re-sourcing

State of play and roadmap concepts: Renewable Energy Sector

RE-SOURCING Deliverable 4.1

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List of Abbreviations

AB	Advisory Board (of the RE-SOURCING project)
AFP	Analytical Fingerprinting
AMD	Acid Mine Drainage
ARM	Alliance for Responsible Mining
ASI	Aluminium Stewardship Initiative
ASM	Artisanal and small-scale mining
AWEA	American Wind Energy Association
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe
CESA	Clean Energy States Alliance
CO_2-eq	Carbon dioxide equivalent
CSC	Concrete Sustainability Council
CSO	Civil Society Organisation
D	Deliverable (of the RE-SOURCING project)
DDPMSG	direct drive permanent magnet synchronous generators
DDSG	direct drive electrically excited synchronous generators
DFIG	double fed induction generators
DIN	Deutsches Institut für Normung (German Institute for Standardization)
DRC	Democratic Republic of the Congo
EBRD	European Bank for Reconstruction and Development
EHS	Environment, Health and Safety
EITI	Extractive Industry Transparency Initiative
EU	European Union
gha	Global hectares
GHG	Greenhouse gas
GRI	Global Reporting Initiative
ICMM	The International Council on Mining & Metals
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IFC	International Finance Cooperation
ILO	International Labour Organization
IRENA	International Renewable Energy Agency
IRMA	Initiative for Responsible Mining Assurance
ISEAL	International Social and Environmental Accreditation and Labelling Alliance
ISO	International Standardization Organization
kWh	Kilowatt hour
LCA	Life cycle assessment
LME	London Metal Exchange
LSM	Large-scale mining
MAC	Mining Association of Canada
MW	Megawatt
NGO	Non-Governmental Organisation
OECD	Organisation for Economic Co-operation and Development
PSC	Platform Steering Committee (of the RE-SOURCING project)
PV	photovoltaic
REE	Rare earth elements

REO	Rare earth oxides
RE-SOURCING	Global Stakeholder Platform for Responsible Sourcing
RS	Responsible Sourcing
SDGs	Sustainable Development Goals
Si	Silicon
SOMO	Centre for Research on Multinational Corporations
t	Metric tonne
TSM	Towards Sustainable Mining
UNO	United Nations Organisation
US	United States (of America)
WEEE	Waste electrical and electronic equipment
WEF	World Economic Forum

Executive Summary

Growth in the use of renewable energy is an essential requirement, if the global community hopes to meet the Paris Agreement's goal to permanently keep global temperatures increase well below 2°C. As a result, the sector is currently witnessing an enormous expansion in capacity. While energy production from renewable sources is considered a "green" alternative, compared to energy from fossil fuels, the extraction of the required raw materials, the manufacturing of equipment, and recycling within the sector might not be meeting sustainability principles.

This report is a stock tacking of the current state of the renewable energy sector with focus on issues along the supply chain that need to be addressed in order to achieve a sustainable and responsible supply chain. These problems require immediate and decisive action to avoid worsening due to increased demand.

The RE-SOURCING project focuses on wind and solar PV energy and their respective supply chains, because of their importance for future energy supply. This report assesses three stages of the supply chain: (i) mining, with focus on copper for renewable energy technologies in general, rare earth elements for wind turbines, and silicon for photovoltaics; (ii) manufacturing of equipment, mainly wind turbines and solar PV panels; (iii) their collection and treatment.

Various sustainability challenges along the supply chain were identified. Both, the extractive and the manufacturing sections of the chain have issues linked to human rights and environmental sustainability, such as human rights violations and significant environmental impact, a lack of commitment to paying fair wages or gender equality, and conflict with local communities. The manufacturing of steel for wind turbine towers, or of metal grade silicon for solar panels is very energy intensive. Inadequate collection and treatment of equipment for both technologies can be the cause of environmental pollution (toxins from solar PV batteries) and considerable amounts end up in landfills (composite materials from wind turbine blades).

The report's narrative analysis verified that the issues identified really are relevant problems for the sector. For the narratives, key words and phrases were chosen representative of the current responsible sourcing agenda and the renewable energy sector. The results of the analysis showed that the narratives chosen to investigate are quite well reflected online. Many of the narratives are so-called timeless narratives, that means they are very powerful and create a lot of engagement. However, the analysis also shows where the project needs to engage further to support the development of responsible supply chains.

Apart from issues in the renewable energies' supply chains, this report also looks at standards and sustainability schemes addressing these problems. Various initiatives promoting sustainable practices for the mining sector were assessed, considering minerals and metals, as well as guidelines included. The availability of standards and frameworks specific for the manufacturing and recycling stage is rather limited. Most manufacturing standards focus on the quality of the equipment and not on the process itself (environment, health and safety guidelines).

Finally, a gap analysis was conducted to assess whether the standards and initiatives cover challenges present in the renewables' supply chains. The first gap arises from the large number of guidelines for the mining sector –an international framework is missing, that clearly defines terms relevant for the sector and provides guidance both for companies on what standards to apply and for customers on what to look for in a company. This also applies to the manufacturing of equipment and its collection and treatment. For both hardly any international guidelines are available yet. Other very important subjects are the issues of environmental sustainability and resource efficiency. Especially, when considering the increasing supply of renewable energy, the corresponding increase of raw materials demand must be taken into account. To decrease the environmental impact, the decoupling of economic activities from resource use is required.

The RE-SOURCING project needs to further engage with these topics to assist firms in this sector to ensure that raw materials or renewable energy sources really are sustainable and this is communicated properly to the general public.

As part of the project's roadmap process a vision will be developed with goals that need to be achieved by 2050 to ensure sustainable and responsible supply chains for the renewable energy sector. The foundation of this vision was created in this report based on the concepts of planetary boundaries and strong sustainability.

1 Introduction

1.1 The RE-SOURCING Project

Responsible Sourcing (RS) is becoming a reality for more and more businesses, NGOs, and policymakers. Everyone is striving to keep ahead of rapidly evolving ecological and social needs, company practices, business models, government regulations, and initiatives spearheaded by civil society, etc.

In response to the growing challenge of responsible sourcing, **the RE-SOURCING Global Stakeholder Platform has been started in 2020**.

RE-SOURCING, funded under the European Union's (EU) Horizon 2020 programme, is a four-year project coordinated by the Institute for Managing Sustainability, at the Vienna University of Economics and Business. The project's consortium consists of 12 international partners in- and outside the EU working together to create the RE-SOURCING Platform. The project's vision is to **advance and establish Responsible Sourcing as a minimum requirement among EU and international stakeholders**. The project will foster the development of a globally accepted definition of Responsible Sourcing, facilitate the implementation of RS practices through direct knowledge exchange within its network and beyond, and advocate for Responsible Sourcing in international political forums.

To guarantee a thorough and comprehensive Responsible Sourcing framework, RE-SOURCING will take a holistic approach by integrating firms and industries (up- and downstream**) across the mineral value chains of three sectors**: Renewable Energy, Mobility and Electronics – all of which play a decisive role in the EU Green Deal and the clean energy transition. As such, RE-SOURCING equally takes into account traditional minerals, conflict minerals and green tech minerals in its approach. The main target groups of the project will be EU and international industry stakeholders, EU policy makers and civil society.

The RE-SOURCING project actions will:

- facilitate the development of a globally accepted definition of RS;
- develop ideas for incentives facilitating responsible business conduct in the EU, supporting RS initiatives;
- enable the exchange of stakeholders for information and promotion of RS;
- foster the emergence of RS in international political fora; and
- support the European Innovation Partnership on Raw Materials.

RE-SOURCING will deliver:

- For EU and international business stakeholders:
    - increased capacity of decision-makers for implementing responsible business conduct;
    - better understanding and awareness of RS in three sectors of renewable energy, mobility and electric and electronic equipment; and
    - facilitated implementation of lasting and stable sectoral framework conditions for RS.

- For EU policymakers:
  - increased capacity for RS policy design and implementation;
  - innovative ideas on policy recommendations for stimulating RS in the private sector; and
  - better understanding and awareness on RS in three sectors of renewable energy, mobility and electric and electronic equipment.

- For Civil Society:
  - integration of sustainable development and environmental agenda into the RS discourse;
  - an established global level playing field of RS in international political fora and business agendas; and
  - better understanding and awareness on RS in three sectors of renewable energy, mobility and electric and electronic equipment.

1.2 The Renewable Energy Sector

The energy sector has been subject to an immense transformation, moving it towards the expansion of renewable energy and away from fossil fuels. Energy production from renewable sources has been identified as a key factor, to stay within the limits of 1.5°C global temperature rise as defined by the UN Paris Agreement 2015 (UNFCCC 2015). Countries worldwide are aiming to expand their renewable energy capacities and providing clean and affordable energy services. However, there is still a lot to be done to achieve long-lasting change, support investments, and foster technology innovations (IRENA 2017). The European Green Deal's target for being a carbon-neutral continent by 2050, Costa Rica's roadmap to net zero emissions by 2050, or New York's plan to reach 70% renewables in electricity production by 2030 are only some of the policies recently adopted by countries and states (REN21 2020).

However, the expansion of renewable energy also has consequences for the demand of raw materials required for the construction of equipment, plants, and infrastructure. According to Hund et al. (2020) many minerals crucial for renewable energy production are likely to display growth rates of up to 965% (Lithium) by 2050 (The World Bank 2020b). This poses a lot of pressure on the world's primary and secondary mineral production. Furthermore, raw materials extraction is often associated with negative impacts on environmental, social, and economic aspects, including greenhouse gas emissions, human rights violations and corruption.

Additionally, in the manufacturing and recycling of equipment for energy production, sustainability issues can occur. For example, the release of toxic waste from solar panel production, or the limited recyclability of wind turbine blades.

These problems require decisive actions on the part of governments and industry alike, to ensure a clean and affordable energy supply.

Responsible sourcing initiatives as part of the wider sustainability agenda address these challenges not only within the mining sector, but along the value chain. Numerous approaches have been developed targeting specific problems (e.g. safe and fair labour practices), or sectors (e.g. responsible practices in mining) by offering mostly voluntary guidelines, standards, etc., that in some cases are adopted by national or regional regulatory frameworks (Farooki et al. 2020).

The project RE-SOURCING aims at coordinating these initiatives to provide a holistic value chain approach supporting the development of a responsible and sustainable supply chain for the sector of renewable energy. Guidelines in form of a roadmap shall be provided offering a step by step approach to achieve responsible sourcing in the sector by 2050.

This report takes stock of the current situation of the renewable energy sector with a focus on existing challenges for sustainability and responsibility. It also identifies existing sustainability standards and initiatives relevant to the technologies (wind turbines and solar PV) and raw materials (copper, rare earth elements, and silicone) covered. An overview of the RE-SOURCING project's proposed vision for the sector up to 2050 and gaps resulting from the current initiatives will be given. The Annex provides a preliminary list of flagship cases; examples of governments, firms and associations tackling the responsible sourcing challenge in innovative ways.

1.3 Methodology: The Roadmap Process

The roadmap approach and process are well suited for the RE-SOURCING project to develop a vision for responsible sourcing in the renewable energy sector. It allows for the engagement with all relevant stakeholders i.e. European and international policymakers, businesses along the raw material value chains, Civil Society Organisations (CSOs), and academia. The process lends itself well to developing recommendations for actions and collectively defining an agreed vision. In order to achieve the vision, recommendations for actions will be developed involving all relevant stakeholders. For details on this approach please see an earlier publication by the RE-SOURCING project "D1.2 The RE-SOURCING Common Approach" (Degreif et al. 2020).

"*The initial development of the technology roadmapping approach in the late 1970s by Motorola (Willyard and McClees 1987) was to support the linkage of strategic product and technology plans. Having since evolved, the tool offers a key benefit, as it organises and clearly communicates the current achievements and challenges, and the future vision, juxtaposed with the means to realising said goal (Phaal et al. 2007). Roadmapping has become one of the most widely used approaches for driving innovation and strategy planning, both at firm and sector levels*" (Degreif et al. 2020, p. 28).

The roadmap for the renewable energy sector is developed according to a predefined process (see Figure 1) which aims at involving as many stakeholders of this sector as possible in order to obtain different views on all relevant aspects of the supply chain. The aim is to achieve a result that is widely accepted and adopted by all parties involved. The RE-SOURCING project is characterised by offering a multi-stakeholder platform that is open to all groups involved in order to generate the largest possible pool of knowledge resources.

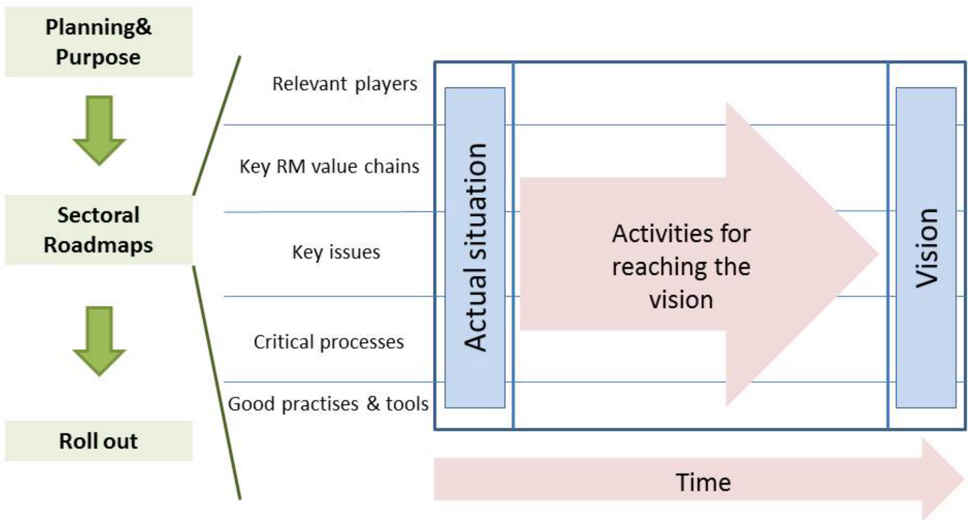

Figure 1: Roadmap Process for the RE-SOURCING Project

An important aspect is the open approach to problems in the supply chain. Only through open communication can problems be uncovered and solved in a joint effort. The RE-SOURCING project supports a risk-based approach. This means that the intensity of the measures depends on the severity of the problem. No stakeholder should be excluded because of prevailing issues, but rather be supported in solving them.

The first step is the preparation of this "State of play and roadmap concepts" report in cooperation with experts from the project's Platform Steering Committee (PSC), the Advisory Board (AB), and external experts.

This is executed in six stages:

1. Development of a draft report based on the project deliverables D1.1 State of Play in the international responsible sourcing agenda and EU downstream sector challenges, D5.1 Common approach for peer learning and good practice guidance, and further desk research focusing on the challenges the renewable energy sector is facing, and initiatives and standards aiming at promoting responsible and sustainable practices.
2. First round of consultations: In an online meeting the draft report is presented and members of the PSC and AB are asked for their input.
3. Based on the results of the first two stages a narrative analysis is conducted. For details see chapter 4 Narrative Analysis.
4. The input from PSC and AB members and results from the narrative analysis are incorporated in the report.
5. Second round of consultations: The revised report is in turn presented to PSC and AB members in a further online consultation. Moreover, external experts are asked for their input, either in online meetings, phone calls, or written Q&A.
6. Finally, the feedback of the second consultation and expert interviews are incorporated and the deliverable is finalised.

The finalised report will be used as a baseline for discussion in the roadmap workshop where further stakeholders are involved and asked to contribute to the development of the final roadmap. The involvement of stakeholders in the renewable energy sector value chain is key for the roadmap's acceptance and successful implementation. The final roadmap will then also include mechanisms for the further implementation of RE-SOURCING good practice cases ('flagship cases'). Flagship cases are examples of companies or organisations that can provide good practice guidance and support peer learning (for further information please see Annex).

2 State of Play

There are many forms of renewable energy production, including but not limited to hydropower, wind and solar power, and geothermal energy.

While these forms of energy production do not require input of non-renewable raw materials for energy generation, they remain very material-intensive when it comes to the production of equipment and construction of power plants.

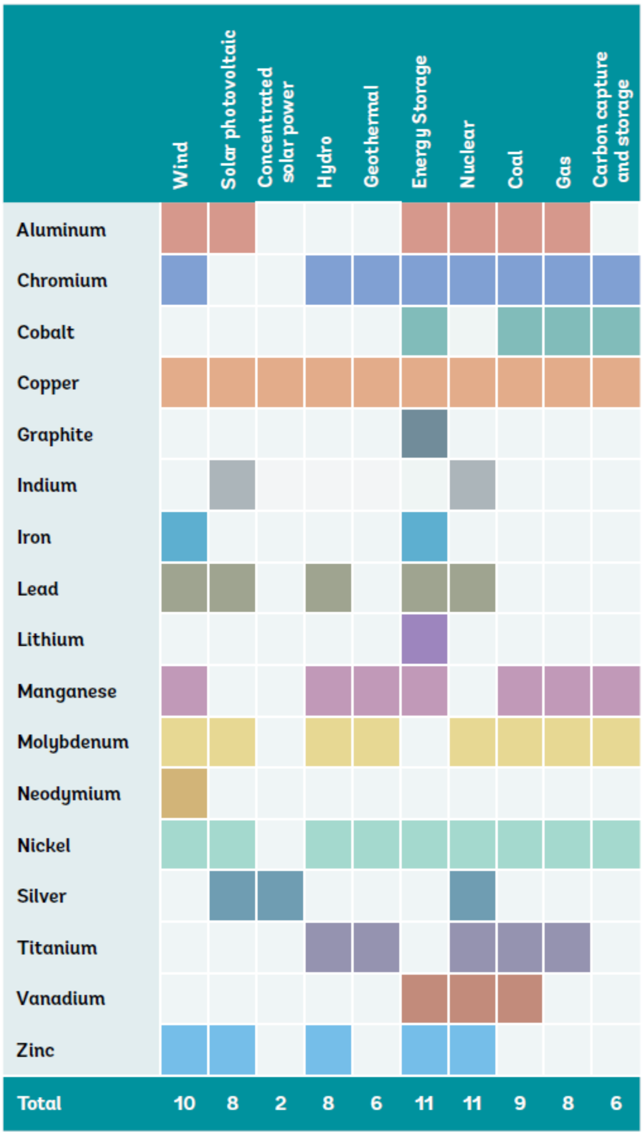

Figure 2:Materials required von the construction of various low-carbon energy technologies (Hund et al. 2020)

Figure 2 shows minerals needed for the construction of several different types of energy production, clearly demonstrating the importance of metals, e.g. copper, for the clean energy transition.

As part of the Critical Raw Material Study 2020 by the European Commission an analysis of materials used for wind turbine generators and photovoltaics (PV) was conducted. It was found that both methods rely on a number of (for the EU) critical raw materials, depending on the technology employed. For example, wind turbine generators require niobium, boron, and rare earth elements (neodymium, dysprosium, praseodymium) when a permanent magnet generator system is used. Commercial PV technologies use boron, germanium, silicon, gallium, and indium (Bobba et al. 2020).

Wind and solar PV power show the highest growth rates of renewable energy technologies with 23% and 36.5% respectively in 2018 (IEA 2020) and are considered the two technologies with the largest growth potential over the next years (according to PSC consultations). This is also in line with the findings of the study by Bobba et al. (2020), which considers wind and PV technologies to be of great importance for the EU in the future.

Therefore, the RE-SOURCING project will focus its efforts on the raw materials copper, rare earth elements, and silicon required for wind and solar power manufacturing.

Phasing out of fossil fuels completely, is still a long way away. In 2018 energy from renewable sources only accounted for 13.5% of total global energy supply. Oil and gas still accounted for the largest supplies of almost 60% combined (IEA 2020).

