end-of-life. Circularity strategies not only contribute to decrease supply dependency of primary raw materials, but also reduce the negative environmental effects caused by mining activities (Gaustad et al., 2018). Accelerating an innovative European recycling infrastructure

that is able to scale-up recycling technologies for critical raw materials, which are yet barely recycled (Reck & Graedel, 2012), would lay the groundwork for promoting the development of design-for-recycling activities by companies. Such activities enable long product life-times, reuse of components, and the recycling of critical raw materials that are often only used in small amounts and that would otherwise be lost by dissipation (Ciacci, Reck, Nassar, & Graedel, 2015). By setting ambitious recycling targets and establishing a framework of taxation that reflects a product's carbon footprint, the EU could incentivize companies within the single market to substitute primary raw materials with secondary raw materials. Implementing a border adjustment mechanism as already discussed within the EU's Green Deal (European Commission, 2019) could, if required, ensure competitiveness of domestic recyclates in comparison to imported primary raw materials. A joint European approach would also require training of highly qualified specialists and supporting start-ups at the different stages of the value chain in the raw materials-related sectors.

It remains unclear, however, a) how the German raw materials strategy (BMWi, 2020) can contribute to drive a more geopolitical approach with regard to trade distortions in the raw material markets caused by China (European Commission, 2017a), b) how the strategy is linked to the EU's Green Deal (European Commission, 2019) and c) to the European Commission's plan of a sustainable transformation of the European economy to a carbon-free economy (European Commission, 2015). Incongruities with European policies have already made the initial German raw materials strategy of 2010 an object of criticism (Mildner & Howald, 2013).

The continuing low level of integration with EU measures is of particular interest, as, with its ambitious strategic aspirations (von der Leyen, 2019), the European Commission would likely support such German efforts. In recent years, a lot of the raw materials-related EU policy measures focused on diplomacy, R&D funding and recycling (Barteková & Kemp, 2016; Løvik, Hagelūken, & Wäger, 2018). Elsewhere, however, projects have left the R&D sphere and have been up-scaled to industrial processes, actual mine production and setting up processing plants (Barteková & Kemp, 2016; Hanafusa, 2020; Scheyder, 2019a, 2019b; Schmid, 2019a). The EU has been outpaced as Milan Grohol, a representative of the European Commission's Directorate on Raw Materials, recently stressed. Using rare earths as an example, Grohol described the EU's position "*[...] as losing on all fronts, from mining and processing to recycling, which something [sic!] which is quite worrying*" (Cole, 2019). Consequently, the European Commission under its new President, Ursula von der Leyen, aims to be a "Geopolitical Commission," which pushes forward a European Union that is "more strategic, more assertive and more united" (von der Leyen, 2019). The European Commission would seemingly like to act more strategically in the field of CRMs. A major focus of its "New Industrial Strategy for Europe" is put on CRMs and raw material supply (European Commission, 2020). With its industries' high dependence on CRM supply, Germany could be a main supporter and also benefit from such a strategic European approach.

Conclusion

The revised German raw materials strategy follows the original strategy of 2010. Since then, external circumstances and global developments have changed fundamentally.

The current technological changes in the automotive industry, in renewable energy production and new information technologies require huge amounts of different critical raw materials. This change toward a green economy comes at a time of global economic and political developments, which is exacerbated by increasing dangers from resource nationalism, protectionism, and trade disputes. The revised German raw materials strategy attempts to find answers to these new challenges for the German economy. Promising approaches include investigating market distortions, supporting sustainable raw material production, and increasing recycling and circular economy activities. However, some major doubts concerning the success of the revised strategy remain, specifically with regard to German industries' willingness to engage in raw material production and to the relatively small financial impact of the German government on the global raw materials markets. Raising awareness among German industries and supporting a European approach with a more strategic and active European policy would, therefore, be a real contribution to Germany's supply security that could indeed have an impact on stabilizing supply.

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Note

- 1 Translation of the acronym "GABEK".
- 2 There is no official English version yet of the revised German Raw Materials Strategy, all direct quotes are translations by the author and might differ slightly from a future official translation.

About the Author

Marc Schmid is Research Affiliate at the Chair of Statistics, Martin Luther University Halle-Wittenberg.

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