

POLICY PAPER: ENERGY TRANSITION AND DEMAND FOR RAW MATERIALS



Energy transition, necessary for the successful implementation of the Paris Agreement and the delivery of the United Nations Sustainable Development Goals, requires development and large-scale deployment of low-carbon technologies. These will increase global demand for different minerals and metals, what mandates a wide range of adjustments at the state level. The need to re-think, reduce, replace, recycle, redesign and re-distribute the use of scarce commodities is particularly heightened.

The message put forward at the 2017 Raw Materials Conference on June 23rd in The Hague was threefold: 1) realizing energy transition requires large amounts of raw materials and a significant upscaling of mining activities; 2) such activities have to be carried out in a sustainable manner, and should respect human rights, the needs of local communities, and the environment; 3) transition to a circular economy model in product chains is required to mitigate existing and emerging challenges in the short run. Circular design of windmills and solar panels is needed.

The challenges, takeaways and recommendations outlined in this policy paper were compiled on the basis of extensive in-house research, information gleaned at the round-table and the raw materials conference, and reflect the informed opinions of relevant stakeholders representing the government, private industry and knowledge institutes.

INTRODUCTION

The Paris Agreement, adopted by 196 countries in December 2015, sets the ambitious target of limiting global temperature rise to 2°C above pre-industrial levels. This will have a significant impact on the international energy sector, as a transition towards alternative and more sustainable forms of energy – renewables included – is set to become a priority for developed and developing economies alike. In line with the commitments made in Paris, the long-term objective of the European Commission is to transition Europe towards a low-carbon economy by 2050. The milestones outlined in the 2030 Framework for Climate and Energy include a decrease of total greenhouse gas (GHG) emissions by 40% relative to 1990 levels and a renewable energy target of at least 27% of final energy consumption in the EU as a whole.¹ In the Netherlands, the Energy Agreement (“Energieakkoord”) signed in 2013 aims to increase the share of renewable energy from 4.5% in 2013 to 15.9% in 2023, and to achieve an average energy efficiency saving of 1.5% annually. These measures are geared towards realizing a total energy savings objective of 100 petajoules in 2020 and, by extension, towards meeting the goals outlined in the EU Energy Efficiency Directive.²

However, current activities are insufficient to meet the stated ambitions (Figure 1). According to the 2016 National Energy Outlook (NEV), neither the target of 14% renewable energy by 2020 nor the target of 100 petajoules in additional energy saving by 2020 will be attained. Instead, the share of renewable energy is expected to reach 12.5% to 12.7% only. The 16% renewable energy target for 2023, however, is still considered to be within reach. This is largely thanks to development of offshore wind, small-scale renewable energy production, and projected reductions of total energy consumption.³

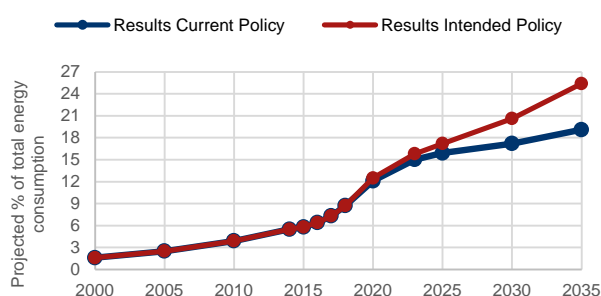


Figure 1: Development of renewable energy share between 2000 and 2035.⁴

Several projects to increase Dutch renewable output by 2020 have been planned. Although biomass is expected to remain the dominant source of renewable energy on a final energy consumption basis, the Energy Agreement focuses primarily on expanding the capacity of wind power (Figure 2).⁵ While there has been little progress in the timely deployment of onshore wind energy – due to complex discussions in a number of provinces – the rollout of offshore wind energy is set to advance in the coming years. Three new offshore wind farms are currently under construction. Taken together, these are expected to produce an annual total of 3,500 megawatts (MW) by 2020.⁶ Solar power is expected to grow less rapidly in comparison with wind energy. Although there are no large-scale government projects that invest in solar capacities, campaigns geared towards raising awareness about the technology combined with tax incentives have fostered significant growth in private-sector solar installations between 2000 and 2015.⁷

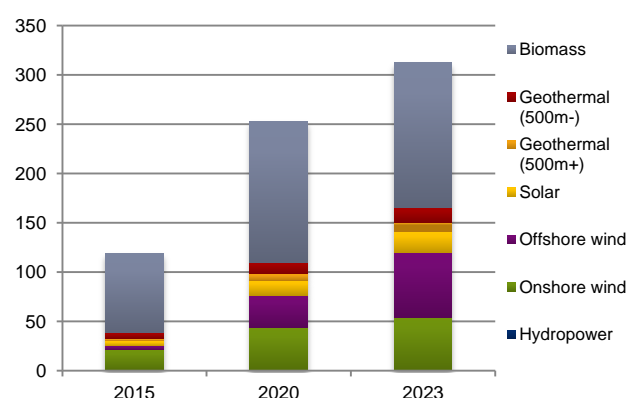


Figure 2: Gross final consumption of renewable energy by technology (in petajoules).⁸