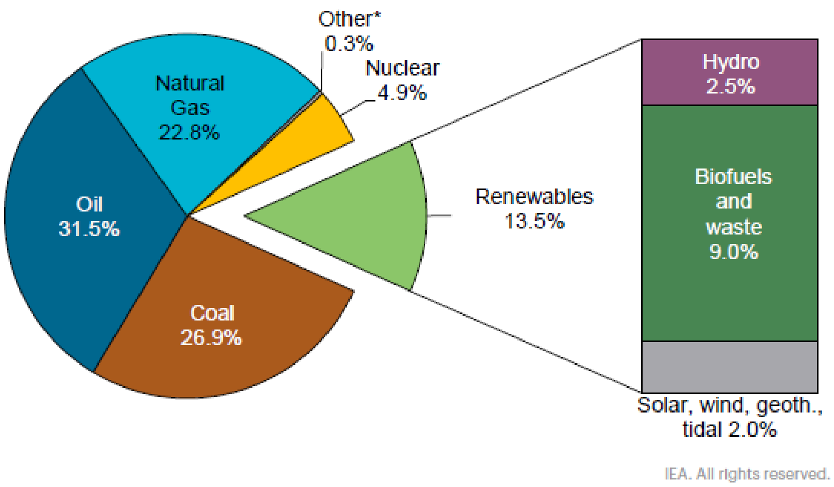

Figure 3: Distribution of global energy supply in 2018 (IEA 2020)

Aiming at limiting the global temperature rise to 1.5°C IRENA (2019b) predict an energy transformation based on wind and solar power. This would entail a capacity increase of wind power until 2050 by 900% (onshore) and 4000% (offshore). Solar PV capacity would have to be increased to 18 times the capacity of 2018 levels. Renewable energy technologies in general will account for 65% of total primary energy supply (IRENA 2019a).

This capacity increase goes hand in hand with a growing demand for raw materials. For example, until 2050 the Nickel demand is expected to increase by 108%, Neodymium and Copper by 37% and 7% respectively (The World Bank 2020b). Even though improvements in efficiency and the deployment of new technologies can be expected (e.g. onshore wind is expected to decline by 25% until 2030 due to larger wind turbines and improved capacity factors (IRENA 2020a)).

This remarkable increase in raw materials demand has the potential to worsen issues discussed in chapter 2.2 if no appropriate measures are taken.

The following section examines the supply chains of the materials and technologies chosen for further evaluation. This is necessary to identify key players in the supply chains and where issues may arise. This is followed by a discussion of the challenges around responsibility and sustainability in the renewable energy sector, as well as standards and initiatives that are already in place trying to solve these problems.

2.1 The Supply Chain

For assessing the state of play of the renewable energy sector for wind and solar PV energy, we first map the current status of the supply chains.

The mapping starts with the extraction of copper, rare earth elements (REE), and quartz (SiO_2, primary raw material to produce silicon metal and polysilicon). Both REE and silicon metal have been identified as critical raw materials for the EU and for the transition to a climate-neutral economy. This means that they are of great importance for the European economy, while being subject to increased supply risk (depending on import reliance of the EU and concentration of supplying countries) (Bobba et al. 2020; EL Latunussa et al. 2020).

2.1.1 Raw Material's Mining, Processing & Consumption

Copper is not classified as critical for the EU. Even though the apparent consumption is very high with 2.57 Mt per year and it is an essential raw material for many industry sectors, such as tubes and wiring, digital appliances, etc., there is also a large production in the EU. Copper mining activities in the EU account for 4% of total global extraction. The supply mainly comes from Poland, Spain, Bulgaria, and Sweden. Globally, Chile is the largest producer accounting for approximately 28.5% of total global supply, followed by Peru, and China (Reichl and Schatz 2020; Eynard et al. 2020). Poland accounts for 27% of EU supply and is next to Germany one of the main producers of refined Copper in the EU. The EU's refined copper production represents 12% of global production. Moreover, downstream industries producing rods, bars, wires, tubes, etc. are active in the EU, with approximately 80 companies accounting for 35,000 jobs (Eynard et al. 2020).

Rare earth concentrates (REO-content) are mainly produced in China, accounting for 73.23% of global supply in 2018, followed by Australia and the United States. In 2018 there was no EU production. However, there are several projects currently in the development phase: Norra Kärr, Tasjo, and Olserum in Sweden with resource estimates of 333,000 tonnes; Matamulas, Spain with 35,890 tonnes; and one project each in Germany and Finland. Extraction of rare earth is dominated by China, as well as the further processing and production of semi-finished and finished products (see Figure 4) (EL Latunussa et al. 2020).

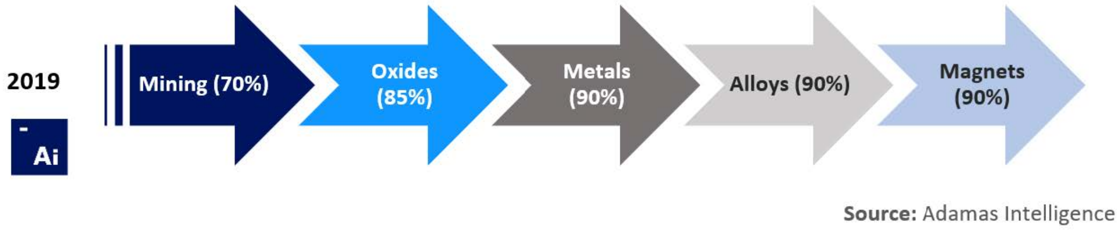

Figure 4: Share of Chinese production in rare earth's supply chain (EL Latunussa et al. 2020)

High purity quartz is the main source for the production of silicon metal. Globally, China is the largest producer of silicon accounting for 64% of global supply in 2019 (Dolley 2020). It is classified as a critical material for the EU, with the EU accounting for approximately 18% of global consumption, and approximately 6% of global supply of silicon metal. Producers in the EU are France, Spain, and Germany. Usually, high purity quartz is extracted and processed into silicon metal on-site (Schnebele 2020a; EL Latunussa et al. 2020). The main source of EU supply is Norway, followed by France, and China.

The downstream consumption is dominated by the chemical industry using silicon metal in the production of silanes and silicones, consuming 54% of total supply. The production of solar PV cells accounts for 6% of EU consumption. Worldwide, the solar industry has a slightly higher share of 10% of total consumption. There are numerous quartz mines and resources reported throughout the EU, however, it is unclear whether these resources have the high purity required for silicon metal production. Sweden, among others, has 52 known quartz deposits with three active mines mainly producing quartz for the ferro-alloy industry. Additionally, known unexploited occurrences contain medium to high purity quartz (EL Latunussa et al. 2020).

2.1.2 Manufacturing of Solar PV Panels and Wind Turbines

Solar PV panels: China is not only the largest producer of the raw material required for the production of the most widely used solar cells, it also is the largest manufacturer of solar cells. The top four global manufacturers of solar panels, with the largest market share in 2019, are based in China. Only three manufacturers in the top 10 ranking are not Chinese. Outside the top 10, there are various European companies producing solar panels. Some of the larger manufacturers include the REC Group (Norway), Hanover Solar (Germany), the ATERSA Group (Spain), or Kioto Solar (Austria) (Bloch 2020; SolarFeeds Marketplace 2019).

Wind Turbines: The two largest producers for wind turbines are the European companies Vestas (Denmark) and Siemens Gamesa (Germany/Spain). Considering only off-shore installations, Siemens Gamesa is in the lead. Within the top 10 there are five Chinese companies, as well as one US manufacturer. Wind turbines and associated equipment for the European market are mainly manufactured in Europe, apart from minor volumes of electrical equipment being produced in China, India, and North Africa. While China, India, and Brazil also have large wind turbine industries, they mainly meet their domestic needs (Stromsta 2020; Renewable Energy World 2020; Wilde-Ramsing et al. 2020 (forthcoming)).

2.2 Challenges

In this section the issues and challenges identified for the renewable energy value chain are organised according to the stage of the chain. The sectors where most problems were identified are mining and processing/refining, manufacturing of equipment, and recycling. The identification of issues in these sectors and the highlighting of individual problem cases should not lead to a quasi-boycott of certain stakeholders. The authors believe it is important to address challenges openly so that we can work together to solve them.

2.2.1 Mining & Processing

The **RE-SOURCING Project** will focus on:

- **Copper, Rare Earth Elements,** and **Silicon** Mining & Processing
- Human Rights Violations: Human rights violations occur in the mining and processing stage of all raw materials discussed in this report. This includes conflicts with local communities and indigenous people, violation of women's rights, and forced labour.
- Environmental Impact: Currently many mining operations are cause for large environmental impacts, which must be addressed to make the sector more sustainable. These are: land use, tailings, waste rock, ARD, energy consumption, air emissions & wastewater.
- Health & Safety: Health and safety of both, workers and local communities are important aspects of improving reputation and acceptance of mining operations.
- Transparency and Traceability: To avoid financial crime (e.g. corruption, tax evasion) the transparency of operations and money transfers needs to be improved. Traceability of raw materials is a necessary tool to ensure responsible practices along all stages of the value chain.

Mining and processing operations can be connected to large environmental impacts, as well as to human rights violations and financial crime. Moreover, mining accounts for approximately 11% of global energy use (The World Bank 2020b). To enable a just energy transition to a clean and decarbonized system, it is therefore critical to improve conditions in the mining sector.

Franks (2015) groups the mining impacts into 5 categories:

1. rights, including human rights violations, dispossession of indigenous land;
2. environment, e.g. generation of waste and its release into the environment, disaster due to tailings dam failures, and impact on biodiversity;
3. development, which entails the lack of engagement of companies in regional and local development;
4. fuelling conflicts, including direct or indirect support to non-state armed groups and state security forces; and
5. lack of transparency, mainly corruption and tax evasion.

The Responsible Mining Foundation (2020) investigated 38 large scale companies according to six thematic areas: economic development, business conduct, lifecycle management, community wellbeing, working conditions and environmental responsibility. Their research indicates that companies need to increase their efforts in all areas to meet society's expectations and the SDGs. Many have made commitments to economic, social and governance issues, however, decisive action is still missing.

Kiezebrink et al. (2018) conducted a study on due diligence by wind turbine manufacturers, examining seven manufacturers supplying the Dutch market (MHI Vestas Offshore Wind, Siemens Gamesa, Lagerwey, Goldwind, Nordex, Enercon, and General Electric (GE)).

The study shows that the largest impacts along the value chain of wind turbine manufacturers can be found in the mining stage. For many minerals required for the production of wind turbines (aluminium, copper, iron, and rare earth elements) negative implications have been reported. A major issue is the effect mining can have on local communities and indigenous people, as it often damages food sources, or land and water resources essential for their livelihoods, as well as land important for indigenous traditions and culture. Forced displacements and inadequate compensations can lead communities to ruin.

These accounts are reflected in data from the Environmental Justice Atlas, where individual projects (planned, cancelled, or mines in operation) are assessed according to their environmental and social impacts. Details are discussed in individual commodity chapters.

Furthermore, the processing, smelting, and refining of metals can also cause significant impacts, both on the environmental and social aspects. Environmental impacts linked to mineral processing are landscape destruction, contamination of soil, water, and air, dust, noise, acid rock drainage, acid seepage, and acid metal pollution. All these issues can have negative effects on health and safety of neighbouring communities. Processing and further smelting and refining are usually very energy intensive processes. Depending on the source of energy, this can generate large amounts of carbon dioxide and sulphur dioxide emissions (Wilde-Ramsing et al. 2020 (forthcoming); Tost et al. 2018a). Many metals are recovered by using floatation. A process relying on large quantities of water and chemicals. Remaining slurries are usually stored in tailings dams whose failure can cause enormous devastation on a large scale.

2.2.1.1 Copper

The major copper producers are large scale mining operations in Chile with a market share of approximately 28.5%, followed by Peru and China (11.9% and 7.6% respectively) (Reichl and Schatz 2020). Other important producer countries include the DRC and Zambia located in the African Copperbelt, a region known for its vast copper and cobalt deposits. Here mining is conducted both by large-scale mining (LSM) companies and by artisanal and small-scale mining operations (ASM). ASM is an important source of income and livelihoods for the local population, but it remains largely informal in the majority of mineral-producing countries.

ASM in the Copperbelt: The DRC produced 6% of global copper supply in 2018, making it the largest African producer. LS mining operations in the DRC is usually produce copper as a main product and Cobalt as a by-product, whereas ASM cobalt production is located at specific deposit sites with higher cobalt concentration. Due to the significant drop of cobalt prices in the second half of 2018, continuing in 2019 and comparatively stable copper prices, many AS miners switched to copper extraction. The parallel existence of LSM and ASM is often a cause of conflict. One reason is that LSM operations have licenced areas that have previously been used by ASM and thus deprive the local population of their source of income; or unauthorised ASM activities take place in areas licenced to LSM operations. Unauthorised and informal ASM on LSM concessions is found to be more exposed to the risks of child and forced labour. Women are often not allowed in mining activities due to superstitions that they influence the ore grade. Some LSM companies try to drive AS miners off their concessions by employing armed forces often leading to violent confrontations (Maiotti et al. 2019).

Corruption can also play a role in both types of mining activities. On the one hand, concerning the acquisition of mining licences for LSM, and on the other hand illegal payments by ASM to government officials, or beneficial ownership of cooperatives and buying depots. The correct and full payment of taxes is also an issue. Controls in the area are limited due to a lack of appropriate instruments, such as a weighbridge (Maiotti et al. 2019).

Both types of mining operations are responsible for a large environmental impact in the Copperbelt region. Due to the growth of the Zambian ASM sector and a lack of regulations for appropriate environmental protection and reclamation, the environmental problems are increasing (Kambani 2003; Katz-Lavigne 2020). LSM is reported to cause water pollution through effluent discharge containing acid, lead, mercury, etc. Consequently, there are severe health issues faced by neighbouring communities and reduced food security, amongst others. The loss of income and threatened livelihood also leads to secondary challenges, such as an increasing number of teenage pregnancies, crime and alcohol abuse. In some regions, copper production has also been associated with high cancer rates in local neighbourhoods. Antofagasta, a mining city in Chile, reports one of the highest cancer rates in Chile. Similar observations have been made in Jiangxi Province, China, where workers are exposed to arsenic in copper smelters (Leth et al. 2019; Wilde-Ramsing et al. 2020 (forthcoming)).

The Environmental Justice Atlas (2015b) recounts various copper mining projects causing environmental problems and negatively impacting indigenous lands. For instance, Imperial Metals, Canada, is responsible for a tailings dam failure in 2014 contaminating local lakes and river systems. Clean-up efforts are still ongoing. Some planned projects are also cause for concern, e.g. Pebble mine, Alaska, and New Prosperty Gold-Copper Mine, Canada. Both projects could have a severe impact on indigenous lands that are the main source of food and also important spiritual places. A project in Peru – Ria Blanco Mine Majaz – has been halted due to strong opposition by the population.

Another issue that can occur from copper mining is Acid Mine Drainage (AMD) or Acid Rock Drainage which refers to AMD from mine waste rock. AMD is formed when metal-sulphides react with oxygen and water forming sulfuric acid, metal ions, and sulphate. This can cause severe pollution of surface- and groundwater if not treated correctly. However, the main source of AMD is pyrite (FeS_2) oxidation (Akcil and Koldas 2006; Skousen et al. 2018).

2.2.1.2 Rare Earth Elements

About 20% of total rare earth production is used for the production of magnets (mainly neodymium Nd, samarium Sm, praseodymium Pr, and dysprosium Dy) (Schüler et al. 2011; Haque et al. 2014).

Depending on the future deployment of this technology, a strong increase in demand for rare earth elements for renewable energy applications can be expected.

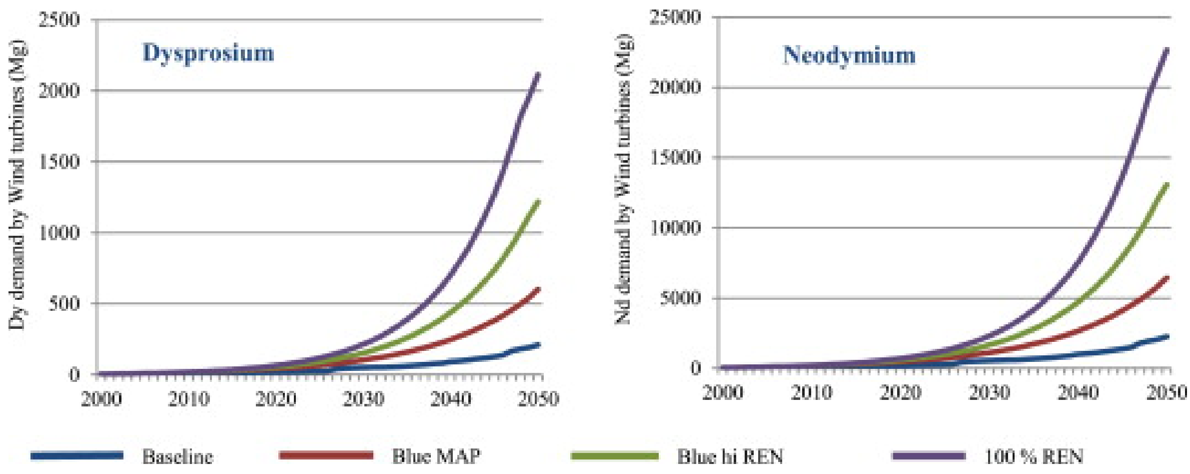

Figure 5: Projected demand of Nd and Dy until 2050 according to different secenarios of renewable energy employment (Habib and Wenzel 2014)

Concentrates of rare earth elements (REE) are mainly produced in China (in 2018 approximately 73.2%), followed by Australia and the United States with 11.3% and 11.0% respectively (Reichl and Schatz 2020). Rare earths are usually mined as a by-product, e.g. of iron, titanium, or uranium ore. The extraction activity can be done through open pit or underground operations, or in-situ leaching. The processing is dependent on the type of deposit with floatation being one of the prevalent methods. The largest rare earth mine is located in China called Bayan-Obo. This mine has been in the public eye due to vast amounts of waste gas, waste water, and radioactive waste being produced and discharged (Grahem 2015; Schüler et al. 2011; Haque et al. 2014).

There are many potential sources of environmental pollution in rare earth mining and processing. Figure 6 gives an overview. The tailings dams of floatation operations emanate the main risks, including leaching of chemicals, heavy metals, and radioactive elements. A dam failure has the potential of causing environmental disasters of enormous proportions (Schüler et al. 2011).

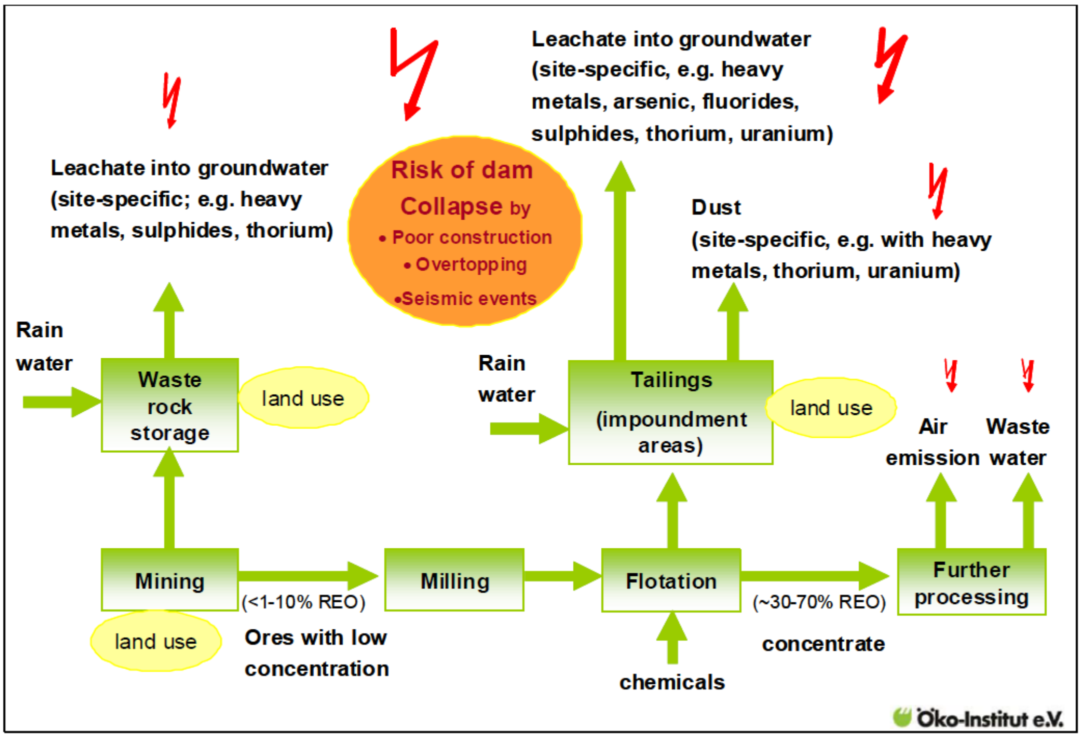

Figure 6: Risks of rare earth mining without or with insufficient environmental protection systems (Schüler et al. 2011)

The processing and further refining of REE is very energy intensive and can produce harmful air emissions containing sulphur dioxide, dust, radioactive substances, etc. if not treated correctly. From an environmental perspective, small illegal mines in China pose a serious threat. It is estimated that approximately 20,000 tonnes of rare earth concentrates are illegally mined (compared to 163,869 t total global production). These mining and processing operations usually do not operate any waste (solid/water/air) treatment facilities causing serious environmental damage and posing health hazards for the surrounding communities. (Schüler et al. 2011).