THE NEXUS BETWEEN RAW MATERIALS AND ENERGY TRANSITION

Power generation accounts for around 40% of global CO₂ emissions.⁹ As a result, low-carbon technologies are set to play a fundamental role in the energy transition and are essential for achieving both EU and international climate and energy targets. Besides carbon capture and storage (CCS), nuclear fission and fusion energy, and fuel cell and hydrogen technologies, the EU's Strategic Energy Technology (SET) Plan identifies **four low-carbon technologies** as priority areas. These are wind, solar PV, electricity grid and bioenergy (biofuel).¹⁰ In addition to power generation, the energy transition will also lead to an increase in the material demand in other sectors. One of the most important ones will be the **automotive sector**.

A wide range of different metals and minerals is required for the development and large-scale deployment of low-carbon technologies and, by extension, for meeting the ambitious goals stipulated in the Energy Agreement (Figure 3). In addition to demand for rare minerals, large-scale electrification will require the construction of new infrastructure. This will result in a substantial increase in demand for common materials such as copper, aluminum, lead, and steel. The linkages between the energy transition and international raw material chains thus merit closer attention.

Technology	Metals Requirement	Lifespan
Wind	Dysprosium, Manganese, Neodymium, Molybdenum, Nickel, Chromium, Copper, Concrete	25 years with normal maintenance and inspection. ¹¹
Solar PV	Tellurium, Indium, Tin, Silver, Gallium, Selenium, Cadmium, Copper, Lead, Silicon	Standard solar panel warranty is 25 years and the average life of a solar system is 30 years. The average lifespan of PV batteries is between 6 and 12 years. ¹²
Electricity Grid	Copper, Lead	N/A
Biofuel	Ruthenium, Cobalt	N/A
Plug-in hybrids (PHEV) & electric vehicles (BEV)	Lithium and Cobalt (Batteries), Neodymium, Terbium, Dysprosium and Lanthanum (Permanent Magnets)	From 5 to 20 years. Tesla's vehicles come with an 8 years battery warranty. ¹³

Figure 3: Metals requirements of the selected low-carbon technologies. Metals highlighted in red are included in the 2014 EU critical materials list.¹⁴

CHALLENGES

The following challenges were compiled on the basis of extensive in-house research. In addition, they incorporate information gleaned through participation in a round-table and the 2017 Raw Materials Conference organized by the Ministry of Foreign Affairs of the Netherlands supported by HCSS.

Future Demand

As a result of the large-scale deployment of low-carbon technologies that are necessary to meet the stated climate ambitions, demand for bulk- and special metals is expected to increase rapidly in the coming decades. Renewable technologies exhibit lower energy density and thus require a considerably larger volume of raw materials to operate effectively when compared to fossil-fuel based technologies.¹⁵ In addition, large-scale electrification – necessary due to a shift *away* from fossil fuels for heating – requires the construction of new infrastructure in developed and developing economies alike, and is thus likely to result in increased global demand for copper, aluminium and nickel. Rapid urbanization and population growth in the developing world means renewable technologies must power larger economies,¹⁶ while a growing consumer demand for competing technologies (i.e. smartphones) means demand is not limited to the energy sector alone.¹⁷ The interaction between such factors places considerable strain on the global supply chains of critical materials.

Future Supply

Energy transition poses a particular challenge for energy suppliers wishing to keep up with rapidly increasing demand. Not all technologies are viable for long-term and large-scale energy production because the materials needed for their deployment are subject to limited supply or a high level of risk.¹⁸ Future supply may be limited by a handful of complementary factors, including bottlenecks in production, the cost of bulk transport, the economic feasibility of extraction and refining efficiency, among others. When considering future supply, it is important to make a distinction between *depletion* and *scarcity*. While depletion refers to stock reduction, scarcity is an economic phenomenon and occurs when demand for a resource exceeds the supply of that resource. With that in mind, resources will become scarcer if the demand grows rapidly and supply cannot keep up. However, we are not depleting our resources as long as they remain available in societal stocks. While physical depletion is unlikely to occur in the long run, making resources available – and their extraction profitable – in the next 40 years will be problematic unless we have rigorous, long-term global resource governance in place.

Uneven Geographical Distribution

The geographical distribution of mineral deposits is uneven. The largest suppliers of critical raw materials (CRMs) to the EU are developing countries or nations in transition – China, Brazil, Russia and South Africa, in particular.¹⁹ Some of the CRMs are sourced from challenging and conflict afflicted environments, such as the Democratic Republic of Congo. Economic welfare in these countries tends to be associated with a high degree of dependence on the export of natural resources. Such a form of dependence incentivizes suppliers to resort to trade-restrictive measures and makes them vulnerable to the impact of demand fluctuations resulting from the adoption of circular economy models in importing countries.²⁰ Both of these phenomena may place further strain on global mineral supply.²¹ In addition, conducting business in the countries under discussion – China in particular – increases the risk of exposure to corporate espionage and trademark theft, which in turn erodes the competitiveness of European firms internationally.²²

Energy and Mining

To meet the expected rise in demand, mining activities for critical minerals need to be scaled up significantly. Increased mining will, however, consume additional energy: in 2013 alone, 10% of global energy consumption was due to the extraction and processing of mineral resources.²³ The introduction of renewable energy sources to

power mines could help alleviate some of the environmental impact associated with mining operations. In the case of South Africa, for example, the installation of solar panels at mining sites helped reduce carbon emissions and demonstrated sustainable mining practices.²⁴ Another aspect that merits further consideration is that many of the minerals needed for the energy transition are not mined on their own, but are largely recovered as by-products during the extraction and refining of other metals. Indium, for example, is a by-product of zinc processing operations; gallium is recovered from bauxite (aluminium) ore; selenium and tellurium occur in copper ores.²⁵ Because these by-products often constitute small fractions of the host metal, it will likely prove difficult to increase their supply – not to mention the significant amounts of waste such mining would generate.²⁶

Environmental and Social Impact

To access rare and high-value commodities, unregulated, illegal and often unethical mining has been carried out. Given the ambiguity surrounding the supply chains of certain rare commodities, tracking the origins of mineral supplies is increasingly perceived as necessary. However, conflict-free sourcing is only a first step. The environmental impact of mining activities is significant and includes issues such as water and soil contamination, habitat degradation, and air pollution. Possible future reliance on deep-sea mining will likely obliterate entire ecosystems before they are even explored. In addition to environmental degradation, mining operations – particularly those run at an artisanal scale – impact societies by relying on child and forced labour, dangerous working conditions, and by being connected to organised crime and terrorism. This, despite the fact that they typically constitute a local source of employment. Although large-scale mining is generally not to be blamed for these issues, it can nonetheless have a significant social impact, as its presence often goes hand-in-hand with communal friction, increasing levels of violence against women, and challenges related to access to clean water. To facilitate economic development in mining communities, policymakers and corporations alike must adopt policies that enforce responsible mining standards and must work more closely with non-criminal artisanal mining operations. If the mitigation of environmental and societal impact is prioritized, sustainable supply of raw materials can be ensured in the long run.

Political Uncertainty and Governance Practices

Energy transition in the Netherlands requires a sizeable and long-term private sector investment into low-carbon technologies. While a wind turbine can become profitable within four months of being brought online, solar panels take years.²⁷ Many raw materials are also subject to delayed returns on investment. Copper mines for example require over 10 years to become operational. This means that they should ideally be developed *today* to ensure an adequate supply *tomorrow*. Investments of such scale are characterized by a high degree of uncertainty. A similar dilemma has developed surrounding the economics of the circular economy, which require public financing to make the processing of small consumer electronics – in which the quantities of materials sought for extraction are relatively low – a profitable proposition. The political assurances necessary to mitigate such dilemmas are largely incompatible with the current free market ideology pursued by the Netherlands. Governance can also contribute to energy transition by utilising fiscal policy to ensure a level playing field – local or international. At the supranational level, the formation of international coalitions allows for the development of integrated governance practices, which can address the globally diffused issues associated with energy transition in a more comprehensive way.

Data collection

To keep the two degrees centigrade target within reach, all major investments into renewables will need to be made in the next 5 years. The lack of reliable geological data on metal and mineral deposits, particularly throughout Africa, makes it difficult to justify such investments and contributes to an overreliance on countries that have already established themselves as raw materials suppliers. Governments in developing countries, which likely host a sizeable percentage of unidentified (terrestrial) mineral deposits, are reluctant to make eight-figure investments into geological surveys, as they yield little immediate return. Data collection facilitates long-term planning and market intelligence on future demand is crucial for many developing countries. The World Bank offers loans for prospecting and data collection, but as loans are – by definition – *not* grants, this scheme does not sufficiently address the root causes.