Again, the Environmental Justice Atlas (2015a) reports a number of projects where environmental and social conflicts have been encountered. An operational mine in Chalco, Yulin, Guangxi, China, has been reported to have caused pollution (noise and waste) and biodiversity loss. Neighbouring communities repeatedly protested against the operation, as further issues including surface and groundwater pollution, as well as loss of landscape are feared. There are a number of planned projects in Kenya (Mrima Hill), Sweden (Norra Kärr), and Greenland (Kuannersuit/Kvanefjeld) that are a cause for concern due to their location in environmentally sensitive areas; e.g. Norra Kärr is close to a Natura2000 area and Mrima hill, a Nature Reserve and National Monument.

Apart from environmental issues, resource efficiency also plays an important role. Starting at the mine, a high cut-off grade can lead to a higher waste to ore ratio and an unsustainable use of resources. At the next stage, the processing, efficiency depends on the type of process used and the location. Chinese mines using floatation are reported to have very low recovery rates of only 40% to 60%; with the in-situ leaching method recovery rates of approximately 75% are achieved. (Schüler et al. 2011).

2.2.1.3 Silicon

Pure silicon or silicon metal is mainly obtained from quartz (SiO_2), , and the reserves and resources are abundant. Quartz can either be extracted from vein type deposits by drilling and blasting or from fluvial deposits by excavation methods. The main producers are China, Russia, and the United States (silicon content of ferrosilicon and silicon metal combined) (Schnebele 2020b, 2020a; European Commission 2017; Dolley 2020).

The EU classifies silicon metal as a critical raw material in their 2020 criticality study. This is mainly due to the high consumption of silicon metal within the EU (approximately 17% of global consumption) opposed to a small EU production (approximately 6% of global supply) (EL Latunussa et al. 2020).

While no reports of major issues concerning quartz mining activities could be found, there are issues that need to be considered further downstream the supply chain in the processing of quartz to silicon metal and polysilicon.

The processing of quartz to high-purity silicon (polysilicon) is very energy intensive. The first step is a carbothermic reduction which reduces quartz to silicon metal by placing it in a submerged furnace together with coke and charcoal. Electrodes supply electric energy and heat the furnace to 2000°C at the bottom and up to 1300°C at the top. Molten silicon metal with a purity of approximately 98.5% is produced at the bottom. Further processing to achieve higher purities is usually done via the three-step Siemens process. During this process the reactant is heated and silicon is vaporized. It then precipitates on a silicon “starting seed” producing high-purity polysilicon. The high energy consumption is cause for a high carbon footprint as the heat is often produced with coal (Nunez 2014; European Commission 2017; Cowern 2012).

In 2019 the Chinese autonomous Xinjiang region alone accounted for one-third of polysilicon used by the global PV industry, another 50% are produced in the rest of China. However, especially the Xinjiang region is in the focus of the US government due to allegations of human rights abuses and forced labour of Uighur and other Muslim minorities. American producers are required to prove that materials sourced from this region have not been produced using forced labour. This could potentially mean that sourcing from Xinjiang has to be stopped altogether as this requirement cannot be fulfilled (Copley 2020).

2.2.2 Wind Turbine Manufacturing

The **RE-SOURCING Project** will focus on:

- Human Rights: Renewable Energy technologies manufacturers have been found to lack in commitment to basic human rights principles, land rights, indigenous people rights, and gender equality.
- Environmental Impact: The production of materials for wind turbines shows a high energy consumption and depending on the energy source high CO_2 emissions, even more so if permanent magnet generator systems are used.
- Occupational Health & Safety: The production of wind turbines poses many risks for the health and safety of workers, e.g. health implications of working with epoxy resins or fibreglass.

Wind turbines are used to produce electricity from a renewable resource – wind or moving air. Wind creates kinetic energy causing the blades of the turbine to rotate, thus creating rotational energy. This rotational energy is in turn transformed into electrical energy through the use of generators. There are different types of wind turbines. The two main categories are onshore and offshore technology that can be further differentiated according to the type of generator system used. The generator and the magnet used also determine the materials required for the construction of the turbine. For example, electromagnets found in different types of generators consist of iron cores surrounded by wound copper wire. Other turbines might use permanent magnet generators that require rare earth magnets (neodymium, iron, and boron Nd-Fe-B magnets). The trend for wind turbine technology is moving towards larger wind turbines with higher capacities. Currently, the largest available turbines have a capacity of 8 MW and a rotor diameter of 164 m (IRENA 2020c; Wilburn 2011; Kügerl 2020).

The three main parts of a wind turbine are the tower, the nacelle, and rotor blades (see Figure 7).

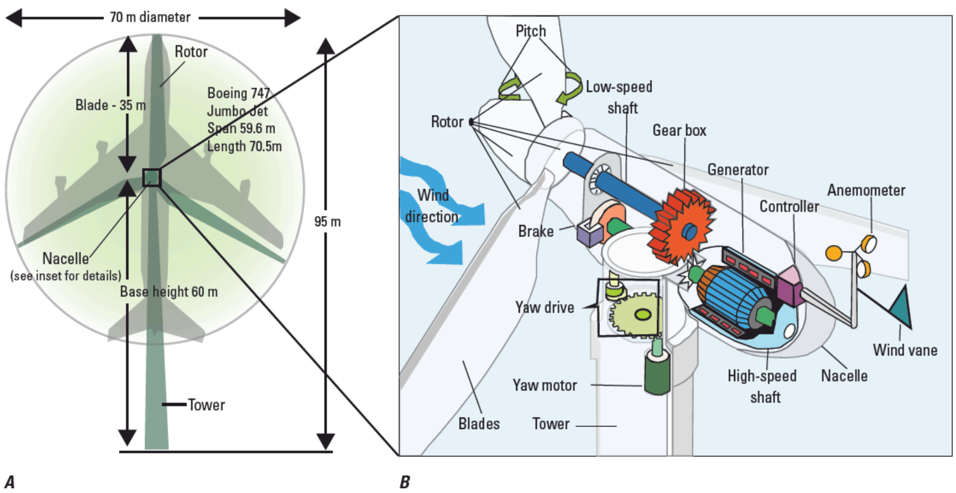

Figure 7: Dimensions and components of a typical wind turbine (A) components of the nacelle using a gearbox (B) (Wilburn 2011)

The production of wind turbines is considered as heavy industry associated with hazards comparable to the car and aerospace industries. Wind turbine and equipment manufacturing is expected to provide for more than 220,000 jobs in Europe by 2020. The risks for workers are mainly injuries and fatalities due to slips, trips, and falls, crane operation, working in confined spaces, exposure to noise, hazardous gases, vapour, and dust. The epoxy resins used for the production of turbine blades can cause allergies and dermatitis, and can affect women's ability to have children. Fibreglass production generates styrene, a solvent vapour, which is difficult to control. Styrene, dust, and fumes from fibreglass, hardeners, aerosols, and carbon can cause serious health issues such as liver and kidney damage. Other problems include dizziness, drowsiness, and sleepiness, dermatitis, blisters, and chemical burns, as well as reproductive effects (Wilde-Ramsing et al. 2020 (forthcoming)).

Wind energy production is one of the fastest growing renewable energy technologies and is considered a clean technology. Nevertheless, the production of the wind turbine, operation, maintenance, installation, and servicing can have environmental impacts. This also applies to the end-of-life treatment and/or recycling. Manufacturing accounts for approximately 80% of energy consumption in the life cycle of a wind turbine and thus, is the source of the highest global warming potential.

According to life cycle assessments that have been identified, more than half of the emissions can be associated with the production of the steel tower (see Figure 8). However, most assessments include emissions of raw material extraction and processing in the manufacturing stage. This means that a major share of the emissions for the tower production are associated with the steel manufacturing itself rather than the equipment manufacturing. Further impacts are caused by foundation and nacelle production. The emissions by the blade production are associated with the manufacturing of epoxy resin and fiberglass. It is estimated that the material production itself accounts for more than 70% of energy consumption in the manufacturing stage, leaving less than 10% for the equipment manufacturing (Oebels and Pacca 2013; Priyanka and Garrett 2019; Siemens Gamesa Renewable Energy, S.A.).

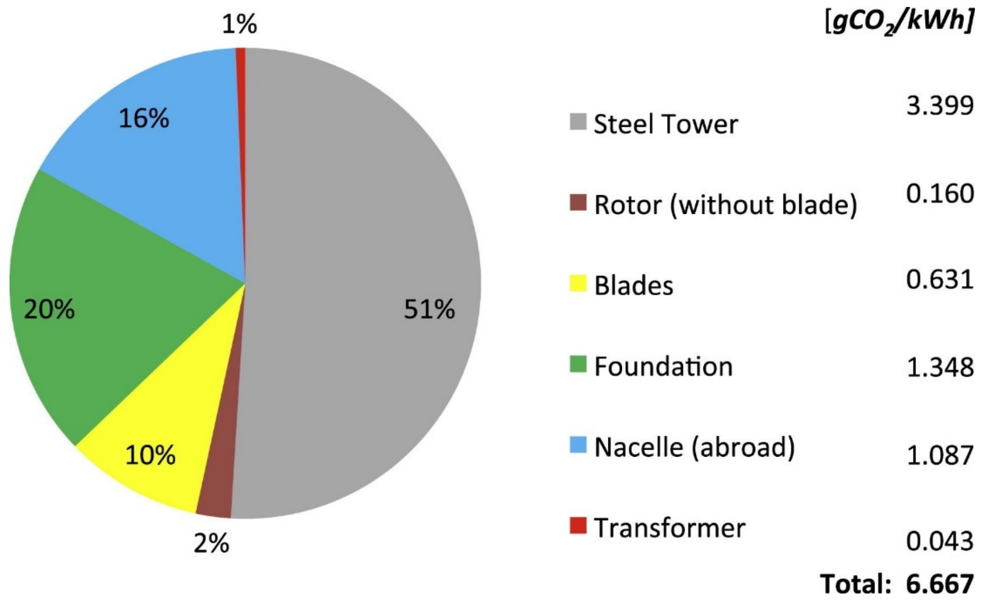

Figure 8: CO_2 emissions per component and kWh in manufacturing stage (Oebels and Pacca 2013)

Schreiber et al. (2019) conducted a comparative life cycle assessment (LCA) of three types of wind turbines that differ according to the drive systems used (i) direct drive electrically excited synchronous generators (DDSG), (ii) direct drive permanent magnet synchronous generators (DDPMSG), and (iii) double fed induction generators (DFIG). Turbines of the DDPMSG type use rare earth elements for the permanent magnet construction. This makes the overall construction lighter as less steel is required, relative to the other two types. However, the impact of the permanent magnet production is significant. The parameter evaluated in this LCA with the highest impact is the category 'resource depletion, minerals, fossils and renewables' and this is dominated by the rare earth production.

Apart from the environmental impact of the manufacturing process, human rights and labour conditions in factories have to be taken into consideration. The Business & Human Rights Resource Centre (2020b) conducted a study on the adherence of renewable energy companies (16 companies were evaluated) to basic human rights principles as defined by the UN Guiding principles as well as further sector specific indicators, such as indigenous people's rights, land rights, etc. Only nine of the assessed companies publicly committed to respect human rights across all activities and basic international labour rights.

Sector specific topics are labour, health and safety, which evaluate policies and practices by the companies to fundamental labour rights including living wage, worker health and safety, as well as closing the gender wage gap.

Only one company in the above study committed to paying a living wage to its employees, and three more companies already reached or are committed to closing the gender wage gap.

Impacts on indigenous peoples' rights, abuse of land rights, and other human rights violations have mostly been found in connection to the extraction of raw materials (see chapter 2.2.1) and wind farm constructions (Business & Human Rights Resource Centre 2020c; Kiezebrink et al. 2018).

2.2.2.1 Manufacturing of Rare Earth Magnets

About 20% of installed wind turbines use DDPMSG drive systems. They are preferred in offshore conditions due to their robustness and reliability as there is no need for a gearbox (Venås 2015; IRENA 2019b; Schüler et al. 2011). Permanent magnets consist of neodymium, iron, and boron at a ratio of 29%, 70%, and 1% respectively. Usually, Neodymium is not used in its pure form, but rather as a mixture with other rare earth elements, depending on the ore used. Praseodymium is a common component as it has similar properties. Dysprosium can be added for positively influencing the magnetic field at higher temperatures and improving the corrosion resistance. Terbium has similar effects (Kügerl 2020).

2.2.3 Solar Panel Manufacturing

The **RE-SOURCING Project** will focus on:

- Human Rights: Renewable energy technologies manufacturers have been found to lack in commitment to basic human rights principles, land rights, indigenous people rights, and gender equality.
- Environmental Impact: The production of silicon wafers for PV panels requires large amounts of energy, water, and chemicals, all of which can have a significant impact if not monitored and treated appropriately. Resource efficiency regarding losses during production needs to be considered.

Solar power production utilizes the radiation of the sun and transforms it into electricity or heat. Two different types can be differentiated, solar cells or photovoltaics (PV) that convert sunlight into electricity. These can be used on a small-scale, for example installed on roofs for personal use, or on large-commercial scale. Concentrated solar power (CSP) uses mirrors to concentrate the solar rays. The concentrated rays then heat fluids to create steam and power a turbine. This in turn generates electricity in large-scale power plants (IRENA 2020b). The RE-SOURCING project will focus on the first type.

The main issues connected to the production of solar PV panels and other PV equipment are the use of chemicals, as well as water and energy consumption. Data about the environmental footprint is difficult to obtain. Operating standards differ greatly from country to country and research has to mainly rely on data published by the companies themselves. Studies have found that manufacturing in China has twice the carbon footprint of their European counterpart, largely due to fewer environmental standards and electricity production using coal-fired power plants. Of the 10 largest solar panel producers worldwide in 2019, seven companies are Chinese, and two of the remaining three companies also manufacture at least partly in China (Yue et al. 2014; Nunez 2014; Bloch 2020).

The California based Silicon Valley Toxics Coalition has developed a scorecard for solar panel manufacturers assessing 37 companies according to their extended producer responsibility, emissions reporting, worker rights, health and safety, etc. This scorecard serves to support transparency and responsible sourcing by helping consumers, investors, and others choose suppliers that adhere to sustainable and socially responsible practices. 100 points can be scored in total, distributed over seven categories. More than half of the evaluated companies scored zero points, only one managed to achieve the highest score (The Silicon Valley Toxics Coalition 2020).

One of the largest solar panel producers Jinko Solar (top producer in 2019) came under scrutiny for polluting a nearby river by dumping toxic water in one of its Chinese plants. However, they notably increase their sustainability efforts and managed to achieve 100 points in the 2018-19 solar scorecard (compared to <10 in 2014) (The Silicon Valley Toxics Coalition 2020, 2015; Nunez 2014).

Energy Consumption: Yue et al. (2014) compare three different photovoltaic technologies, mono-crystalline silicon, multi-crystalline silicon, and ribbon silicon produced at two different locations, Chinese compared to European manufacturing in a comparative LCA. They show that factors such as Energy payback time and carbon footprint are significantly higher for the production in China (see Figure 9).

However, with stricter Chinese energy and environmental policies being brought in, this is expected to improve (in 2019 and 2020 new laws and regulations were and will be enforced, strengthening environmental pollution prevention, carbon footprint reduction, etc.). Transport was not included in the evaluation (Qing et al. 2020; Yue et al. 2014).

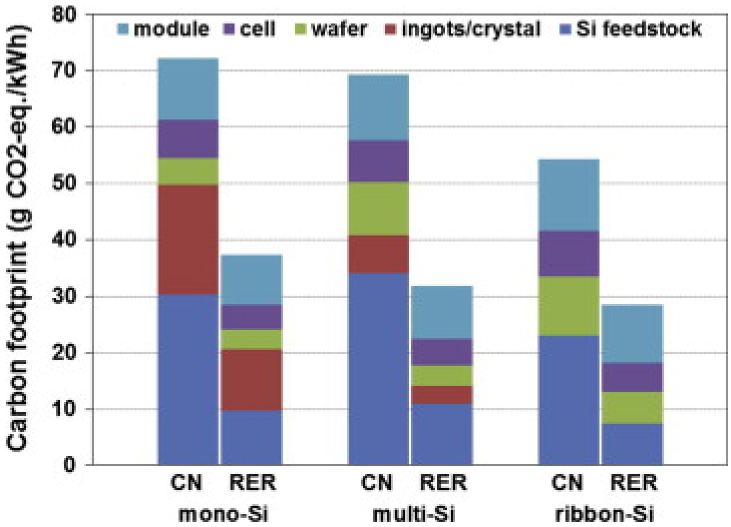

Figure 9: Comparison Carbon footprint of the production of three different solar panels in China (CN) and Europe (RER) (Yue et al. 2014)

Human Rights: The 16 companies assessed by the Business & Human Rights Resource Centre (2020b) mainly manufacture both wind and solar equipment, and also include investors. Therefore, the results outlined in chapter 2.2.2 are valid for solar panel manufacturers as well.

Use of Chemicals: One of the main technologies applied in the solar sector is polycrystalline silicon solar cells due to their conversion efficiency. However, the production of crystalline silicon is highly energy intensive and large amounts of waste gas and wastewater, as well as solid wastes are produced. The dangers of environmental pollution if the waste products are not treated correctly are high. Crystalline silicon solar cells production requires large amounts of chemicals. They are used for silicon wafer surface corrosion to remove phosphorus silicon glass. This process generates wastewater containing fluorine, hexa-valent and trivalent chromium compounds, and high concentrations of suspended solids. The water treatment is a complex and expensive process generating hazardous waste sludge that again can cause secondary pollution if not handled correctly. Silicon cleaning and battery production produce wastewater with fluoride contaminants.

Waste gas containing hydrogen and nitrogen oxides, chlorine gas, carbon dioxide, etc. is a by-product of several processes, including phosphorus silicon glass production and plasma etching. The glass production not only consumes high energy amounts, it also produces a lot of dust during processing endangering workers with silicosis (Qi and Zhang 2017).

Resource efficiency: Another issue in the production of silicon wafers is the large amount of kerf losses[1]. Studies suggest these losses can exceed 50% depending on wafer thickness and diameter of the wire used for cutting. These losses consist of high-purity silicon which is often declared as hazardous waste and disposed of instead of being treated and returned to the process. However, an economical viable recycling process has not been developed yet. Especially with regard to potential energy and resource savings, this part of PV production requires increased attention (Li et al. 2021; SIKELOR 2020; Fischer 6/9/2020).

2.2.4 Wind Turbine Collection & Treatment

The **RE-SOURCING Project** will focus on:

- Turbine Blades: The main problem for the recycling or reuse of wind turbine materials is the collection and treatment of turbine blades. New technologies for treatment, ideas for reuse, etc. are necessary to avoid huge amounts of land fill.
- Occupational Health & Safety: The dismantling of wind turbines can pose great health risks to workers, including exposure to harmful substances.
- Environmental impact: The dismantling process also needs to take the restoration of land used for wind farms into consideration.

Wind turbines generally have a high recyclability of approximately 80% to 90%. The major part of the components – such as steel from the tower, concrete from the foundation, etc. can be reused. However, so far this has not been possible for wind turbine blades, due to their complex structure of composite materials. Over the next couple of years 15,000 wind turbine blades will reach their end-of-life. This large volume poses great challenges for collection and waste disposal or processing. New technologies need to be developed to sustainably treat and reuse the materials to make the wind sector sustainable from cradle to grave (ETIP Wind 2019). Per MW wind energy capacity, an estimated 12-15 tonnes of blade material are required. Assuming an expansion of wind energy to 5,044 GW by 2050, as proposed by IRENA, an enormous waste volume will need to be handled. Currently there are three main options employed: (i) disposal, including landfill or incineration without heat recovery, (ii) energy recovery or recycling, i.e. incineration with energy recovery, thermal, chemical, or mechanical recycling, and (iii) repurposing, e.g. co-processing in a cement kiln. Reclamation of the original components would be preferable given circular economy considerations. However, this technology is not ready for commercial use yet. Other studies suggest the use of blades for polyvinyl chloride (PVC) production, roofing for temporary housing, office or home furniture, city furniture, etc. (Nagle et al. 2020; Lewandowski et al. 2019; Bank et al. 2019).