DISCUSSION TAKEAWAYS

CLIMATE POLICY

Although geological resources are abundant, the rate and *timing* of their extraction will – in the absence of a rigorous, long-term policy framework – likely prove inadequate to realize a full energy transition within 40 years. As long as climate policies remain insufficiently ambitious, mining companies will face uncertainties and struggle to supply the demand in the given timeframe. Politicians have to be aware of significant risks in supply and demand of resources, and respond in the right manner:

1. **Foster awareness in policymaking.** There is a need for a greater awareness of the structural changes required to achieve energy transition. Energy transition is the end goal, but multi-sector reform is needed to realize it. Policymakers tend to focus too strongly on the end result and pay insufficient attention to the strategic issues that need to be addressed in order to achieve it. Although the creation of the Ministry of Transition was mentioned as a possible solution, coherence and coordination of efforts across *all* ministries would be more suited to tackle different strategic issues related to the energy transition.
2. **Energy transition requires a holistic approach and effective information sharing among different stakeholders.** In addition to integrating approaches across the government, there are great opportunities for cooperation with civil society and research institutions. Technological specialization varies across the private sector and different actors have a different assessment of issues that need to be tackled in relation to the energy transition. Such fragmentation of knowledge not only problematizes the work of advisory bodies that are tasked with informing policymakers, but it also limits the potential for organized collective action. This problem is not unique to the private sector. Niche specializations have developed within academic and public sectors, too. Increased information sharing between and within the private, academic, and governmental sectors would help to produce a more holistic view that would ideally prevent the public sector from focusing on technology-exclusive issues – the procurement of metals used in biofuel production, for example – and would facilitate the adoption of a more comprehensive policymaking framework.
3. **Shift the tax burden towards polluters.** Governments appear reluctant to use taxation to steer their economies from linear to circular. For energy transition to succeed, it is important to bring tax and spending in line with the stated environmental goals.

The business case for a green economy is currently hindered by subsidization of the largest energy consumers. Governments should shift the burden so that labour is taxed less, while the fossil fuel industry and companies and consumers who produce and buy environmentally harmful products are taxed more. Increasing taxes to polluters, phasing out harmful subsidies, and creating economic incentives for green products and services would not only address environmental challenges but also encourage financial institutions to shift investments towards circular economy.

4. **Increase public funding for research on metals and minerals.** At the moment, there is an overt focus on the bio-based industry. Focusing on one sector only – be it energy, food, or construction – is not sufficient to solve the problem. While the Netherlands Organization for Scientific Research (NWO) provides funding for raw materials research, none of the budget is allocated to research on minerals and metals.
5. **Signal a long-term commitment to the pursuit of energy transition.** Opening new mines requires mining companies to make large investments of both time and capital. To do so, these ventures require stable long-term demand in order to be financially viable. Such demand cannot exist within the private sector without public sector commitment to the pursuit of energy transition in the long run. The degree of political commitment is currently limited, and needs to be stepped-up to ensure commercial viability of renewable technologies.

CIRCULAR ECONOMY

Transitioning towards a circular economy, in which the majority of commodities are no longer consumed but rather continuously recycled, is needed to ensure the continued availability of raw materials. The increasing demand for raw materials due to the energy transition heightens the need to re-think, reduce, replace, recycle, re-design and re-distribute the use of scarce minerals and metals. A circular economy should not be perceived as an end goal in itself, but rather as an important part of carbon emissions reductions. While recycling can mitigate the aforementioned challenges in the short run, substitution should be considered as a long-term solution.

1. **Stimulate technological innovation.** Research into new techniques for recycling scarce metals and materials as well as possible less critical substitutes in the production process will reduce the dependence on critical commodities. Similarly, there is a need for the development of new technologies that improve the energy yield, increase the efficiency of renewable energy systems and reduce the total demand for energy. Governments could play an important role in stimulating scientific research into these topics by providing funding to universities and negotiating relevant grant-awarding schemes at the EU level, for example.
2. **Enhance recycling behaviour.** Changes in societal behaviour are needed to ensure the viability of the circular economy. Large quantities of re-usable raw materials remain 'captured' in retired products – such as laptops, tablets and cell phones – because end-users fail to submit them to processing facilities. Consumers either lack awareness of where to submit retired products, or are reluctant to do so due to personal information stored on such devices. For waste to become an important resource for production processes, recycling should take into account privacy concerns of end-users. While changes in

consumer behavior should originate within the private sector, which remains central to developing circular models, government initiatives are likely to play a key role in mitigating consumer scepticism vis-a-vis the trustworthiness of recycling initiatives.

3. **Raise consumer awareness.** Increasing public knowledge about the importance of circularity of manufactured products and the performance of manufacturing companies may lead to shifting consumption patterns through boycotts or selective purchasing, for example. Introducing standardized measurements for the environmental impact and circularity of consumer products would give consumers an objective benchmark to hold corporations accountable.
4. **Circularity and environmental standards.** Climate change mitigation and circularity of the economy do not always align. While recycling can help to reduce vulnerabilities in the supply chain, and contributes to the circularity of an economy, it may lead to sub-optimal environmental outcomes. One example thereof is when the recycling process consumes additional energy and increases pressures on the environment.
5. **Require life-cycle impact planning.** Because the renewable technologies in which minerals are used have limited life cycles, any form of non-recyclable metal use results in depletion in the long term. Keeping this in mind, planning for end-of-life reusability of the (critical) metals and minerals used in production processes is key. End-of-life reusability planning must be instituted to ensure that enough raw materials remain available for the production of renewables in the long run. Governments should shy away from adopting technologies which deplete metals through non-recyclability, even if they are more energy efficient. As each method of incorporation requires the development of a unique method of eventual extraction, legislation that pursues technology-based regulations fragments recycling capability within the market. Legislative initiatives which focus on circular economy would see improved effectiveness if regulators approached the issue from a metal-based perspective, as such an approach would allow for the development of standardized *per-metal* extraction techniques.
6. **Incentivise development of substitute mineral applications.** Increase in energy demand in the future may result in scenarios where nations find themselves unable to procure a sufficient volume of minerals to meet their energy needs. This problem is compounded by the fact that many renewable sources of energy have short life cycles. While planning for future developments (see point 5) is a positive first step, technological progress may allow substituting minerals that are scarce with others that are more abundant and, consequently, help to escape the scarcity trap. Governments should foster research into possible substitute technologies and mineral applications through the provision of financial incentives.
7. **Standardize recycling processes.** Production of low-carbon technologies is spread out across Europe. Dutch windmills, for example, are partially produced in Denmark and assembled in the Netherlands. As a result, imported products are often incompatible with local recycling processes. This problem can be alleviated by circularity-related planning and regulation at the European level. Such regulation would ensure that when wind

turbines approach the end of their life cycle, components produced in Denmark can be recycled in the Netherlands. If regulations at the European level cannot be achieved, developing them at the national level would represent a positive first step.

8. **Mining and recycling sector need to work together.** Supply and demand systems are dynamic, making it impossible to foresee the developments of the next 20-30 years. With regards to metals which are extremely scarce, supply in 10-15 years cannot be guaranteed. Recycling sector also faces limitations: copper, for example, remains in society for 30-40 years before it can be recycled. The maximum amount of copper that can be extracted from recycling is not sufficient to meet increasing global demand due to the energy transition. As long as economies grow, and as long as we demand more than we can recycle, mining and recycling sector need to work together to meet the growing demand.

RESPONSIBLE MINING

The practices surrounding mineral extraction in the developing world are frequently problematic, and are commonly associated with hazardous working conditions and environmental degradation. Aside from representing a moral dilemma, these practices negatively impact the international security because they foster instability in exporting states and because they are tied to inefficient production ratios. Governments can take the following steps to mitigate these problems:

1. **Incentivise corporate coordination with artisanal miners.** In developing countries, many metals are mined artisanally. Artisanal mines comprise a large part of the overall supply. They may, for example, account for approximately 20% of the gold currently in circulation.²⁸ These operations are small, and – because they are carried out without corporate oversight – rife with human rights abuses, child labour, and dangerous working conditions. Artisanal cobalt mines, for example, typically fail to provide workers with filtration masks, thus exposing them to cobalt dust which can cause several forms of lung disease. The profits from these mines may also go towards funding terrorism or other illicit activities such as money laundering or bribery. Some issues relating to artisanal mining can be solved by larger mining companies, which may be able to regulate the *modus operandi* of such operations by working more closely together with them. Such coordination need not entail corporate absorption of artisanal operations, but *should* attach conditionality – ideally in this case in the form of best practice adoption vis-a-vis labour conditions – to procurement schemes. From a government perspective, incorporating measurements regarding corporate interaction with artisanal operations into mandated due diligence schemes would be a viable option.
2. **Develop a framework which ensures traceability.** Much due-diligence currently occurs *after* metals have been processed by a smelter. Because smelters combine metals from both clean and dirty sources, tracing minerals to their origins *post-processing* has proven challenging. A useful approach to ensuring that manufacturers shy away from purchasing conflict minerals is to develop a method of certifying smelters and to sanction businesses that choose to engage with non-certified entities. Smelters which source their minerals from mines which infringe on the guidelines set forth in the OECD's due diligence guidance should not receive certification. Such a scheme has been put in place through the Conflict Free Sourcing Initiative

(CFSI), which traces – with the exception of gold – minerals included under the 3T's and certifies smelters accordingly.²⁹ The Responsible Mining Index, which is currently under development and will be published in early 2018, will similarly trace mine working conditions, and give corporations a tool through which to screen business partners. Currently, there is no government scheme in place to sanction companies which do not subscribe to due diligence practices and participation is voluntary. If a sanction scheme cannot be implemented, an initiative to ensure market forces incentivise due diligence and ethical sourcing would represent a positive first step.