Apart from the issues with treatment and recycling itself, the dismantling of wind turbines also poses health and safety risks for the workers. The risks of exposure to harmful substances are similar to the issues discussed in chapter 2.2.2 Wind Turbine Manufacturing, with risks increasing for off-shore facilities (Wilde-Ramsing et al. 2020 (forthcoming)).

[1] Kerf losses are waste products (mainly consisting of high-purity silicon particles) that occur when silicon ingots are sliced into thin wafers, for more information please see Li et al. 2021, or SIKELOR 2020.

Finally, the site restoration of land used for wind farms needs to be taken into consideration. Even though this has not been a major issue so far due to the limited number of cases, it appears that a plan for decommissioning does not include adequate restoration measures, or is not communicated properly to affected communities. Stakeholder involvement in the end-of-life planning needs to be improved (Wilde-Ramsing et al. 2020 (forthcoming)).

2.2.5 Solar Panel Collection & Treatment

The **RE-SOURCING Project** will focus on:

- Environmental Impact: Solar Panels are generally well recyclable; the issue is the appropriate collection and treatment of the panels. E.g. in China a lot of photovoltaic equipment is burned causing severe environmental pollution and potentially has adverse impacts on biodiversity and human health.
- Economics & Policy: Recycling needs to become economically attractive for companies and policy guidelines need to be established for increasing waste streams in the future.

Economic Issues: Currently the main issue in the collection and treatment of PV is that only small quantities of solar panels are decommissioned and enter the waste stream due to their long lifespan of 20-30 years. For this reason, the number of treatment facilities is limited and the recycling per se is not economically attractive yet. With available technologies a little over 90% of solar panels can be recycled. This is mainly done in existing glass and aluminium recycling plants. However, effective treatment of the entire solar panel is key to extract critical metals used, such as silver, tellurium, or indium. (Nunez 2014; Qi and Zhang 2017; SolarPower Europe 9/23/2019a, 9/23/2019b).

Additionally, there are two individual solutions for adequate recycling currently in use. (i) independent recycling providers, such as the European PV Cycle or the Australian Reclaim PV Recycling, and (ii) collection and treatment by solar PV manufacturers. PV Cycle is a collective organisation offering collection and treatment of PV modules, batteries, etc. according to regulatory requirements on a global scale. Within the EU, collection and pick-up services are provided.

The solar panel manufacturer First Solar operates their own recycling facilities in the US, Germany, and Malaysia. Collecting and recycling their end-of-life solar panels (for further details see Annex section 1.2.6) (PV Cycle 2020; First Solar 2020).

According to the EU criticality study Veolia opened an end-of-life recycling plant for PV wastes in 2017 in cooperation with PV Cycle and the Syndicat des Énergies Renouvelables. This plant increased its capacity from 1,800 tonnes of material in 2017 to 5,000 tonnes in 2019 reaching a recovery rate of 94.7%. Furthermore, ReSiTec a Norwegian company recycles silicon materials that are generated in the photovoltaic industry during solar cell manufacturing and uses it to produce high purity, micronized silicon powders for further application in batteries or ceramics. The company operates plants in Norway and Asia (EL Latunussa et al. 2020; ReSiTec 2018; Rollet and Beetz 2020).

Environmental Impact: If photovoltaic equipment, such as solar batteries are not treated appropriately when decommissioned, potentially harmful substances are released into the environment. Substances, including silicon, lead, cadmium, phosphorus, and flame retardants can have negative impacts on water, soil, and air quality potentially leading to serious health issues and impacts on biodiversity. In China the burning of electronic products, including solar cells or storage batteries, is still a common practice causing severe secondary pollution. The implementation of strict recycling regulations will be essential (Qi and Zhang 2017).

3 Standards & Sustainability Schemes

The term ‘responsible sourcing’ has become in vogue with firms, governments, and international institutions, investors and civil society. Various, mainly voluntary initiatives promote responsible and sustainable production practices with different intensity along the supply chain. Especially the mining sector has been the target of many initiatives and standards, partly overlapping, but failing to provide an internationally standardised framework. It has become a challenge to navigate in a largely fragmented spectrum of operational and reporting principles (Farooki et al. 2020).

However, to achieve the fully sustainable and responsible supply chain that is required to overcome challenges such as climate change, resource depletion, and human rights violations, it is imperative this ineffectual approach becomes a joint and targeted effort.

This chapter reviews standards and initiatives along the value chain and compares their approaches and points of focus (see Figure 10).

We focus on standards and initiatives relevant for the renewable energy sector and the raw materials included in this report. The authors make no claim of completeness of this list. There are numerous other responsible sourcing standards and initiatives that focus on specific materials that are not covered in this report.

Figure 10: Standards and Initiatives for the renewable energy supply chain

3.1 Mining & Processing

The mining sector has been the focus of many initiatives and voluntary standards to improve production practices and impacts caused by mining operations, including respect for human rights, prevention of conflicts, stakeholder management, or environmental protection. These standards and initiatives partly overlap thematically, others aim at a specific problem related to the mining sector, or only consider a few minerals.

This section provides an overview of the most relevant standards for the mining industry covering the raw materials to be considered in the roadmap for the renewable energy sector (copper, rare earth elements, silicon) and focus on standards and initiatives on a global level.

3.1.1 IRMA[2]

The Initiative for Responsible Mining Assurance (IRMA) is a voluntary certification, assessing mines against the *Standard for Responsible Mining,* which was developed through a collaborative, multi-stakeholder process involving mining companies, purchasers of mined materials, affected communities, labour unions, and NGOs. The standard applies to all large-scale mining operations, independent from the type of operation (surface, underground, or solution mining) and the type of commodity mined. It gives mining companies the opportunity to receive certification for good practice and industry leadership in sustainable and responsible production. Moreover, it provides assurance for customers that the products they purchase are produced in a responsible way. Certifications are conducted by an independent third-party. The standard is grouped into four principles: (i) business integrity requirements, (ii) planning for positive legacies requirements, (iii) social responsibility requirements, and (iv) environmental responsibility requirements.

Principle 1: Business Integrity is aimed at increasing transparency of the mining sector. This includes guidelines for legal compliance, revenue and payments transparency. It also involves community and stakeholder engagement, human rights due diligence as well as complaints and grievance mechanism and access to remedy. The goal is to build trust and credibility with impacted communities and stakeholders.

Principle 2: Planning for Positive Legacies accompanies a mining operation from project start, with environmental and social impact assessment and management, to end-of-life looking at planning and financing of reclamation and closure. Local community related issues are also incorporated, such as obtaining the support of communities and delivering benefits, or appropriate management of resettlements. Free, prior and Informed Consent and emergency preparedness and response are also addressed under this principle.

Principle 3: Social Responsibility involves the management of fair labour and terms of work, as well as health and safety of workers in the workplace and the surrounding community. It includes the prevention of conflicts in conflict-affected or high-risk areas including security arrangements and the conflict free coexistence with artisanal and small-scale mining operations. Furthermore, the cultural heritage of local communities and indigenous people are considered.

[2] Based on IRMA 2018.

Principle 4: Environmental Responsibility considers the largest challenges in terms of environmental pollution, including waste and material management, air quality, GHG emissions, mercury and cyanide management. It also supports the protection of biodiversity, ecosystem services and protected areas. Water management, noise and vibration are also addressed.

3.1.2 ICMM[3]

The International Council on Mining & Metals (ICMM) published the 'Mining Principles' to support the achievement of the UN Sustainable Development Goals (SDGs). They argue that in order to reach the SDGs minerals and metals are required and need to be produced in a sustainable and responsible manner.

The *ten principles* are as follows:

1. Ethical business – Application of ethical business practices, corporate governance, and transparency systems;
2. Decision-Making – Integration of sustainable development in corporate and management strategy;
3. Human Rights, including respect for human rights, culture and traditions of employees and affected communities;
4. Risk Management
5. Health and Safety
6. Environmental Performance, including continual improvement of water consumption, energy use, etc.
7. Conservation of Biodiversity, including integrated approaches to land-use planning
8. Sustainable Production – contribute to a successful circular economy system of products containing minerals and metals;
9. Social Performance – support the development of local communities on social, economic and institutional level;
10. Stakeholder Engagement – proactive engagement of all involved stakeholders, including implementation of the Extractive Industries Transparency Initiative (EITI), and the Global Reporting Initiative's (GRI) Sustainability Reporting Standards.

Companies committing to the ICMM principles will be certified by a third-party validation following a self-assessment and need to repeat this process very three years. This process will provide guidance for companies on issues that need to be addressed and provide transparency and comparability to stakeholders, investors, customers, etc. The principles are aimed at industry scale companies with 27 company members and 35 association members at the moment.

[3] Based on ICMM 2020.

3.1.3 EITI Standard[4]

The standard by the Extractive Industry Transparency Initiative (EITI) is available at global level and aims at countries where a coalition of government, companies, and civil society actively pursue the implementation of this standard. The mission of EITI is transparency along the value chain of oil, gas, and minerals. This includes information on contracts and licences, revenues, etc. (overview see Figure 11).

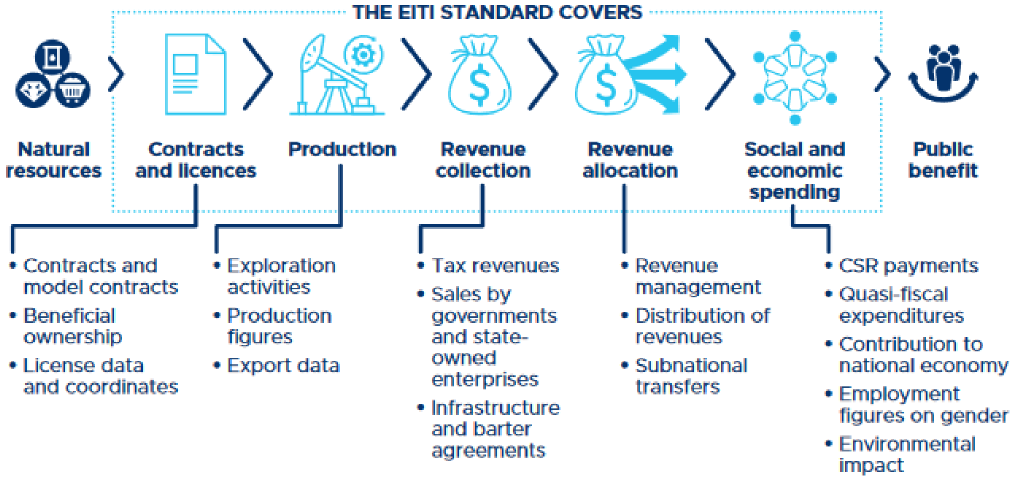

Figure 11: Data disclosed under the EITI (EITI August 2020)

The main principle of EITI is that natural resources belong to the citizens. By disclosing all relevant information an informed public debate shall be fostered. Corruption and tax evasion shall be prevented, public and corporate governance strengthened, and inclusive development supported. So far 54 countries have implemented this standard.

3.1.4 IFC Guidelines for Mining

The International Finance Cooperation (IFC) developed Environmental, Health, and Safety Guidelines (EHS Guidelines) providing a general framework for good practice applicable to all industry sectors. For details on the general guidelines see chapter 3.5.6 IFC . Additionally, industry specific guidelines are published. The EHS Guidelines for Mining are applicable to all types of mining operations and mineral processing, with the exception of the extraction of construction materials which are covered separately. The guidelines focus on impacts related to mining operations throughout all stages of a mining project. Industry specific issues dealt with include acid rock drainage and metals leaching, waste rock dumps, and tailings. The guidelines also include recommendations on sector specific occupational health and safety aspects, for example the use of explosives, and geotechnical safety. The section on community health and safety considers possible impacts on local communities, such as the safety of tailings dams, or land subsidence.

[4] Based on EITI August 2020; Extractive Industries Transparency Initiative 2020.

Finally, recommendations on mine closure and post-closure are included, among others on the financial feasibility (International Finance Corporation IFC 2020, 2007). It should be noted, however, that due to their age (they were published in 2007), the IFC standards do not address some of today's most relevant climate change issues in sufficient detail.

3.1.5 The Copper Mark

The Copper Mark is a framework specifically for the copper industry to support responsible production practices. A joint framework for copper, lead, nickel, and zinc is currently under development. The goal is to provide independent certification for copper producers, allowing them to demonstrate their contribution to sustainable development. The SDGs provide the basis for the requirements of the Copper Mark with focus on SDG 12 "Responsible Consumption and Production. To receive the Copper Mark, 32 criteria have to be fulfilled. These criteria were developed by the Responsible Minerals Initiative and cover environmental, social, and governance areas. A company can also qualify for the Copper Mark by implementing equivalent sustainability systems and standards (The Copper Mark 2020).

3.1.6 Alliance for Responsible Mining

The Alliance for Responsible Mining (ARM) is an initiative to support the artisanal and small-scale mining (ASM) sector. The goal is to support the development and legitimization of ASM and the inclusion of ASM products in the formal economy. This entails socially and environmentally responsible production, including the implementation of technological advances and the adoption of good practices. ARM also supports gender equality and diversification. The initiative develops voluntary standards to help ASM achieve a certification giving firms access to fair markets and prices for their products. The focus of ARM, and its most important standard, is the "Fairmined Standard" on gold production and its value chains (Alliance for Responsible Mining 2018). This initiative has been included in our considerations as ASM is also present in other mineral supply chains, such as copper.

Another ARM programme is the CRAFT (Code of Risk-mitigation for ASM engaging in Formal Trade) passport. It supports the elimination of the worst practices in ASM and the miners understanding for international standards and expectations. This code is focused on gold, the 3 Ts (tin, tungsten, tantalum), cobalt, and gemstones, but it can also be applied to other minerals without any territorial exclusions (Alliance for Responsible Mining and RESOLVE 2020).

3.1.7 Natural Resource Charter[5]

The Natural Resource Charter is a guidance document published by Natural Resource Governance Institute built around 12 core precepts (see Figure 12). This guidance is meant for governments as a decision support system for the development of a country's natural resources to obtain the highest possible benefit for countries and citizens.

Figure 12: Natural Resource Charter Decision Chain (Natural Resource Governance Institute 2014a)

The 12 precepts are grouped into three categories. First, the domestic foundation for resource governance is addressed to help governments define the legal requirements for the extraction of natural resources, to ensure the greatest benefit for the people, and at the same time provide transparency and accountability for decisions.

Category two is aimed at the actual management of resources including economic decisions, such as the attribution of extraction licences. Taxation, revenue collection and spending, as well as environmental impacts and effects on communities are addressed in this category. The focus is again on transparency of the decision-making processes.

The third category covers the international foundation for resource governance and targets companies and international organisations. Companies are required to commit to environmental, social, and human rights standards as well as sustainable development. Both governments and international organisations should actively support the implementation of standards in the upstream industries to support sustainable development along the entire value chain.

However, it seems that the Natural Resource Charter has not really established itself so far and other, newer standards (e.g. IRMA) have taken on a more important role.

[5] Based on Natural Resource Governance Institute 2014a, 2014b.

3.1.8 World Bank Climate-smart mining initiative

The World Bank recognises the need for minerals for the clean energy transition. As mentioned in chapters 2 and 2.1 material demand is going to increase making it strictly necessary to ensure the energy transition is conducted in a responsible and sustainable way. Issues such as the high energy consumption of the mining sector, its social and environmental impact have to be addressed. Moreover, developing countries need to be able to benefit from the increasing demand of raw materials mined in these regions. The Climate-Smart Mining Initiative has been developed to achieve just that. There are four areas on which the inititive focuses: (i) climate mitigation, (ii) climate adaption, (iii) reducing material impacts, and (iv) creating marketing opportunites (The World Bank 2020a). For an overview see Figure 13.

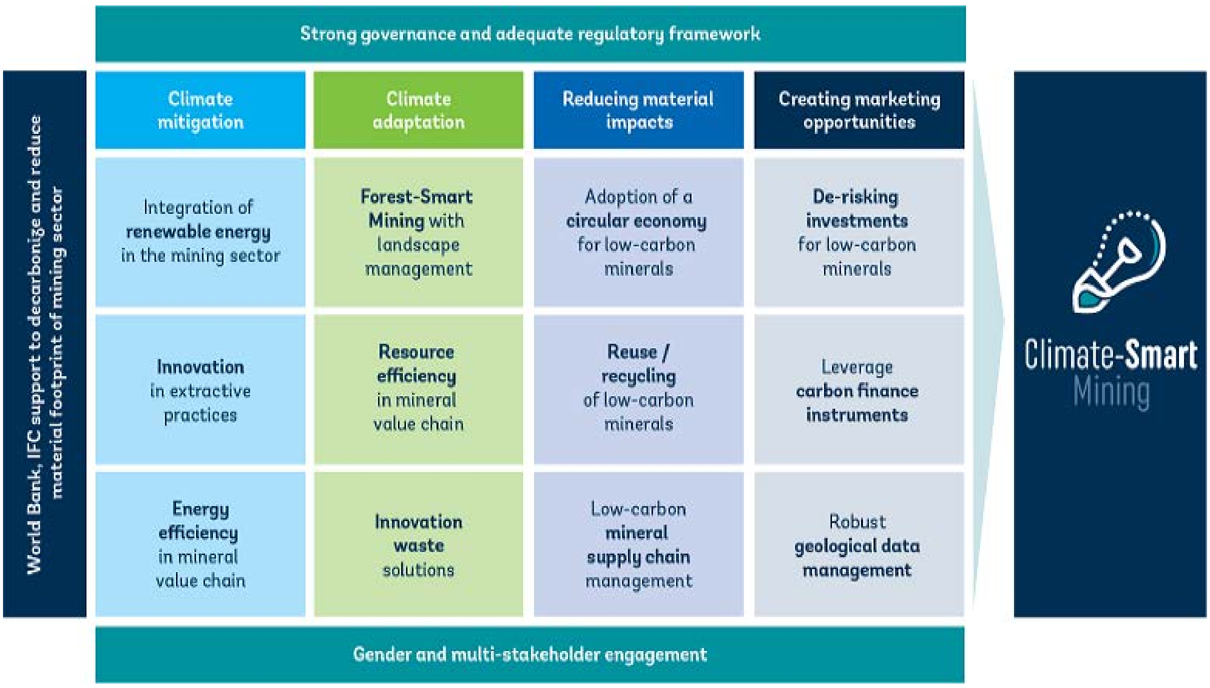

Figure 13: Focus areas of climate-smart mining initiative (The World Bank 2020a)

3.1.9 OECD Guidance for Meaningful Stakeholder Engagement in the Extractive Sector

The Organisation for Economic Co-operation and Development (OECD) Due Diligence Guidance for Meaningful Stakeholder Engagement in the Extractive Sector is based on the Guidelines for Multinational Enterprises and addresses risks and challenges of engaging with stakeholders of oil, gas, or mineral extraction operations. (For details on the Guidelines for Multinational Enterprises see chapter 3.5.2.) The goal is to integrate all relevant stakeholders in the process from project planning to business operations, keeping them informed and giving them the opportunity to take part in the decision making. This shall be reflected in management systems as well as in practice. By doing so, adverse impacts of the extraction operations, including human rights violations or conflicts with indigenous communities. The guidance offers a framework, practical tools, and approaches for both management and on-the-ground personnel.

The approach is organised in seven "key steps to ensure meaningful stakeholder engagement": (1) position stakeholder engagement strategically, (2) understand the local and operating context, (3) identify priority stakeholders and interlocutors, (4) establish support systems, (5) design appropriate and effective engagement activities, (6) ensure follow through on commitments, and (7) monitor and evaluate engagement activities (OECD 2020c, 2020b).

3.1.10 Global Reporting Initiative

The Global Reporting Initiative (GRI) is an organisation providing standards for sustainability reporting on a global scale with the goal of supporting companies "understand and communicate their impact on critical sustainability issues such as climate change, human rights, governance and social well-being". The GRI is a voluntary standard not only for the mining sector, but for companies along the entire supply chain. This is not a system providing guidelines on sustainable behaviour but rather to increase transparency. The GRI believes that an informed public can drive change and companies' decision making (GRI 2020; Kickler and Franken 2017).

3.1.11 European Bank for Reconstruction and Development

The European Bank for Reconstruction and Development (EBRD) published a new mining strategy in 2017 in conjunction with their other policies on environmental and social governance, green economy transition, public information, etc. While mainly providing guidelines for EBRD involvement in mining projects, the strategy also offers guidance for governments on policy development and supports companies in the introduction of new technologies and good corporate practices. The measures proposed by the EBRD are grouped into six categories: (1) Competitive, including introduction of new technologies, local sourcing of materials, and increasing operational efficiency (2) Well-governed: entails the implementation of health and safety management, EITI principles, or the development of tailored corporate governance action plans (3) Inclusive, supporting local recruitment and training programmes, as well as local development and diversification of the workforce (4) Green: successful management of environmental and impacts, improvement of energy efficiency and EHS regulations, etc. (5) Resilient: introduction of new type of financing and financial instruments to support development and help mitigate price shocks (6) Integrated, e.g. use of mining infrastructure by local businesses and communities, access to new markets by diversifying the product portfolio, etc. (EBRD 2017).

The Environmental and Social Policy by the EBRD includes specific performance requirements for issues such as environmental and social risks, labour and working conditions, and biodiversity conservation.

3.1.12 Towards Sustainable Mining

Towards Sustainable Mining (TSM) is a framework developed by the Mining Association of Canada (MAC) mandatory for all their members in every country they operate. This system provides guidance for companies on how to manage their environmental and social responsibilities. Even though this is a standard developed with a focus on Canadian companies, it is gaining international recognition and has already been adopted by several other organisations. Participating organisations include among others the Finnish Mining Association (FinnMin), the Argentinean chamber of mining (Cámara Argentina de Empresarios Mineros), and the Botswana Chamber of Mines (The Mining Association of Canada 2019a).

TSM provides tools and guidelines for three focus areas: (i) communities and people, (ii) environmental stewardship, and (iii) energy efficiency. The three overarching topics are subdivided into eight operational areas. For each area a so-called TSM Assessment Protocol is provided, supporting companies to develop, measure, and report their management systems and performance in these areas. The operational areas are: (i) indigenous and community relationships, (ii) energy and GHG emissions management, (iii) tailings management, (iv) biodiversity conservation management, (v) safety and health, (vi) crisis management and communications planning, (vii) preventing child and forced labour, and (viii) water stewardship (The Mining Association of Canada April 2019).

Each TSM Assessment Protocol lays out a clear set of criteria and indicators allowing companies to measure their performance, explains what good practice looks like, and provides case studies of successful implementations. Additionally framework documents are published for some areas describing the commitment in more detail, or providing guidance for areas where no protocol exists, e.g. mine closure framework (The Mining Association of Canada 2019b).

3.2 Wind Turbine Manufacturing

The ***IFC*** also provides Environmental, Health and Safety Guidelines specifically for wind energy, where both on- and offshore wind energy facilities are included. This standard focuses on the lifecycle of a plant from visual impacts, via biodiversity and noise nuisance, to occupational health and safety. It does not cover the manufacturing of equipment itself (International Finance Corporation IFC 2015).

The ***American Wind Energy Association (AWEA)*** is currently developing a number of standards and recommended practices for the wind energy sector. There are three standards that are in the process of public review or have just finished this phase: (i) technical standards, (ii) workforce standards, and (iii) environmental, health, and safety standards (American Wind Energy Association AWEA 2020).

Further standards are being prepared by the ***International Electrotechnical Commission (IEC)***. The upcoming standards will cover following aspects for wind turbine generator systems: safety, measurement techniques, and test procedures. There are already standards in place for design requirements and noise measurement techniques, as well as monitoring and controlling systems for wind power plants. These are currently focusing on onshore plants and will be expanded to offshore wind turbines, as well as gearboxes and performance testing. IEC standards focus on quality (including durability) and product safety. The IECRE is the IEC's conformity testing system for the "renewable" energy” sector (IEC 2020b; Sauer 9/24/2020).

The ***International Standardization Organization*** also provides technical standards for wind energy systems, focussing on design requirements (ISO 61400-4:2012), monitoring and diagnostics of wind turbines (ISO 16079-1:2017 general guidelines; 16079-2 drivetrain monitoring, under development) (ISO 2020).

3.3 Solar Panel Manufacturing

For the manufacturing of solar panels and solar equipment no standards, other than general occupational health and safety, environmental or human rights standards could be found. For those see chapter 3.5.

However, there are some standards (in preparation) focusing on later stages of the lifecycle of solar equipment.

The technical committee TC82 by the ***International Electrotechnical Commission (IEC)*** currently provides more than 50 standards, technical specifications and reports for solar photovoltaic equipment. Ranging from performance testing to component safety. Due to the large increase of possible applications and technologies of PV systems, the IEC is in the process of developing further standards for photovoltaic energy systems and all elements that are included herein. This will entail system commissioning, maintenance, and disposal; characterization and measurement of new thin film photovoltaic module technologies; new storage system technologies; and applications with special site conditions, including tropical zones, or marine areas. As already mentioned for wind turbines, the main focus is on quality certification of products and equipment and the conformity according to the standards is controlled and verified by the IECRE (IEC 2020a; IRENA 2013).

In the US the ***Clean Energy States Alliance (CESA)*** developed standards and requirements for solar equipment, installation, licensing and certification in cooperation with the US Department of Energy Sunshot Initiative. This serves as a guideline for states and municipalities (Argetsinger and Inskeep 2017).

The ***EU*** is working on developing new directives for Eco-design, Energy Label, Ecolabel, and Green Public Procurement for solar photovoltaic modules, inverters, and systems. This is currently at the stage of preparatory studies to evaluate the feasibility of such directives. If executed, these directives will go beyond the manufacturing stage, but rather cover the entire life cycle of PV systems (European Product Bureau 2020).

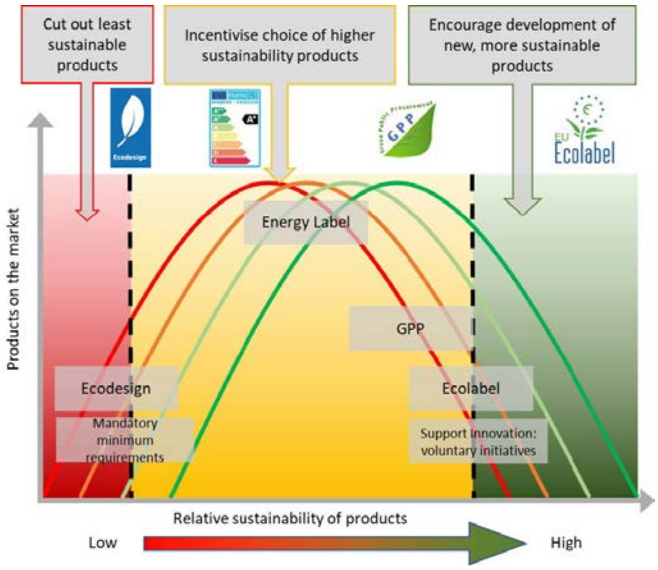

Figure 14: Relative sustainability of products according to Ecodesign and Ecolabel (Sauer 9/24/2020)

As shown in Figure 14, on the one hand, the Eco-design directive will provide guidance on minimum sustainability requirements for entering the EU market. The Ecolabel on the other hand, is meant for products leading in sustainability efforts (Sauer 9/24/2020).

In some ***countries***, there are already some standards and initiatives assessing the environmental impact and providing guidelines for sustainable production of solar PV equipment and systems. Examples are: the NSF/ANSI 457 “Sustainability Leadership Standard for Photovoltaic Modules and Photovoltaic Inverters” in the US and the NPCR 029 “PCR – Part B for photovoltaic modules used in the building and construction industry, including production of cell, wafer, ingot block and solar grade silicon” (Norway). The NSF/ANSI 457 provides a framework and performance objectives for manufacturers of PV modules and PV inverter components regarding sustainability and corporate performance. However, it also goes beyond the manufacturing stage providing sustainability attributes and performance metrics for customers (NSF/ANSI 457-2019). The NPCR provides guidance for companies towards the achievement of an environmental product declaration (EPD) (Product Category Rules NPCR 029:2020). The IECRE aims to bring these initiatives together in an "Environmental Impact Unit". This unit should create a uniform framework with feasible and measurable requirements and specifications (Sauer 9/24/2020).

3.4 Collection & Treatment

For the collection and treatment of wind turbines mainly general standards can be applied. For instance, the ***IEC EHS Guidelines for Wind Energy*** contain issues and recommendations related to the decommissioning of wind power plants. However, the ***German Institute for Standardization (DIN)*** developed the first industry standard for dismantling and recycling of wind turbines. This development was initiated by RDRWind in cooperation with 25 companies, experts and government representatives, as a large wave of wind turbines will be decommissioned in 2021. The DIN SPEC 4866 for "Sustainable Dismantling, Disassembly, Recycling and Recovery of Wind Turbines contains guidelines for the entire dismantling process, from tendering, via planning and concept development, to the actual dismantling activities, and the documentation. This standard has the potential of becoming an international framework for wind turbine recycling (Technical Rule DIN SPEC 4866; RECYCLING magazine 7/23/2020).

In some European countries, Germany, Austria, Finland and the Netherlands, there is a legislation in place forbidding composite materials from being landfilled. Others, for example France, are considering introducing mandatory recycling rates for wind turbines (Schmid et al. 2020).

WindEurope set up a cross-sector platform in collaboration with Cefic (European Chemical Industry Council) and EuCIA (European Composites Industry Association) in order to advance wind turbine recycling with specific focus on turbine blades. In addition, they are currently working on international guidelines for wind turbine dismantling and decommissioning (WindEurope-Accelerating-wind-turbine-blade-circularity; WindEurope 2020; Schmid et al. 2020).

For solar equipment the best-known standard is the European directive on waste of electrical and electronic equipment (***WEEE directive***). This directive includes a section on photovoltaic panels and provides a framework for collection, transport, and treatment of photovoltaic panels on the notion of extended producer responsibility (Solar Waste / European WEEE Directive 2020).

In Australia, the statutory authority ***Sustainability Victoria***, together with other states and territories, is working on a suitable national solution for the forecasted increase of PV waste in the coming years. Currently PV products are considered e-waste and banned from landfill (Sustainability Victoria 2020).

3.5 Standards & Sustainability Schemes Covering Various Stages of the Supply Chain

3.5.1 LME Responsible Sourcing[6]

The London Metal Exchange (LME) recently introduced guidelines for brands selling via their market. The requirements by the LME are based on the OECD Due Diligence Guidance for Responsible Mineral Supply Chains from Conflict-Affected and High-Risk Areas and their five-step framework for risk-based due diligence in the mineral supply chain. These five steps are: (1) establishment of a strong company management system, (2a) identification of risks in the supply chain, (2b) assessment of risks with adverse impacts, (3) design and implement a strategy to respond to cases identified in step 2, (4) third-party audit of supply chain due diligence, and (5) transparent reporting of due diligence.

One of the main targets of this initiative is to provide transparency for customers. All brands will have to disclose their results of the certification according to the LME guidelines. Moreover, companies have to apply ISO 14001 and ISO 45001 or OHSAS 18001 standards to reduce environmental impacts and ensure occupational health and safety. Producers unwilling to adhere to this regulation will be unlisted. However, the LME also recognises the need for flexibility of their requirements according to the type of operation. For example, ASM shall not be excluded from their market, the LME rather tailors their risk assessments according to the circumstances and allows more time for their completion. There are different approaches of achieving the LME requirements. For companies in whose supply chain red flags have been identified, or on a voluntary basis the "recognised alignment-assessed standard track" is applicable. A company can choose an external or internal standard that is aligned with the OECD five step guidance and has to undergo regular audits to show their compliance. For companies with no identified red flags, the "Audited and published LME RFA tracks" are possible. These companies can use a template provided by the LME for conducting a Red Flag Assessment (RFA) and then submit it for review, either by the LME or a third-party auditor. Here no additional standard is necessary.

3.5.2 OECD Guidelines for Multinational Enterprises & Due Diligence Guidance for Responsible Mineral Supply Chains

An important framework by the OECD are the Guidelines for Multinational Enterprises with the corresponding Due Diligence Guidance for Responsible Business Conduct. The guidelines contain recommendations from governments on responsible business conduct, expectations, and legislation for specific countries. Responsible business conduct includes the identification and management of risks in a company's supply chain and its operations, the contribution to economic, social, and environmental development of the host country, as well as the overall contribution to the sustainable development goals. The guidance offers practical support for the implementation of the guidelines (OECD 2020d, 2020e).

[6] Based on LME London Metal Exchange 2019.

The OECD Guidelines are aligned with the International Labour Organisation's Tripartite Declaration of Principles concerning Multinational Enterprises and Social Policy, and the UN Human Rights Principles (OECD et al.).

Furthermore, the OECD developed sectoral guidance to help with the practical implementation and the observance of the guidelines. This guidance provides a framework for companies for identifying and addressing risks to people, environment, and society related to their operations, services, or products.

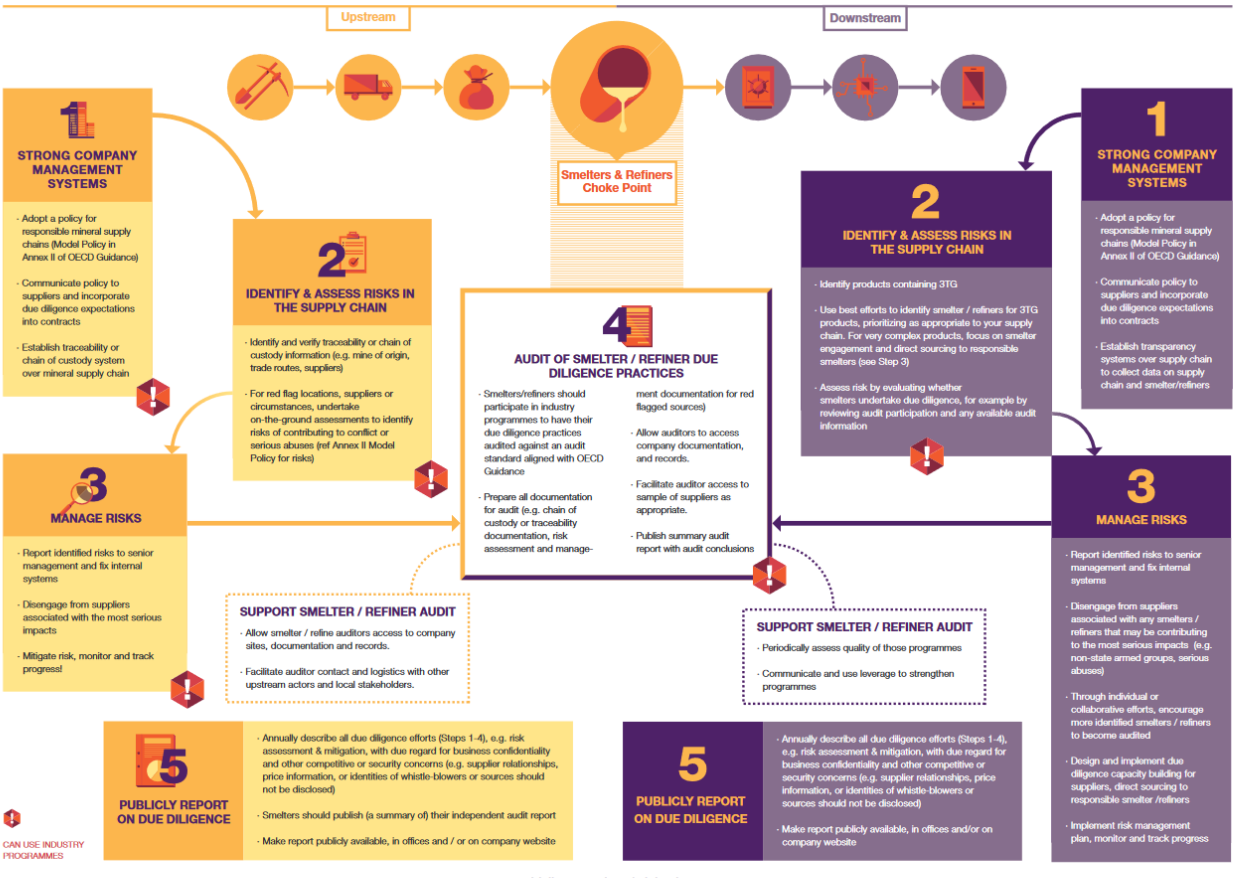

Figure 15: OECD 5-Step Framework for mineral supply chains (OECD 2020e)

One of the sectoral guidance documents is the Due Diligence Guidance for Meaningful Stakeholder Engagement in the Extractive Sector discussed in chapter 3.1.9.

The second guidance relevant for raw materials' supply chains is the Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas. This guidance provides a framework for companies along the entire mineral supply chain for the identification and management of associated risks, mainly addressing human rights violations and conflicts. Upstream companies are required to establish a chain of custody to ensure traceability and transparency for their production and sourcing.

On-the-ground assessments, collaboration with local governments and businesses are necessary to improve practices, prevent, and mitigate “red flags” in the supply chains. Downstream companies need to proactively collect information and conduct due diligence in their sourcing practices (OECD 2020a). The assessment is divided into 5 steps for both up- and downstream companies (see Figure 15).

The guidance includes specific supplements on the sourcing of the conflict minerals tin, tungsten, tantalum, and gold (3TG). The supplement for the 3Ts is considered relevant for all base metals, and gold for all precious metals.

3.5.3 ISO-Standards

Internationally recognized standards for many different areas of business are developed by the International Standards Organisation (ISO), for instance quality management, environmental management, health and safety, or energy management standards. Many of them are relevant for companies along the supply chain of the renewable energy sector.

The ISO 14000-series is a collection of standards for environmental management. Companies are certified according to ISO 14001:2015, and the additional documents from the series support the implantation of this standard. Companies have to implement an environmental management system addressing the identification, management, monitoring, and prevention of environmental issues. The goal of ISO 14001 is to continuously improve an organisation’s environmental performance, for example by using resources more efficiently, reducing waste, and creating trust with stakeholders. The accreditation is conducted by a third-party auditor and has to be updated on a regular basis. A further standard from this family worth mentioning, is the ISO 14064 on the quantification and reporting of greenhouse gases (ISO 2015b, 2015a, 2018d).

Another important standard is the ISO 45001 (or its predecessor OHSAS 18001) for occupational health and safety management systems. This standard provides a framework for safe and healthy workplaces, for minimizing and eliminating hazards and risks, and preventing work-related injuries or illnesses. Again, the continual improvement is a very important aspect of the certification (ISO 2018b).

ISO 50001 covers the energy management of companies. It provides guidelines for improving energy efficiency to cut costs, conserve resources, and contribute to the reduction of global warming (ISO 2018c).

The ISO also has a standard on social responsibility, the ISO 26000, providing guidance for organisations on how to integrate social responsibility in their policies and practices, on stakeholder engagement, and transparency on commitments, performance and other issues relevant for stakeholders and social responsibility in general (ISO 2018a).

Considering responsible sourcing the ISO-standard most relevant is the ISO 20400 “Sustainable procurement”. This standard is a framework for procurement processes of all types of organisations supporting the implementation of sustainability considerations in purchasing decisions. Suppliers are vetted according to their working conditions, product or service sustainability, and other socio-economic issues (e.g. poverty and inequality). Guidelines for accountability, transparency, respect for human rights, etc. are provided (ISO 2017).

Other relevant standards, include the ISO 9001 for Quality Management Systems.

3.5.4 Sustainable Development Goals

"The Sustainable Development Goals are the blueprint to achieve a better and more sustainable future for all." (United Nations Sustainable Development 2020)

The Sustainable Development Goals (SDGs) by the United Nations consist of 17 goals addressing issues such as poverty, human rights, global warming, and responsible consumption and production practices. All UN member states agreed on reaching these goals until 2030. For the renewable energy sector this has numerous implications. The two main goals relevant for the renewable energy sector are Goal 7 "Affordable and Clean Energy" and Goal 13 "Climate Action". However, the renewable energy sector can also contribute to the achievement of the other 15 goals. A consortium of four organisations, the Sustainable Development Solutions Network, Equitable Origin, the Business & Human Rights Resources Centre, and the Columbia Centre on Sustainable Investment prepared a catalogue of recommendations for the renewable energy industry to achieve the SDGs. This is an extensive report including guidelines for each goal. Their aim is to minimise negative impacts from the vast expansion of renewable energy production and maximise the positive potential of the industry. The suggestions include: (i) access to renewable energy for local communities, (ii) local recruitment of workers and sourcing of goods and services, (iii) active collaboration with governments to support the process of energy transition, (iv) comprehensive environmental and social impact assessments need to be conducted including the assessment of impacts on local communities, and human rights, (v) due diligence along the entire supply chain, including responsible sourcing with regards to human rights violations (Lobel et al. 2018; United Nations Sustainable Development 2020).