3. **Enforce gender equality.** Ensuring that women who live in the vicinity of mines receive due compensation is key. Large corporate mines may draw individuals from a wide area, and cause considerable environmental degradation. These phenomena have a disproportionately negative impact on women, as they must travel further to reach clean water, for example, and because they may fall victim to increased violence. As mining wages are often spent locally, it is also common for women who live in the vicinity of such operations to engage in sex work. These dynamics trap women in 'vicious' cycles and prohibit their prospects of pursuing personal development through education, for example. This problem can best be addressed by mandating mining companies to provide monetary compensation to women. Development of a policy which would enforce such a practice would be helpful.
4. **Ensure fair compensation.** When mining companies start a new operation, they typically negotiate compensation agreements with affected locals. Such negotiations may lead to uneven pay between individuals. This causes friction within the community, and often leads to resentment. It is important to ensure that communities – when faced with an actor as intimidating as a mining corporation – are well positioned to bargain. Here, mandating mining companies to pay a fixed value per individual would represent the most viable option. In the event that this practice cannot be implemented, providing communities with counselling on how to bargain communally would represent a positive initiative.
5. **State regulation is needed to further enhance a level-playing field.** Responsible procurement schemes such as the OECD due diligence guidance and various EU regulations have begun to institutionalize sustainability. The impact of these frameworks is limited by opt-in mechanisms and limited mineral scope, respectively. Governance of minerals *in general* is complicated because industry-wide standards of measurements cannot be realistically applied. This is because the negative effects associated with extraction and the positive effects associated with integration differ by mineral and geography. The international adoption of standardized indices to expand measurements pertaining to corporate behaviour in this area – whether by expanding metals covered or by enforcing existing frameworks – would help to further enhance a level-playing field. While more rigorous regulation at the international level is key, the building of a stronger consensus on the issue of corporate social responsibility within the private sector would go a long way. The introduction of indices to standardize measurements relating to energy transition – such as the level of recyclability of products and the social and environmental impact of the supply chain – is essential to give consumers and investors an objective benchmark to hold corporations

accountable. Governments can contribute to this policy objective by putting initiatives in place which acclimatize consumers to the issue. This will serve to strengthen consumer demand for responsibly sourced products, thus levelling the playing field through market mechanisms.³⁰

- 6. Use renewables for mining.** The environmental impact of mining operations is not limited to the area immediately surrounding the extraction point. Large mining operations utilize diesel-powered heavy machinery for a variety of tasks. Bulldozers and tractors often play a part in the extraction process itself, while heavy pickup trucks are required to transport raw ore and individuals to-and-from the extraction site.³¹ The processing of ore into metal is also a source of considerable carbon emissions.³² The release of carbon emissions during the mining process diminishes the positive impact of energy transition, as it compounds the very problem the minerals used in low-carbon technologies are intended to mitigate. Incorporating renewable technologies to power milling and drilling could help alleviate some of the environmental impact associated with mining operations. Chile, which has revised its energy contracts to incorporate renewables in powering copper mines, provides a good example of such efforts.

RESILIENT SUPPLY CHAINS

Concentration of production and refining make supply chains less resistant, and resources more scarce. Increasing the resilience of the national mineral supply chains reduces uncertainty of supply. Uncertainty can be partially reduced by diversifying the country's import portfolio, and can be further mitigated by implementing policies which reduce negative externalities associated with extraction.

- 1. Diversify import portfolios.** Much of the world currently relies on China for a large percentage of critical mineral imports. Due to China's ability to extract minerals regardless of financial viability of such operations, the country is likely to remain a vital source of mineral supply in the foreseeable future. Concentration of production means that supply of minerals is subject to shocks on the ground. Moreover, China's ability to extract minerals at low cost continues to impede the ability of European corporations to extract resources locally, in spite of available deposits. Dependence on China can be mitigated in several ways. First, the European Commission could facilitate further exploration of European mineral potential in remote regions. Second, a comprehensive EU-wide regulatory framework with regards to the recycling of minerals and metals could be enacted. Finally, continued focus on developing universal standards for measuring sustainability would serve to reduce the risk associated with doing business with suppliers outside of China, what would help diversify corporate supply chains. By diversifying import partners and by facilitating a circular economy, such policies have the potential to increase supply chain resilience in Europe.
- 2. Facilitate data collection.** A lack of geological data, primarily in developing nations, on the availability of metal and mineral deposits contributes to an overreliance on countries which have established their capacity to produce them. This lack of information reduces the efficiency with which mining investments can be made and makes it more difficult for governments to adopt long-term plans. In order to reduce

dependence on China and other major raw material suppliers, investments should be made to address this lack of reliable data. Exploring yet unidentified terrestrial deposits should be given priority over deep-sea mining, which is often quoted as a viable last-resort for mineral extraction but which can have devastating consequences for the ocean environment.