3.5.5 International Labour Organisation

The ILO provides a comprehensive system of international labour standards. The goal is to support men and women equally to obtain decent work. The labour standards are subdivided into conventions (legally binding principles) and recommendations (complementary principles supporting conventions, non-binding). Eight fundamental conventions have been identified that form the core of labour standards. These include the following issues: (i) freedom of association and collective bargaining, (ii) elimination of forced and compulsory labour, (iii) elimination of child labour, (iv) elimination of discrimination. Especially considering the globalisation of economy it is important to have international standards for the successful abatement of inequalities and inhuman working conditions worldwide. The standards are often applied on national level additionally to national regulations, or are used as guideline for national legislation. The ILO standards are applicable to all industry or service sectors. (ILO 2019, 2020).

3.5.6 IFC Environment Health and Safety Guidelines

The International Finance Corporation (IFC) developed an extensive set of environmental, health, and safety (EHS) guidelines. The collection consists of general guidelines applicable to all industry sectors, as well as sector specific guidelines. The sector specific EHS guidelines for mining and wind energy can be found in the according chapters (3.1.4, 3.2). The general part is a technical reference document with good practice examples and performance levels for various issues that are considered achievable.

Recommendations are grouped into four categories: (i) environmental, including air emissions, waste management, etc., (ii) occupational health and safety, with issues such as physical, chemical, or biological hazards, (iii) community health and safety, considering water quality, traffic safety, or disease prevention, and (iv) construction and decommissioning, again with the three previous subcategories. (International Finance Corporation IFC 2020).

3.5.7 Material specific standards

ResponsibleSteel is an international certification scheme covering the entire supply chain of steel. Apart from mining, every stage is covered by their own guidelines and for the extraction sector they cooperate with existing standards such as IRMA and TSM.

The reason for the development of this standard was the widespread use of steel. It is the most widely used material in the world and is essential for many industries, including the energy sector. Steel production has a major impact on the environment, partly because of its high energy consumption, as well as social and economic impacts. However, through responsible action by all parties involved, these impacts can also be positive.

The aim is to reduce GHG emissions, create jobs, promote local development and support the achievement of SDG12 "Responsible Consumption and Production". The standard is based on 12 principles covering environmental, social and governance issues. Further guidelines will be developed in the course of 2020 (ResponsibleSteel 2018).

For aluminium there is the ***Aluminium Stewardship Initiative (ASI)***, including a performance standard and a chain of custody standard according to which a third-party certification is conducted. The goal is to ensure that sustainability and human rights principles are met in the production, use, and recycling of aluminium. ASI is a member of the International Social and Environmental Accreditation and Labelling (ISEAL) Alliance (ASI 2020). The ISEAL Alliance is an association for sustainability standards, assessing them according to Code of Good Practice and supporting the development of credible standards *“that address the most pressing social and environmental issues we face in the world today”* (ISEAL Alliance 2020).

The Concrete Sustainability Council (CSC) is an international certification scheme for the entire supply chain of concrete. The standard covers four topics: management, environmental, social, and economic with requirements from sustainable purchasing, health &safety, life cycle impact, and local community, to local economy, and ethical business. Before being admitted to the certification process certain prerequisites have to be satisfied. These are: (i) ethical and legal compliance, (ii) human rights, (iii) indigenous people rights, (iv) environmental and social impact, and (v) tracing of materials (Concrete Sustainability Council 2020).

3.5.8 UN Human Rights Principles

The human rights principles of the United Nations (UN) shall be mentioned here for the sake of completeness. These principles form the basis for many of the requirements of the above-mentioned standards.

"Human rights are universal and inalienable; indivisible; interdependent and interrelated. They are universal because everyone is born with and possesses the same rights, regardless of where they live, their gender or race, or their religious, cultural or ethnic background. Inalienable because people's rights can never be taken away. Indivisible and interdependent because all rights – political, civil, social, cultural and economic – are equal in importance and none can be fully enjoyed without the others. They apply to all equally, and all have the right to participate in decisions that affect their lives. They are upheld by the rule of law and strengthened through legitimate claims for duty-bearers to be accountable to international standards." (UNFPA 2005)

The UN provides guidelines in form of the "UN Guiding Principles on Business & Human Rights" outlining the duties of countries and enterprises in respecting and protecting the human rights (United Nations Human Rights 2011).

As studies have shown, 40% of the largest companies worldwide fail to identify and mitigate risks for human rights in their supply chains. Not only civil society organisations, but also investors therefore increasingly demand for national legislations to include mandatory human rights due diligence regulations. Some European countries have already followed this need for more stringent guidelines. For example, France introduced a "Corporate Duty of Vigilance Law" requiring companies to disclose their due diligence measures.

The Netherlands are introducing a "Child Labour Due Diligence Act" which is not only applicable for Dutch companies, but also companies supplying the Dutch market.

Other countries, including Austria, Switzerland, and Luxembourg are considering similar steps (Anderson 2020; Business & Human Rights Resource Centre 2020a; RBC 2020).

3.5.9 UN Global Compact

The United Nations Global Compact is a cooperation between the UNO, companies, and governments to support sustainable and responsible development. So far 11,383 companies and 157 countries have committed to the initiative. Companies are required to *"align strategies and operations with universal principles on human rights, labour, environment and anti-corruption, and take actions that advance societal goals"* (UN Global Compact 2020).

3.6 Summary & Comparison

BGR study on sustainability schemes: The BGR (Federal Agency for Geosciences and Natural Resources Germany) investigated sustainability schemes for mining also including some of the standards and initiatives evaluated in this report. The BGR covers five categories in their assessment, all categories are further subdivided into issues and sub-issues (see Figure 16), resulting in 108 parameters.

Identified five categories and fourteen subordinate issues					
1. Human an workers' rights	2. Societal-welfare	3. Use of-natural resources	4. Emissions and land-reclamation	5. Company governance	–
Serious human rights abuses	Community rights	Land use & biodiversity	Closure & land rehabilitation	Business practices	–
Employment conditions	Value added	Water use	Mine wastes & waste water	Management practices	–
Occupational Health & Safety		Energy use	Air emissions & noise		–
		Material use			

Figure 16: Parameters for the evaluation of sustainability schemes (Kickler and Franken 2017)

The study by BGR includes the following standards relevant for this report: IRMA, IFC, GRI, ICMM, and TSM. They show that IRMA is the most comprehensive standard of the three covering 65 sub-issues. It is followed by IFC with 60. TSM is the least comprehensive of the five standards with 9 sub-issues covered. However, IFC is the most comprehensive standard in terms of requirements per issue, followed by IRMA. IRMA is the most extensive standard considering community rights and value added underlining their goal to increase respect for local stakeholders in mining operations. Other areas where IRMA is more comprehensive than the other reports are employment conditions, and water use. The Fairmined Standard by the ARM is also included in the BGR study and can be classified as a very comprehensive standard showing the highest scores in categories for employment conditions together with IRMA. Fairmined addresses 57 of the 108 sub-issues (Kickler and Franken 2017). The ARM solely focuses on artisanal and small-scale mining. However, for this sector the Fairmined Standard (for gold) takes a holistic approach also including downstream industries with aspects from organisational and social development, environmental protection, and work conditions.

Evaluation of Standards & Initiatives not included in BGR study: The Risk Readiness Assessment of the Copper Mark covers 32 issues from legal compliance, via child labour and freedom of Association and collective bargaining, to transparency and disclosure. That is less than 30% of parameters evaluated by the BGR.

The Natural Resource Charter focuses on supporting governments in raw materials policy related areas, rather than impacts caused by mining operations. This is only included in certain subchapters related to the management of local impacts, and the role of international companies. It aims at maximising the economic benefits for countries and communities.

The EITI standard supports the disclosure of all relevant information from the extractive industry, including the awarding of extraction licences, production date, revenue streams, taxation, etc. The main goal is to achieve accountability and prevent financial crime, and thus promoting understanding from an informed community.

The LME bases their responsible sourcing policy on the OECD Guidance for Responsible Mineral Supply Chains. Therefore, the focus is on risks associated with conflict-affected and high-risk areas, including human rights and financial crimes. At the heart of the OECD Guidance is increasing transparency along the mineral supply chain in order to enable identification and mitigation of such risks.

The main goal of the World Bank's climate smart mining policy is to support developing countries benefit from the growing materials demand caused by the energy transition. At the same time, it shall be ensured that environmental and climate footprint of mining operations is minimised. Further details on the issues and requirements covered by this initiative could not be found at the time this report was being prepared.

The OECD Due Diligence Guidance for Meaningful Stakeholder Engagement in the Extractive Sector is very specific and addressed to one issue – the engagement of all relevant stakeholders of oil, gas, and mining operations. The goal is to prevent conflicts and human rights violations.

The EBRD mining policy provides guidelines for investments. Mining companies are to be supported in their development towards a responsible sector with appropriate investments. Governments can ask for assistance in the development of legal policies and guidelines. Actual requirements for company performance can be found in the environmental and social policies which provide quite extensive guidelines. Here nine thematic areas are covered, with numerous sub-categories ranging from GHG emissions via water and waste management to child and forced labour.

Manufacturing: There are many standards dealing with the quality of components of both wind turbines and solar PV equipment, as well as testing and monitoring processes. However, there are no sector specific standards available for the manufacturing process itself, covering e.g. environment, health and safety in factories. Nonetheless, numerous standards are currently being prepared.

Collection and Treatment: An international framework for the recycling process is also missing. The EU has issued guidelines for photovoltaics with the WEEE directive, and for the dismantling of wind farms there is the German DIN SPEC 4866, which could potentially be adopted as an industry standard. However, many countries are currently preparing regulations at national level.

4 Narrative Analysis

The narrative analysis conducted in this first part of the roadmap development is an investigation of the online discourse on topics related to responsible sourcing in general and specific issues of the renewable energy sector. The aim of this analysis within the framework of the project was to investigate terms that are considered important based on the previous literature research. The analysis should provide feedback on whether these terms are actually present in public discourse and whether the project addresses in fact relevant topics. The analysis was conducted by an external company "Significance System", a service provider specialised on analysing "*behavioural interactions with online content, to model human interaction*" (Significance Systems 2019) with specific topics.

The results were assessed from two perspectives: (i) is the topic already under discussion; if so, who are the main actors dealing with the issue and what reactions does the issue elicit in the population; (ii) if a term is not yet a topic of discussion and is not yet considered by the public, it must be determined whether it is important to "push" this topic in order to promote responsible sourcing.

It should be emphasised that the analysis represents only one source of input and is not the decisive factor for further project work.

Chapter 4.1 provides an overview of the process of choosing the narratives for the analysis, and chapter 4.2 discusses the results.

4.1 Methodology

Narratives (key words and phrases) for this analysis were chosen according to the results from the preceding desk research and feedback from PSC and AB consultations (see roadmap process chapter 1.3), covering the three pillars of sustainability: economic, social, and environment.

For the selection of narratives, a set of 211 words and phrases was chosen for both responsible sourcing and the renewable energy sector. The terms were based on issues found relevant during the desk research. With these terms, a Google Trends search was conducted in order to evaluate public interest in the topics.

The terms were then compared to company websites and reports to see whether they are commonly used in the industry or other words and phrases are used more commonly. This added another 80 terms to the list, which were again examined using Google Trends.

Afterwards, a general Google search for all terms was conducted and the number of 'hits' included in the evaluation. The phrases with the best results on Google Trends and the most hits on Google were selected. In order to verify the importance for the project, their results in a Google search were checked according to their relevance for the renewable energy sector and responsible sourcing in general.

Finally, the list of narratives was presented to companies and organisations of the renewable energy value chain, focusing on people in charge of procurement and sustainability, to ensure these terms are not only relevant for the sector, but also correspond to wording commonly used.

The final list of narratives can be seen in Table 1. (The terms in quotation marks are an indicator for the algorithm that these phrases need to be looked up in exactly the stated syntax and wording.)

Resulting from a narrative analysis, a narrative can be classified in one of four categories: (i) timeless, (ii) transformational, (iii) transient, or (iv) tribal. Approximately 82% of all narratives ever tested in the Significance Systems database are transient, that means they are not often addressed in media and they do not have the power to engage. Tribal are narratives that relate to a very specific issue that creates a lot of engagement, but only from a very small number of people, about 8% of narratives in the database are tribal. The smallest group of narratives, only 2%, are transformational. These generate a lot of engagement with a large group of people, and represent a transformation in global opinion with respect to the narrative tested. The most powerful type of narratives, creating long-term and deep engagement are timeless, which applies to about 5% of all narratives in the database. These timeless narratives are characterised by being predictive of future behaviour; namely there is a high likelihood the narrative will remain powerful over time and thus significantly influence those who engage with it.

For each narrative the emotional response related to the narrative was also obtained. This is called affect and is predictive for timeless narratives of future emotional responses. Moreover, information on the most influential media and content was received. The media power index is a ranking of "*media voices according to their power to lead debate, shape perception, and drive market performance in terms of preference and desirability*" (Significance Systems 2020). Content refers to individual pieces of content, such as articles, posts, etc. and is again ranked according to their intrinsic power, i.e. their "*ability to drive market performance against preference and desirability*" (Significance Systems 2020). This information is useful to evaluate the key players and countries driving a certain narrative, but also to determine whether the results are actually relevant for this study.

Table 1: Selection of narratives for responsible sourcing and renewable energy

No	Responsible Sourcing	No	Renewable Energy
1	"due diligence" procurement	**1**	"biodiversity loss" renewables
2	“human rights” procurement	**2**	"renewable energy" jobs
3	“responsible procurement” raw materials	**3**	"renewable energy" policy
4	sustainable procurement	**4**	Clean energy
5	“green procurement” raw materials	**5**	transition minerals
6	"environmental impact" procurement	**6**	recycling renewables
7	"carbon footprint" procurement	**7**	"carbon footprint" solar energy
8	"local procurement" minerals	**8**	"solar power" environmental impact
9	"green energy" mining	**9**	"life cycle assessment" (LCA) solar panel
10	"artisanal and small-scale mining"	**10**	photovoltaics "toxic waste"
11	corruption mining	**11**	sustainability "solar energy"
12	"free prior informed consent" mining	**12**	"carbon footprint" wind energy
13	"grievance mechanism" mining	**13**	"wind power" environmental impact
14	"health and safety" mining	**14**	"life cycle assessment" (LCA) wind turbine
15	"social impact" mining	**15**	sustainability "wind energy"
16	mining "living wage"	**16**	"copper mining" environmental impact
17	"value creation" mining	**17**	"rare earth mining" environmental impact
18	ESG mining	**18**	"The Copper Mark"
19	"biodiversity loss" mining	**19**	"WEEE directive" solar panels
20	mining "toxic chemicals"	**20**	"Siemens Gamesa" global agreement
21	mining reclamation		
22	sustainable mining		
23	"responsible mining"		
24	sustainability mining		
25	"responsible sourcing"		
26	"responsible sourcing" minerals		
27	"responsible sourcing" raw materials		
28	"responsible sourcing" blockchain		
29	sustainable "raw materials"		
30	certification "raw materials"		
31	"supply chain" transparency		
32	responsible "supply chain"		
33	"London Metal Exchange" responsible sourcing		
34	"Responsible Minerals Initiative"		
35	"Towards Sustainable Mining"		
36	EITI		
37	ICMM principles		
38	IFC guidelines mining		
39	ILO standards mining		
40	IRMA standard		
41	OECD "responsible mineral supply chain"		
42	World Bank "climate-smart mining"		
43	OECD procurement guidelines		

4.2 Results

The narrative analysis for the RE-SOURCING project was meant as a control mechanism, to assess whether the selected topics are relevant for the responsible sourcing and renewable energy agenda are actually resonating with the global media. Table 2 shows the results of the analysis.

A major result of the narrative analysis indicated that the topics and challenges for the responsible sourcing and renewable energy agenda chosen by the RE-SOURCING team are quite well reflected in the discourse of global media. A large number of the narratives assessed were categorised as timeless narratives (highlighted in green). Few were transformational (orange) and some were on the border between transient and timeless (yellow) or tribal and transformational (blue). The remaining narratives were found transient. The result is very positive, as an unusually high number of the narratives chosen classified as timeless (32.5% for responsible sourcing and 35% for renewable energies). This supports the proposition that the topic areas that were chosen to address in this report accurately reflect the issues that are currently discussed in the media and global public discussions in general.

The remaining narratives were not in the public eye at the time of the analysis, which means for the RE-SOURCING project that these areas need further engagement within the roadmap, but also by policy makers, and organisations promoting responsible practices. The 34 narratives that were found to be transient include “human rights procurement” and “social impact mining” for responsible sourcing, and “biodiversity loss renewables”, or “live cycle assessment solar panels” and wind turbines for renewable energy (for detailed results, please see Table 2 unmarked terms). The measured lack of engagement means these narratives were not attracting attention nor were they strong narratives. The absence of relevance may mean that for the narratives related to achieving sustainability and responsibility in the supply chains, some issues pertaining to these areas may require further investment by the RE-SOURCING project.

Responsible Sourcing: Starting with the topic of responsible sourcing and looking directly at the narrative “responsible sourcing”, the narrative generated a very positive response. The most intense emotions associated with it were joy, contentment, satisfaction, and fulfilment. Other, weaker emotional responses were hope, encouragement, and expectation. These emotions are shown in Figure 17 A. Highlighted in green are positive emotions, blue are emotions with a clear tonality, such as expectation or surprise, red indicates negative emotions. The intensity of emotions is indicated by the intensity of the colours.

The key players driving the narrative of responsible sourcing were the OECD and the London Bullion Market Association (LBMA). Furthermore, Philips, the Human Rights Watch and Trafigura were important supporters of the narrative. Considering the content, this narrative was mainly driven by Walmart and publications on their corporate website. LBMA and Trafigura, also with company-owned publications, were found to have considerably less content power. The results indicated this topic to be relevant for European and American companies alike, as well as global organisations invested in this narrative.

To compare the results and assess what the more commonly used syntax is, sustainable procurement was chosen. The narrative “sustainable procurement” generated the same emotional response as “responsible sourcing”. However, the emotional intensity was found to not be as strong and this is considered a measure for real engagement. The key players driving this narrative were the World Economic Forum (WEF) and UN Global Compact, both can be considered very powerful global drivers, apart from mainly governmental departments. Regarding the content, it appeared there is a global interest in this topic. In addition to the organisations mentioned above, two regions seemed to influence this narrative - Scotland and Canada (the City of Vancouver). A comparison with the narrative “responsible supply chain” again shows similar positive reactions, but “responsible sourcing” remains the strongest narrative.

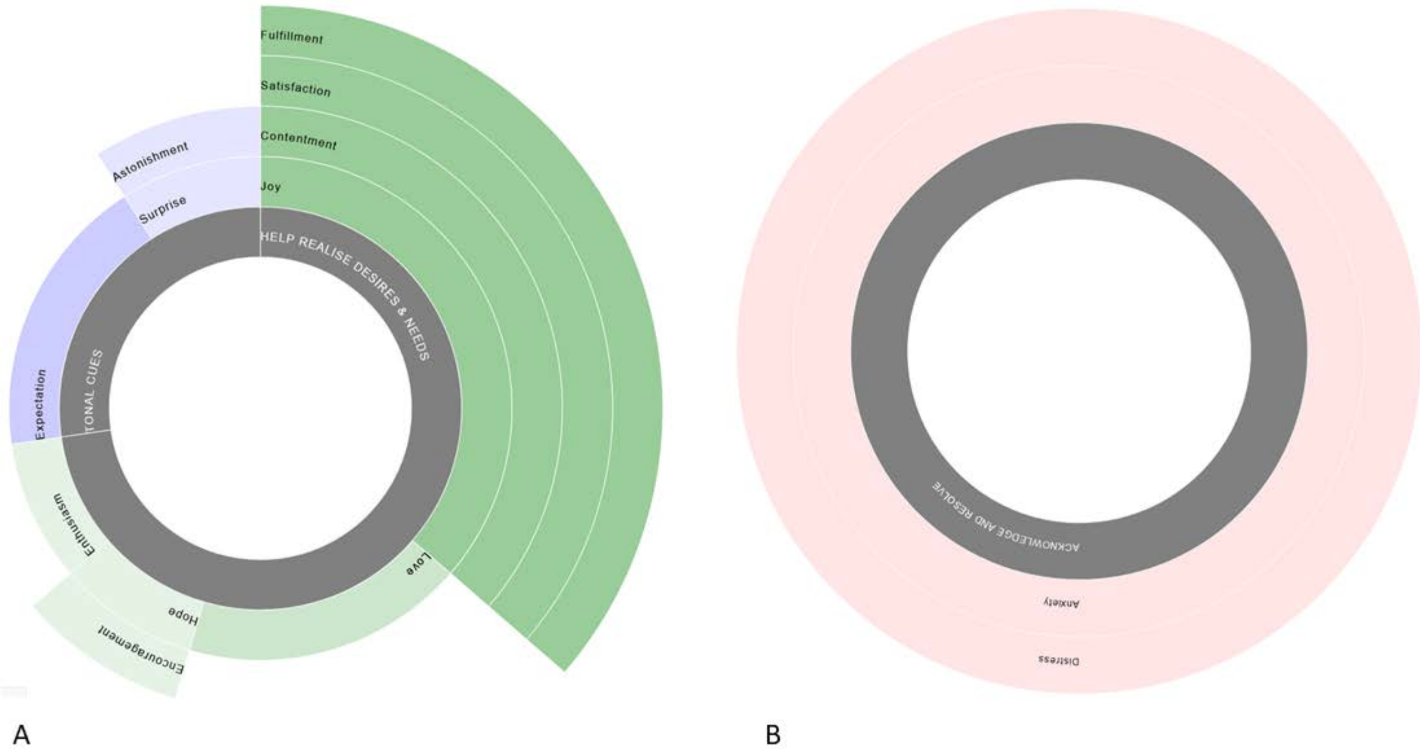

Figure 17: Generated emotions related to (A) "responsible sourcing", (B) “sustainable raw materials”

Sustainability: Looking at some narratives with the terms “sustainability” and “sustainable”, the first thing that was noticeable is that sustainability mining, sustainable mining, and sustainable raw materials were connected to rather negative or neutral (mainly expectation or surprise) emotions. Interestingly, the narrative “sustainability mining” was mainly driven by crypto mining content and stakeholders. It is therefore not relevant for our study. However, “sustainable mining” was highly relevant and included drivers such as the World Bank, ICMM, the Responsible Mining Foundation, etc. What stood out is that by far the strongest content is the Philippines' commitment to the TSM initiative and the narrative was characterised by expectation. Apart from the Philippines, mainly Canada was the dominant country. “Sustainable raw materials” was fully associated with negative emotions (Figure 17 B).

The narrative “sustainable raw materials” is not characterised by a lot of media voices and content, but the strongest drivers were journalistic articles and the EIT RawMaterials. On the content side, the company BioMar a diet producer for fish and shrimp dominated the subject, which is of course not relevant to this project.

Renewable Energy: Looking at the timeless narratives for the renewable energy sector in more detail, it can be noted that even though they were classified as timeless, the content available had a rather weak content efficiency. This means that there is a gap between the needs of the market and the currently related content (Significance Systems 2020). The public needs to receive more information (content) on the topics of clean energy, recycling renewables, etc. (see Table 2 – column Renewable Energy, narratives highlighted in green). This is an opportunity for the RE-SOURCING project on the one hand, and for policy makers and organisations on the other. Through interactions with "timeless" narratives in the form of publications or measures it is easier to get attention and engagement by the public.

Many of the timeless narratives were characterised by a state of expectation and in general the attitude was characterised as positive. However, two narratives stood out – “sustainability wind energy” and “transition minerals”. “Sustainability wind energy" was characterised by expectations, but also negative emotions, distress and anxiety, occured in this context. The topic “transition minerals” was dominated exclusively by negative emotions, e.g. confusion and anxiety to name but a few. The transformational narrative “sustainability solar energy” showed similar responses as “sustainability wind energy” – mainly surprise and expectation, but also negative emotions, such as anger and dislike.

As a transformational narrative, “sustainability solar energy” has the potential of changing the way the topic is perceived and there is a strong opportunity of positioning solar energy as a sustainable energy supply method for the future. However, due to the negative emotions associated with the narrative, further strengthening of this issue needs to be handled carefully. The strongest driver of this topic was SGK Planet, an NGO providing information on climate change, sustainability issues, etc. Governments, the Solar Energy Industry Association, or the WEF had very little power by comparison. On a content side, the US government and governmental associations were dominating the narrative, the same applied to “sustainability wind energy”.

Further results and uses of the results are discussed in chapter 6 Gap Analysis.

Table 2: Results of narrative analysis, green – timeless, orange – transformational, yellow – between transient and timeless, blue - between tribal and transformational, grey - tribal

No	Responsible Sourcing	No	Renewable Energy
1	"due diligence" procurement	1	"biodiversity loss" renewables
2	“human rights” procurement	2	"renewable energy" jobs
3	“responsible procurement” raw materials	3	"renewable energy" policy
4	sustainable procurement	4	Clean energy
5	“green procurement” raw materials	5	transition minerals
6	"environmental impact" procurement	6	recycling renewables
7	"carbon footprint" procurement	7	"carbon footprint" solar energy
8	"local procurement" minerals	8	"solar power" environmental impact
9	"green energy" mining	9	"life cycle assessment" (LCA) solar panel
10	"artisanal and small-scale mining"	10	photovoltaics "toxic waste"
11	corruption mining	11	sustainability "solar energy"
12	"free prior informed consent" mining	12	"carbon footprint" wind energy
13	"grievance mechanism" mining	13	"wind power" environmental impact
14	"health and safety" mining	14	"life cycle assessment" (LCA) wind turbine
15	"social impact" mining	15	sustainability "wind energy"
16	mining "living wage"	16	"copper mining" environmental impact
17	"value creation" mining	17	"rare earth mining" environmental impact
18	ESG mining	18	"The Copper Mark"
19	"biodiversity loss" mining	19	"WEEE directive" solar panels
20	mining "toxic chemicals"	20	"Siemens Gamesa" global agreement
21	mining reclamation		
22	sustainable mining		
23	"responsible mining"		
24	sustainability mining		
25	"responsible sourcing"		
26	"responsible sourcing" minerals		
27	"responsible sourcing" raw materials		
28	"responsible sourcing" blockchain		
29	sustainable "raw materials"		
30	certification "raw materials"		
31	"supply chain" transparency		
32	responsible "supply chain"		
33	"London Metal Exchange" responsible sourcing		
34	"Responsible Minerals Initiative"		
35	"Towards Sustainable Mining"		
36	EITI		
37	ICMM principles		
38	IFC guidelines mining		
39	ILO standards mining		
40	IRMA standard		
41	OECD "responsible mineral supply chain"		
42	World Bank "climate-smart mining"		
43	OECD procurement guidelines		

5 Vision

The Vision of the RE-SOURCING project constitutes the final stage of the roadmap for the renewable energy sector to be achieved by 2050. This chapter provides a first overview of the goals the RE-SOURCING project wants to help achieve. The vision is based on the concepts of planetary boundaries and strong sustainability, providing essential guidelines regarding the preservation of natural capital. The roadmap to be produced over the course of the RE-SOURICNG will provide a step-by-step approach towards achieving the vision.

The goal of the RE-SOURCING project is to develop a roadmap for the renewable energy sector to become a responsible and sustainable supply chain from raw material to product, from mining to recycling by 2050. To do so the current situation has been assessed (see chapter 2 State of Play) and standards and initiatives for sustainable development and responsible sourcing have been reviewed. The next step is to create a vision of the 'ideal' supply chain we want to achieve. The roadmap developed in the further course of the RE-SOURCING project will then include a plan for policy makers and companies on how to achieve this vision.

The basis or rather the 'overarching umbrella' of the vision are the concepts of planetary boundaries and strong sustainability. Planetary boundaries as defined by Rockström et al. (2009) define the threshold limits within which humanity can operate in a safe way and without causing catastrophic environmental changes. They have defined nine boundaries with quantifiable limits for seven of them. The nine planetary boundaries are: climate change, stratospheric ozone, biogeochemical nitrogen cycle, phosphorous cycle, global freshwater use, land system change, rate of biological diversity loss, chemical pollution, and atmospheric aerosol loading (for the last two, no suitable limit has yet been identified).

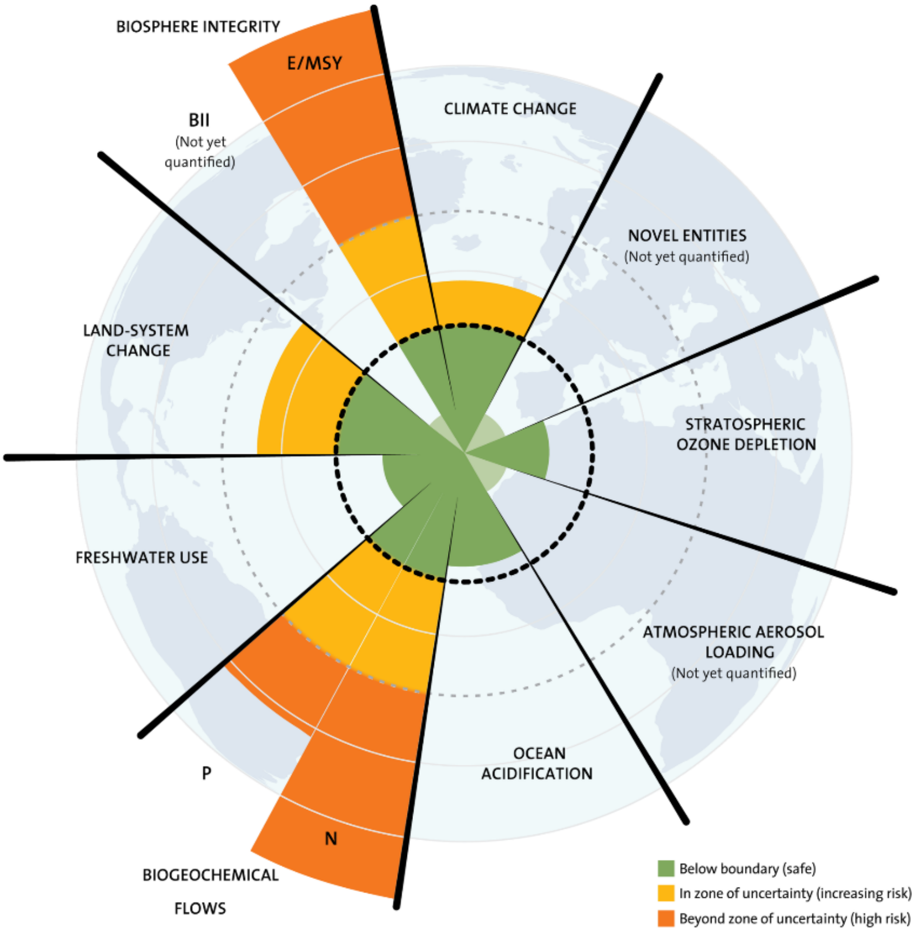

Figure 18: Planetary Boundaries as defined by Rockström et al. (2009) and advances towards and beyond the limits (J. Lokrantz/Azote based on Steffen et al. 2015)

In line with the planetary boundaries 'strong sustainability' argues that natural capital cannot be completely substituted by manufactured capital, but its substitutability is severely limited due to the critical ecosystem services it provides for human existence and well-being (Pelenc and Ballet 2015a).

For instance, a critical regulatory service provided is air quality regulation. If coal use for energy production or fossil fuel use in general were to continue without any limitations, the ability of nature to regulate air quality would be seriously compromised and eventually irreversibly extinct (Pelenc and Ballet 2015b; Tost et al. 2018b).

Sustainable Development Goals: The standards and initiatives assessed in chapter 3 are mainly in line with the SDGs and support the achievement of the 17 goals. This means, that they need to be implemented by 2030. The RE-SOURCING project's horizon to 2050 allows the project goals to be set even higher. Moreover, studies found that the SDGs support the concept of weak sustainability[7] as the goals are currently achieved by causing further environmental degradation (Jain and Jain 2020; Tost et al. 2018b)

[7] The concept of weak sustainability assumes the full substitutability of natural capital by manufactured capital. For more information please see Pelenc and Ballet 2015a.

Vision 2050, WBCSD: A supporter of the strong sustainability concept that is used as a basis for the RE-SOURCING project's vision, is the World Business Council for Sustainable Development (WBCSD). The WBCSD published the "Vision 2050" in 2010, which contains many of the goals we are aiming for. It also sets out a roadmap for achieving these goals. This vision is currently under review and pressing topics such as social tensions and environmental impacts will be brought further into (WBCSD 2020). The Vision 2050 also served as a basis for the World Economic Forum's (WEF) Scoping Paper on the role of "Mining and Metals in a Sustainable World" outlining the importance of consistent global policies and regulations to achieve a sustainable and responsible mining sector.

RE-SOURCING project's targets: Based on this, the RE-SOURCING project's targets for the renewable energy sector have been derived. The goals are grouped according to the three pillars of sustainability: environmental, social, and economic. Additionally, sector specific goals have been defined for the three stages of the supply chain discussed in this report – mining, manufacturing, and recycling (see Figure 19). The goals are based on the assumption of 100% renewable energy by 2050. Moreover, we want to highlight, that the goals follow a risk-based approach, i.e. "the intensity of due diligence is proportional to risk" (OECD 2020e). The authors do not advocate the exclusion of certain stakeholders within supply chains due to prevailing issues. The RE-SOURCING project wants to encourage a joint effort to mitigate and solve problems along the supply chain.

From a strong sustainability standpoint as explained above, the environmental goals are clear – the main target is to limit the temperature rise to 1.5°C, as anything beyond that will permanently damage the climate system. This threshold will likely also be surpassed if the emissions are limited according to the current Paris Agreement. Therefore, even stronger measures are required to limit the GHG emissions to tolerable levels which requires a successful international cooperation and a harmonisation of standards. This includes a reduction of energy and resource-demand (see Figure 19 environmental goal "resource efficiency"), but also a decarbonisation of energy supply (environmental goals "use of renewable energy sources" and "carbon neutral production and transport"). It is necessary, that policies and taxes reflect the severe impact of GHG emissions by introducing high prices for emissions and taking companies to account (economic goals "unsustainability is unprofitable", "companies accept their responsibility", etc.) (Rogelj et al. 2018).

The IPCC finds in their Special Report on Global Warming, that limiting the temperature rise to 1.5°C is not only necessary for the benefit of our climate and eco-system, but also for eradicating poverty and reducing inequalities. Higher temperatures can lead to increasing water and food insecurity, as well as adverse health impacts, and economic losses (social goals "Elimination of poverty and hunger", "Ensure access to food, clean air & water, […]") (Roy et al. 2018).

Figure 19: Vision of the Renewable Energy Sector in 2050, based on (WEF Mining & Metals 2014) (WBCSD 2020) (Franks 2015)

6 Gap Analysis & Next Steps

The gap analysis evaluates missing links between existing standards and sustainability schemes, and the vision of the RE-SOURCING project. The first gap identified arises from this large number of guidelines for the mining sector – a harmonisation of standards and an overarching international framework is required. This also applies to the manufacturing of equipment and its collection and treatment.

Other very important subjects are the issues of environmental sustainability and resource efficiency. Especially, considering the increase of renewable energy supply, the associated increase of demand for raw materials needs to be addressed. To decrease the environmental impact, economic activities must be decoupled from the resource use.

In order to define the project's next steps and develop the roadmap from 2020 to 2050, an evaluation of what remains to be done to achieve the vision (see chapter 5) needs to be conducted, assuming successful implementation of the existing standards (see chapter 3). Therefore, the first step is to carry out a gap analysis. As many of the standards aim at supporting the achievement of the SDGs we can assume that the principles behind all of them need to be successfully implemented by 2030. Using the comparative study of mining standards by the BGR (Kickler and Franken 2017) we can identify issues that are not yet addressed by existing initiatives. The first issue is no single initiative covers all 108 sub-issues identified in the BGR report. There are other issues not covered by any standards assessed (IRMA, IFC, ICMM, and GRI) and some covered by only one. The issues not addressed include: (i) women rights, (ii) alluvial mining, (iii) conflict with agriculture, (iv) conflict with LSM or indigenous, (v) extortion (vi) money laundering, (vii) mergers and acquisitions, (viii) divestment, (ix) pricing and price premium, (x) production practices, and (xi) responsible person for the standard. Especially sub-issues in the category business practices (v-ix) are not considered.

Looking at issues that are covered by only one standard, it is noted that a combination of the four analysed standards would provide for a very comprehensive scheme covering 97 of 108 parameters. Regarding transparency and reporting principles, other initiatives often reference EITI and GRI and no additional guidelines are included in the specific initiatives (Kickler and Franken 2017).

6.1 Issues remaining to be addressed

Some of the issues missing from the five standards discussed above are addressed by the OECD Due Diligence Guidance for Responsible Mineral Supply Chains, and standards based on this guidance respectively (e.g. LME Responsible Sourcing, Fairmined). The OECD provides guidelines on the risks of financial crimes, including money laundering, bribery, or tax evasion. It also covers issues related to ASM, such as the cooperation between LSM and ASM activities and the integration of ASM into formal supply chains. Another risk addressed by the guidance is the declaration of origin and misrepresentation thereof (OECD 2020a, 2020e).

Proof of origin: One issue missing from most mining standards discussed in the BGR's report is the 'proof of origin'. This is usually included in standards relating to conflict minerals. For example, the ARM or the Fairmined Standard respectively, provide traceability back to the ASM operation for their traded gold. However, this type of traceability scheme requires inspectors to be located directly at the operation in order to be able to approve the certification of the raw material. The same applies to the traceability of raw materials along the supply chain when using blockchain. There has to be a supervisor at the mine assessing the production processes, certifying the materials according to a specific scheme, and registering it in the system – a real proof of origin is missing. An example for such a system based on a paper trail chain of custody system is the International Tin Supply Chain initiative (ITSCI) which is also based on the OECD Mineral Guidance. Relevant data associated with the minerals shipped from a mining site is documented by an on-site government agent who tags each bag of material. Their responsibility is the assurance of the origin of the tagged material. This process continues at the processing plant and the exporter. All data is transferred to the ITSCI data centre where it is checked for anomalies ((ITSCI 2020) & expert consultations).

However, according to our expert consultations some work has been conducted in this field since the BGR study. For instance, IRMA is in the process of publishing a ***Chain of Custody Standard***. This standard was developed to provide the base-level requirements for traceability for any mined material from the mine through the downstream chain of custody to the end consumer. The IRMA Chain of Custody Standard will, as needed, be supplemented by Annexes specifying additional guidance for specific mineral supply chains. In addition, this standard has been developed to work in concert with existing and emerging traceability services and technologies (e.g., blockchain, mineral ID scanning, testing, etc.). It also can be used to help validate key systems and documentation through on-site audits that are associated with secure ledgers and testing results. It is also intended to be compatible with other standards and programmes forwarding responsible sourcing of mined materials (e.g. ResponsibleSteel, Responsible Jewellery Council). IRMA will work to adapt expectations when coordinated with other systems working to common purpose to convey value for responsible practices at the mine level down the chain to consumer-facing products (Result of expert consultations, IRMA).

For some minerals the ***Analytical Fingerprinting (AFP)*** Method has been developed. BGR provides this tool for tin, tungsten, and tantalum to check their origin against the details documented. AFP could also be developed for other minerals, but the issue with this method is the costs and who has to bear them. It cannot be the responsibility of the miners alone to provide this proof, rather it should be a joint effort together with the downstream industries demanding this proof (Result of expert consultations).

The proof of origin and mineral traceability in general are important aspects of the OECD Due Diligence Guidance and the EU regulation on the sourcing of conflict minerals (BGR 2020; Schütte et al. 2018). Nevertheless, even though the tracking and tracing of raw materials are important measures supporting responsible sourcing and sustainability initiatives, it can only be considered as a 'means to an end' and does not replace any of the standards or certifications discussed.

Harmonization of sustainability requirements: One of the most important aspects missing to be able to navigate in the jungle of sustainability schemes for mining is a joint framework and a harmonisation of the requirements. It cannot be the purpose to adopt as many standards as possible. This is neither a suitable solution for the mining operations having to apply them, nor the downstream customers having to ensure all their requirements for responsible sourcing are met.