- 3. Make energy transition all-inclusive.** A fully circular economy will not eliminate the need to import minerals altogether. It is therefore important to safeguard the stability of countries which are currently exporting them. As implementation of a circular economy will inevitably reduce the demand for the minerals these countries export, it runs the risk of negatively impacting their economic prosperity. Mitigating this problem requires countries to diversify their exports. Here, the provision of aid – whether in a monetary form or by way of policy advice – is recommended.
- 4. Facilitate a multi-stakeholder feedback loop.** One of the issues associated with multinational governance structures such as the OECD's due diligence framework or the EU's regulation on the standardization of sustainable mining management systems is that policymakers lack the information they need to develop a holistic view of the trends which have the potential to impact – and be impacted by – their decisions. Because legislators are often unwilling to pursue policy initiatives whose potential outcomes are unclear, they often chose to employ a 'Do No Harm' approach to implementation instead. This process often culminates in the enactment of policies that fail to sufficiently address the issues at hand. This issue can be mitigated by facilitating a multi-stakeholder feedback loop. Such approach should aim to involve governments, corporations, and individuals from a wide range of countries in which mining occurs, and should ideally lead to increased access to information and a subsequent expansion of multinational due diligence frameworks.
- 5. Establish resilient infrastructures.** Environmental impacts associated with mining in previously inhabited areas can be reduced by stakeholders working together to eliminate redundant practices. This problem is particularly prevalent in countries where basic infrastructure is limited, what often leads to scenarios in which multiple corporations – all of which operate mines in the same area – invest into building separate infrastructure to transport the minerals they extract. Depending on the type of infrastructure constructed, this can significantly increase the environmental impact of mining operations. As a result, any initiative to facilitate cooperation between governments and corporations with regards to infrastructure construction would represent a step in the right direction. In addition to being constructed in a sustainable manner, planning for future infrastructure should ideally be preceded by an extensive analysis of potential developments in the areas surrounding mines. Such an analysis would serve to ensure that infrastructure is put in place at least *partially* on the basis of future utility for local communities. This would allow mining companies to contribute to the infrastructural development of the countries they operate in, and reduce the net negative impact of their activities on local communities.

POLICY RECOMMENDATIONS

1. The Ministry of Economic Affairs and the Ministry of Foreign Affairs should ensure that sustainability is built into current tendering procedures. Companies developing solar and wind energy projects, for example, should incorporate responsible sourcing and circular design into their business cases. Governments should, in turn, reflect these considerations in the procurement processes, rather than select projects with the lowest up-front cost.
2. A key issue in enforcing due diligence is that there is little consumer pressure on corporations to do so. Consumers need to perceive ethical sourcing and recycling as important, and be willing to bear additional costs. Product labelling, similar to energy consumption labels on products and appliances set by the EU, would help to inform end-users about costs associated with the production process and recycling rates of materials contained inside the products. This labelling should ideally take place at the EU level and should become part of the European Commission's Circular Economy Package. In addition to labelling, financial incentives also hold a potential to enhance consumers' recycling behaviour.
3. Germany's resource dependence is very similar to that of the Netherlands. In addition, Germany plays an important role in the Dutch integrated supply of raw materials.³³ Collaboration between the German Mineral Resource Agency (DERA) and a Dutch research institution, such as TNO for example, on raw material flows and future scarcity would be beneficial in tackling import dependence and acting against future vulnerabilities. In exchange for access to existing knowledge residing within DERA, the Dutch government could contribute to DERA's work by providing specific information on various critical raw minerals which are shipped through or stocked in the Netherlands.³⁴ Such a data-sharing initiative could subsequently be expanded to include other stakeholders both within and outside of the OECD, such as China for example. As the materials used by the Netherlands are often semi-incorporated into products by the time they are imported, the focus should be on information regarding supply chain restriction at the mid-stream level.³⁵ Partnership with DERA could also lead to the establishment of a central data hub where information on the development of demand, supply, stocks, prices, resource nationalism measures, and market imperfections across the value chain – not limited export restrictions – could be found.³⁶

BACKGROUND INFORMATION

The Ministry of the Foreign Affairs of the Netherlands has a vested interest in research on raw materials and the implications of their need for the energy transition. With the support of The Hague Centre for Strategic Studies (HCSS), a round table discussion and a subsequent 2017 Raw Materials Conference were organized in The Hague, The Netherlands, in June 2017. The conference highlighted a growing international consensus regarding the need to ensure ecologically viable continuity of global mineral supply over the coming decades. This will require a rigorous long-term policy framework, sustainable and responsible sourcing of minerals, transition towards a circular economy, an increased resilience of supply chains, and an increase in consumer awareness of the effects of consumption. At the same time, energy transition planning needs to be all-inclusive and take into account concerns and possible negative consequences circularity may inflict on developing countries whose economies are highly dependent on exports of raw materials. For more information about the conference, please visit <http://www.rawmaterialsconference.nl/>.

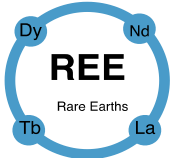

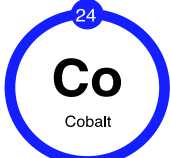

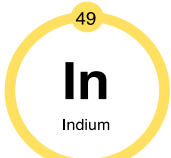
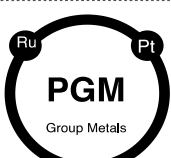

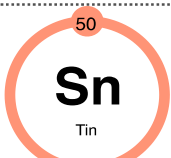
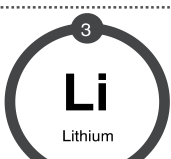

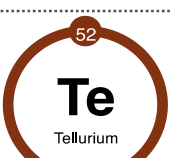
	Technology	Derived From	Imported From	Challenges	Opportunities
	Wind	Secondary Bastnäsite / Mozanite	NL China EU China	Chinese monopoly on exports of REE's; increasing global demand for electronics; almost no recycling; social / environmental issues.	Diplomatic alignment with Germany to secure supply; invest / develop Iron Nitride magnets to replace in future.
	Wind	Primary Chromite	NL China, Slovakia EU S. Africa, Turkey, India, Pakistan	No substitute in magnets; 95% of current reserves in Kazakhstan ; also needed for stainless steel production.	EPCA EU–Kazakhstan (leverage through dependence – EU is largest trade partner Kazakhstan).
	Biofuel Electric Vehicles	Secondary Laterite / Magnamous	NL Uganda EU Russia	DRC is major global producer (child labour / war); competition from consumer electronics; demand for EV's projected to grow.	Invest in development of Li–Air technologies; improve trade relations with Australia.
	Solar PV	Secondary Bauxite	NL Poland, Belgium EU Brazil, China, U.S., S. Korea, Canada, Japan, Russia, Hong Kong, Peru	Past export levies China, Brazil (political instability); key to LED lighting & smartphone displays; past incidence of toxic waste release.	Invest in development of Copper / Zinc–Sulphide thin–film solutions; rely on non thin–film technology; leverage EU trade relation with suppliers.
	Solar PV	Secondary Zinc Deposits	NL Poland, Belgium EU Brazil, China, U.S., S. Korea, Canada, Japan, Russia, Hong Kong, Peru	Past export levies & instances of heavy metals in water supply China, Brazil (political instability); key to LED lighting & smartphone displays.	Australian production may increase due to high Zinc occurrence; alternatives exist for use in competing technologies.
	Solar PV Energy Grid	Secondary Various	NL / EU Unknown World: S. Africa, Russia, Canada	Rapid global development means high projected demand; political instability South Africa (producer world).	High recycle rate from scrap –NL has high consumption of technologies which contain PGM's.
	Solar PV	Primary Silicate Mineral	NL Norway EU Norway, China, Brazil	Majority global reserves in China ; substitutes (Gallium) not easier to procure; wide industrial applications.	Silicon can be recycled; minerals containing Silicon make up about 90% of the Earth's crust.
	Solar PV	Secondary Cassiterite	NL Indonesia, Bolivia, Thailand, Germany, U.K., Chile, Malaysia EU Indonesia, Peru, China, Bolivia, Thailand, Malaysia, U.S.	Licensing schemes / export levies Indonesia, China (political instability / resource nationalism) and links to onset of respiratory disease due to lack of regulation.	Tin used in many non–'function'–driven industries (aesthetics, etc); lead / Germanium can be substituted in Solar cells.
	Electric Vehicles	Secondary Brine / River Filtration	NL / EU Unknown World: Australia, Chile, Argentina	No viable alternatives in Li–Ion battery (projected growth); extraction from ocean water not yet commercially viable.	Lend NL expertise in extraction to nonproductive countries (i.e.: Bolivia); increase rate of recycling from consumer electronics.
	Various	Secondary Laterite / Magnamous	NL / EU Unknown World: Canada, Australia, Norway, Russia	Wide applications in industry; Philippines recent closing of mines (environmental concern) may deprive China of key source.	EU does not consider Nickel critical (suppliers such as Canada are reliable); extensive deposits (though currently uneconomical) have been identified.
	Solar PV	Secondary Copper Refinery	NL / EU Unknown World: Sweden, Canada, Russia, Japan	Substitutes associated with suboptimal performance; makes up only 0.001 ppm in Earth's Crust; Solar expected to grow globally.	Invest in development of Zinc / Copper–Phosphide solar cells to minimise solar dependence on Tellurium.

Figure 4: Challenges and opportunities associated with raw materials required in low-carbon technologies.²⁸

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