An example for such an international framework is the ILO conventions and recommendations that are widely accepted across countries and industries. Sustainability schemes for mining often differ even in the most basic definitions, such as protected areas (Kickler and Franken 2017; BGR 2020; Schütte et al. 2018).

Considering standards addressing the manufacturing stage of wind turbines and solar panels and respective equipment, there are few to none covering this phase. However, this is likely due to the rapid growth and development of the industry. Currently various standards are under development, so it remains to be seen what issues will be covered. Nevertheless, there are a number of non-sector specific international standards covering various aspects of the manufacturing process. There are the ISO-standards for environmental (14001), occupational health & safety (45001), and energy (50001) management. Labour guidelines are covered by the ILO, EHS guidelines are provided by the IFC, and the SDGs and OECD guidelines for multinational enterprises are general governance frameworks.

Recycling Standards: The recycling of wind energy and solar PV equipment is covered by very few standards. Only the EU has a Waste Electrical and Electronic Equipment Directive (WEEE Directive), which also covers PV panels. Particularly considering turbine blades and PV equipment, such as batteries, international frameworks need to be established to prevent the increase of unused landfill or pollution by battery toxins.

Responsible Procurement: The link between the individual stages of the supply chain is formed by procurement. This is also covered by an ISO standard which provides internationally valid guidelines for the procurement processes of all types of organisations (ISO 20400, see chapter 3.5.3). Other initiatives in this area, e.g. the UNEP Sustainable Procurement Guidelines, or national efforts, e.g. the Sustainable Procurement Guidelines of the Australian government, often focus on public procurement only. Some international companies have internal regulations on how procurement is handled in a sustainable and responsible manner and publish their procurement standards on their website, e.g. Umicore (UNEP 2012; Umicore 2017; Commonwealth of Australia 2018; ISO 2017). For the purpose of this report and further analyses we use the ISO definitions of procurement and sourcing: procurement is the "*activity of acquiring goods or services from suppliers*" and "*sourcing is a part of the procurement process that includes planning, defining specifications and selecting supplier*" (International Standard ISO 20400:2017 (E)).

Guidelines for procurement can potentially affect sustainability schemes on sector level, as they determine requirements customers have to look for in their suppliers. This means that also procurement guidelines could benefit from a harmonisation with sector specific standards. Otherwise, they add to the multitude of already available standards and partially overlapping guidelines.

Timeless vs transient narratives: The narrative analysis conducted for this report also contains narratives on the standards and initiatives discussed mainly for the mining sector, but also related to other stages of the supply chain (for details see chapter 4). Only the EITI can be classified as a timeless narrative, i.e. a narrative characterised by long-term, deep engagement. All other standards included are either transient or tribal narratives – low engagement and significance.

However, the RE-SOURCING team believes they are important initiatives for pushing sustainability and responsibility along the supply chain. In order for them to gain importance, a possibility is to link a transient narrative, to a timeless or transformational narrative. For example, for the WEEE directive to gain engagement and power it could be a possible strategy to strongly interlink it to the topics of "recycling renewables" and "sustainability solar energy". The narrative "OECD responsible mineral supply chain" could potentially benefit from being communicated and published with a strong thematic link to the topic of "responsible sourcing". As the OECD is already a key player of "responsible sourcing", it appears that this is a simple and quick solution. The EITI is a good example of successfully engaging the public in their initiative and content available on their homepage. Both content and media are almost exclusively dominated by the organisation's own reports. The emotional reactions at the time of the study were exclusively neutral and characterised by expectation.

Lack of engagement: Apart from the standards, there are also many other narratives that are important topics for the sustainability and responsibility agenda, but so far, have not created enough engagement. Examples are "human rights procurement" or "responsible sourcing raw materials/minerals". The authors consider both narratives highly relevant in the context of responsible sourcing for the renewable energy sector. These topics require more commitment, because they are related to issues that still exist in the renewable energy sector supply chain and need to be addressed emphatically. This is an important feedback for the RE-SOURCING project to further engage with these topics and actively communicate them to the public, but also policy makers and other organisations need to engage with these issues to ensure that they are dealt with and resolved openly.

Linking to human development: Until 2030, the SDGs have to be implemented and so do the frameworks and standards supporting them (see chapter 3). With the successful implementation of the SDGs many issues discussed in chapter 2.1 will be settled. However, in order to reach our vision guided by the concept of strong sustainability (see chapter 5), there are still some measures to be taken after their implementation is completed. The reason why the achievement of the SDGs is not satisfactory for the RE-SOURCING project is laid out by Jain and Jain (2020). They compare the enhancement of human well-being by using the Human Development Index (HDI) with the carrying capacity of the planet by using the Ecological Footprint (EF). The HDI ranges between 0 and 1 ($<0,55$ means low development, $>0,7$ high human development). The ecologically productive area per person is 1.7 gha. This means a country with an HDI of >0.70 and an EF <1.7 gha can be categorised as sustainable. The assessment shows that countries with a high HDI usually also have an EF exceeding the 1.7 gha.

For example, Finland, Norway, and Switzerland, all countries with a very high HDI, have an average EF of 5.95 gha. In contrast, countries with a low HDI also have a significantly smaller EF.

Jain and Jain argue that this shows the preference of economic and social development over environmental aspects and the respect for planetary boundaries. However, the Sustainable Development Goals Index (SDGI) used to measure the progress towards the SDGs assesses countries positively and with high progress, even though they have a large EF. Considering the parameters used to evaluate the countries' SDGI they can be categorised according to their impact on the resource demand. The largest share of parameters (67.6%) increases the demand for resources. Only 13.6% decrease the demand, and the remaining 18.8% are classified as neutral. It is therefore very important to decouple social and economic development from the consumption of resources and transfer the realisation of dependence between culture and nature into (policy) action.

Resource efficiency: It is imperative to include efforts for resource efficiency in the further development of our roadmap, a consideration many of the identified standards and initiatives, including the SDGs are failing to address.

Resource efficiency can be defined as the ability of humanity to continue to expand the use of eco system services (i.e. services derived from resources), while reducing the actual quantity of resources deployed (resource decoupling) and associated environmental impacts (impact decoupling) (UNEP 2017).

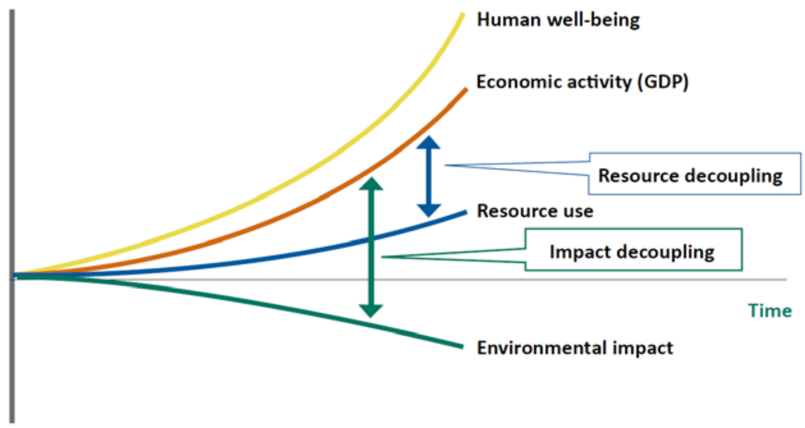

Figure 20: Decoupling of economic growth (measured as GDP) from resource use and environmental impact (Ekins and Hughes 2017)

Decoupling means that resource use or environmental impact do not continue to grow at the same or a similar rate as economic growth. The decoupling can either be relative, i.e. increasing at a slower rate, or absolute, referring to a decreasing development with increasing economic activity. The decoupling of both the resource use and the environmental impact from economic activity as shown in Figure 20 is called "double decoupling". Environmental benefits that can be achieved with increasing resource efficiency are not only limited to the lower environmental impact from mining. We also have to take the impact from resource consumption into account, including but not limited to GHG emissions, or waste disposal. However, resource efficiency is not only an important measure for reducing the environmental impact, it can also bring economic benefits by supporting enterprises and countries withstand price volatility, or encourage cost-saving innovations. Moreover, resource security can be increased (Ekins and Hughes 2017).

There are various ways of increasing resource efficiency: (i) increasing production efficiency, (ii) decreasing waste and losses along the supply chain, (iii) recycling or reusing of waste, and (iv) modify consumer behaviour and consumption patterns. The first three targets are usually summarised as the "3R" – reduce, reuse, recycle (Ekins and Hughes 2017; van den Berg et al. 2016).

Considering renewable energy technologies, resource efficiency is key for a successful transformation from fossil fuel powered energy supply. Currently, the material intensity per unit of delivered electricity tends to be higher for renewable energy than for fossil fuel technologies. Simultaneously to the transition to low-carbon energy technologies, energy demand is increasing as well. Therefore, additionally to resource efficiency, consumption patterns need to change as well to make the transition achievable and affordable. However, policies often fail to include consumption patterns and consumer habits and rather focus on technological innovations. (Ekins and Hughes 2017; van den Berg et al. 2016).

This is a point that some NGOs strongly criticise in the World Bank's climate-smart mining initiative. Under the leadership of Earthworks, 60 NGOs are calling on the World Bank to revise its strategy and, above all, to step up recycling activities. The concern is that the Climate-smart mining initiative will further expand mining activities in addition to the already growing demand, thereby increasing environmental and social impacts. Moreover, the initiative calls for a further strengthening of responsible sourcing of minerals and a rethinking of consumption and transport behaviour (Earthworks 4/30/2020).

6.2 Conclusion

The gap analysis showed where the RE-SOURCING project needs to further engage in the development of the roadmap. It must be ensured that all production steps along the supply chain of the renewable energy sector are carried out in a sustainable and responsible manner. To achieve this, a clear and holistic international framework is required for each step in the supply chain.

Existing standards and sustainability schemes for the mining sector are very comprehensive, but do not contain measures for all the problems that exist in the sector. However, it seems difficult for one standard to cover all challenges because of the different circumstances depending on location and raw material. Mutual recognition and an overarching framework must therefore be promoted. In addition, work needs to be done on the traceability of raw materials in the supply chains.

Current sustainability measures lack guidelines for resource efficiency. In general, environmental sustainability does not receive the same attention as economic and social development. The reduction of resource consumption and its decoupling from economic growth is considered essential for the preservation of natural capital and the achievement of the climate goals.

This report clearly shows the impact an increase of renewable energy production can have on environmental and social sustainability, if prevailing issues along the supply chain are not addressed. The roadmap of the RE-SOURCING project will be developed on the basis of the results of this report in cooperation with stakeholders of the renewable energies' supply chains. The aim is to provide guidance for companies and policy makers on how to address the identified sustainability challenges.

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Annex

1 Flagship cases

A "flagship case" is an example of an activity undertaken by a company, organisation, initiative, or similar that supports responsible production and sourcing. This activity has led to a measurable improvement or reduction of social or environmental impacts, or the traceability of the operations and transparency has been improved.

In this chapter we will introduce a few cases we think can qualify as good practice and should be pursued further in Work Package 5 for detailed elaboration. The preliminary cases presented below will be subject to further investigation in order to be eligible for selection as a RE-SOURCING Flagship case.

1.1 Policy

The Chilean government has been very active in the preparation of a new National Mining Policy (PMN) 2050. This process has gathered relevant stakeholders across all sectors: mining companies, communities, workers, NGOs, universities, government agencies, etc. The PNM 2050 is coherent with the sustainable development guidelines of the United Nations and is expected to be the roadmap for the sustainable development of the Chilean mining industry, in the short, medium, and long-term. The preparation of the PMN 2050 is conducted over four stages. “Fase Central” (central phase) already completed) which involved 150 actors from different stakeholders preparing a document for further evaluation containing 36 agreements and challenges. The next step “Comisiones Técnicas” (technical commission) has nine technical commissions made up of more than 100 participants evaluate this document. In “Fase Territorial” (territorial phase) more than 20 workshops in 16 regions will be hosted involving around 1000 people. These three stages will be finished by the end of 2020. Finally, in “Fase virtual” (virtual phase) open participation is encouraged via virtual meetings and surveys. There are nine areas this policy process is looking at in particular: institutions and mining development, territorial development and citizen engagement, labour conditions and gender equality, productivity and human capital, innovation and value chain, taxes and public investment, mining and environmental sustainability, small and medium-scale mining, indigenous communities. (Ministerio de Minería 2020).

Another initiative by the Chilean Ministry of Mining is the National Tailings Plan (PNDR). This policy aims at defining guidelines, programmes, and tools to face the past (e.g. abandoned tailings) and future challenges, and opportunities (e.g. economic potential from the mineral content of tailings) in this matter. The policy is based on three pillars: (i) safety of the population, (ii) environmental protection, (iii) circular economy and innovation. The policy will contain a specific action plan for each of these pillars (Ministerio de Minería and Servicio Nacional de Geología y Minería 2020).

Chile is also very active in diversifying their workforce and working towards gender equality in the mining industry. In 2018 the working group "Women in mining" has been started as a cooperation between the Ministry of Mining and the Ministry of Women and Gender equality. This initiative prepared 10 recommendations, the "Decalogue of the mining industry for the incorporation of women and the work, family and personal life reconciliation".

Aiming at increasing the participation of women in the mining industry and promoting a diverse and inclusive organisational culture. This declaration was signed by over 20 mining companies, including Codelco, Anglo American, BHP, and Freeport.

(Information kindly provided by Mr Felipe Sanchez, Department of Strategy and Policy Planning, Chilean Copper Commission.)

1.2 Company level

1.2.1 Copper

Codelco is one of the largest global copper producers with headquarters and mining operations in Chile. The company is investing heavily in the modernisation of its production facilities to increase the lifespan of its operating sites, while maintaining stable production levels. To cut GHG emissions and reduce the carbon footprint of its copper mining operations, new technologies such as artificial intelligence and automation, as well as electric vehicles are being considered. For this purpose, Codelco formed a strategic partnership with Sandvik Mining and Rock Technology, using the "AutoMine" system first at Chuquicamata mine to enable a successful transition from open pit to underground mining. This automation system can be applied in combination with manually operated machinery allowing a seamless transition. This system shall be gradually applied to other mines operated by Codelco, e.g. El Teniente. Additionally, Codelco has partnered with the Chicago artificial intelligence company Uptake. Their software solution will monitor equipment, including mills and crushers, but also trucks and pumps. With the collected data continual operation at optimal capacity shall be ensured. Another interesting development is the introduction of a hybrid LHD (load-haul-dump) by Komatsu in El Teniente mine to reduce the carbon footprint and reduce costs while increasing outputs. A further expansion of the electric and hybrid fleet is planned (The Copper Alliance 2020).

Another project worth mentioning is the transformation of energy supply for mining operations at Minera Zaldívar (Barrick Gold Corp. and Antofagasta Minerals in Atacama Desert, Chile) to 100% green energy. This is done in cooperation with the power producer Colbún S.A. who received a 10-year contract conditional to the development of an energy solution based on wind, solar, and hydroelectric installations. The goal is to cut GHG emissions by 350,000 tonnes (The Copper Alliance 2018b).

A contribution to SDG 6 "Clean Water and Sanitation" is made by the commissioning of the second seawater desalination plant at Escondida mine by BHP Billiton. This decreases the dependence on scarce groundwater (The Copper Alliance 2018a).

1.2.2 Rare Earth Elements

Lynas Corp. Ltd. is the second largest producer of rare earth minerals, and operates Mt Weld (Western Australia), including a processing and concentration plant, proving the highest grades of rare earths. At the processing facility three tailings dams are in use. For the tailings an operation manual has been developed to ensure safe day to day operations. Inspections by company employees are undertaken on a daily basis and third-party audits are conducted annually. To reduce the water content and accelerate the drying of the tailings, mudfarming is conducted and water is recovered, retreated and finally re-used. The long-term tailings management plan also includes a contingency plan for mine closure (Lynas Corporation Ltd 2020).

1.2.3 Trading

Trafigura, an important commodity trading and shipping company, has committed to lowering their carbon footprint from international shipping. This is done in three steps: (i) the employment of new vessels with reduced carbon emissions, according to EEDI requirements, (ii) smarter shipping by introducing port, speed, and rout optimisation, this already led to operational efficiency improvements including 50,000 tonnes of avoided CO_2 emissions. Vessel providers are required to disclose fuel consumption and nautical miles as a basis for further calculations and improvements. (iii) The company conducts carbon-based accounting and reporting according to the framework by Smart Freight Centre's Global Logistics Emissions Council (Trafigura 2020).

1.2.4 Wind Turbine Manufacturing

Siemens Gamesa and IndustriALL renew their Global Framework Agreement promoting best labour, social, and environmental practices. The agreement is fully in line with SDG 12 "Responsible Consumption and Production" as well as the ILO guidelines for a just transition. Issues covered are human and labour rights, occupational health and safety, relationships with suppliers (including financial crimes), but also environmental protection (including energy and resource efficiency). Siemens Gamesa will promote this agreement along its supply chain and encourage the implementation among business partners, subcontractors, and suppliers (Siemens Gamesa 2019; Siemens Gamesa and IndustriALL 2019).

Another important aspect of this agreement is corporate and social responsibility and community relations addressing expectations of stakeholders and local development by improving quality of life and creating wealth for local communities. Siemens Gamesa encourages their employees to submit proposals for positive contributions to communities surrounding their operations. In 2019 eight projects (out of 190 submitted proposals) were chosen. These include 'sustainable honey production in Brazil', 'Robots – also for girls', and 'facilitating access to water'. Ranging from no poverty initiatives, to education, and clean water and sanitation support systems in seven different countries (Siemens Gamesa 2020, 2019).

1.2.5 Solar Panel Manufacturing

The Solar Energy Foundation is an organization supporting the employment of renewable energy in developing countries. They offer training and education for solar technicians to promote the expansion of solar energy and the creation of jobs in remote regions. The goal is to support communities by giving them the knowledge and tools to develop their own power systems and improve their living situation, in order to achieve a long-term poverty alleviation (Solar Energy Foundation 2020). The solar panel manufacturer Q Cells supports this initiative by providing training of local students in solar electricity generation (Q Cells 2017).

Another local development activity of Q Cells is its involvement in the initiative "Solar energy goes to school in Saxony-Anhalt". Together with other companies from the solar sector and the Sachsen-Anhalt Ministry of Science and Economic Affairs (Germany), they provide photovoltaic systems and information material for 20 schools. Educating children in future energy supply issues, environmental aspects, and introducing the photovoltaics industry (Q Cells 2017).

Wacker Chemie (Germany), a company producing polysilicon for photovoltaic applications, is a very active stakeholder in the development of responsible supply chains. Wacker is a member of "Together for Sustainability", an initiative for procurement in the chemicals industry that has developed a standardized process for evaluating suppliers' sustainability efforts. Wacker is also member of the UN initiative Global Compact and Responsible Care. The company aims to ensure sustainable supply chains for their production facilities. Issues of focus are labour conditions, ethical and health and safety standards especially considering the handling of hazardous substances, as well as sustainable use of local resources. Suppliers are asked to be certified via the Together for sustainability programme – more than 65% of Wacker's suppliers have successfully undergone the certification to date. Suppliers that do not pass the evaluation are supported in their improvement. If there are repeatedly bad results in re-assessments, business relations can be terminated (Wacker Chemie AG 2019).

The two solar panel manufacturers JinkoSolar and First Solar both committed to 100% renewable energy for their production processes. JinkoSolar published a roadmap "RE100" to achieve this goal by 2025 earlier this year. Their innovation actions to achieve this goal include the construction of new factories close to renewable-rich regions, R&D focus on more efficient solar products to reduce power consumption per watt, or the optimization of production processes in order to save energy. First Solar plans to achieve this goal by 2028. Moreover, the company commits to transforming their facilities to carbon-free electricity by 2026 (JinkoSolar Holding Co., Ltd. 8/6/2020; First Solar, Inc 8/6/2020).

1.2.6 Solar Panel Collection and Treatment

The solar panel manufacturer First Solar employs their own recycling facilities in the US, Germany, and Malaysia. Providing globally available recycling of end-of-life PV panels. They achieve recovery rates of up to 90% for both semiconductor material and glass. Recovered semiconductor material is reused for the production of new modules, and the recovered glass can be reused in new glass products. Cadmium and tellurium components are separated and refined by a third-party. For solar panels sold before 2013, the collection and treatment are pre-financed by setting aside funds from the sale of each product. Customers are supported with information on the correct return of their modules (First Solar 2020).

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