re-sourcing

Renewable Energy Sector

Industry

Roadmap for Responsible Sourcing of Raw Materials until 2050

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Abbreviations

ASM	Artisanal and small-scale mining
CdTe	Cadmium telluride
CSOs	Civil Society Organisations
D1.2, or D4.1	Deliverable of the RE-SOURCING Project (1.2 The RE-SOURCING Common Approach; 4.1 State of Play and roadmap concepts: Renewable Energy Sector)
EHS	Environment, Health and Safety
EoL	End-of-life
EU	European Union
GHG	Greenhouse gas emissions
GRI	Global Reporting Initiative
ICMM	International Council on Mining and Metals
IEA	International Energy Agency
IFC	International Finance Cooperation
ILO	International Labour Organization
IRENA	International Renewable Energy Agency
IRMA	Initiative for Responsible Mining Assurance
LCA	Life cycle assessment
LSM	Large-scale mining
NdFeB	Neodymium iron boron
NGO	Non-governmental Organisations
OECD	Organisation for Economic Co-operation and Development
PV	Photovoltaics
REE	Rare earth elements
RS	Responsible Sourcing
SDGs	Sustainable Development Goals
S-LCA	Social life cycle assessment
SLO	Social licence to operate
SME	Small and medium-sized enterprise
TCFD	Task Force on Climate-related Financial Disclosures
TNFD	Taskforce on Nature-related Financial Disclosures
US	United States (of America)
WEEE	Waste electrical and electronic equipment

Executive Summary

This publication is an **excerpt from the Renewable Energy Sector Roadmap for Responsible Sourcing of Raw Materials with a focus on recommendations for industry players**. The full publication with recommendations for policy makers, industry, civil society, research and academia can be found **here.**

The renewable energy sector is growing exponentially – a necessary requirement for successfully achieving the transition from fossil fuels to clean energy sources and mitigate climate change. Two of the main technologies driving this growth are wind and solar PV energy. While these two technologies are considered sustainable energy sources, the production of the raw materials and equipment that are used for them, are associated with strong environmental and social impact concerns. To ensure a just transition, the implementation of high social and environmental standards in production and sourcing along the entire supply chain is crucial.

Following the State of Play and Roadmap Concepts for the Renewable Energy Sector - a stock taking report of the current sustainability challenges in the renewable energy sector - this report by the RE-SOURCING project focuses on the road towards achieving a sustainable energy transition by 2050. The RE-SOURCING projects 'Vision 2050' for the renewable energy sector based on the concepts of planetary boundaries and strong sustainability describes the ultimate goal to be achieved with the roadmap. This roadmap addresses three raw materials (copper, rare earth elements, and silicon); two technologies (wind and solar PV energy); and three supply chain stages (mining, manufacturing, and recycling) (Fig. I); providing recommendations for industry on achieving a vision for a sustainable renewable energy sector.

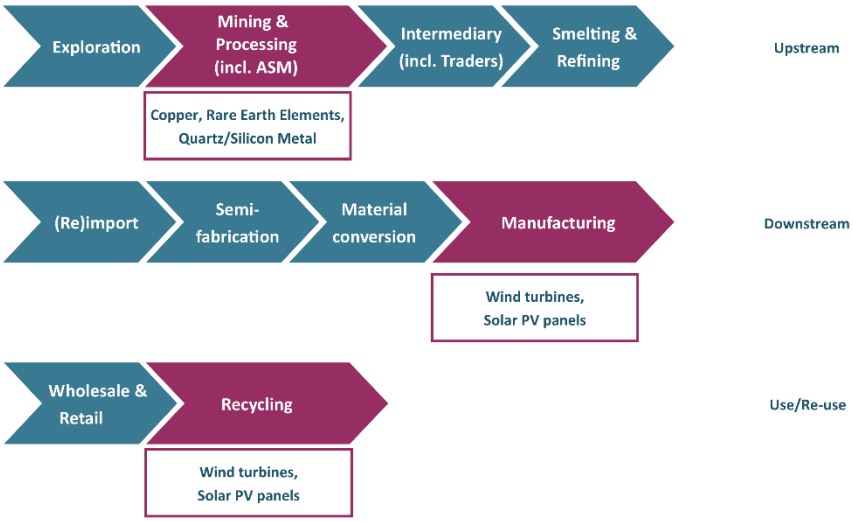

Fig. I: Supply chain stages and materials included in the roadmap

For the development of the sectoral roadmaps, the RE-SOURCING project relies primarily on bringing together existing knowledge from key stakeholder groups and regions. A series of five webinars, supplemented by additional expert consultations, were utilised to elaborate the recommendations presented in this report. Based on the State of Play Report and the consultation process, five key target areas have been identified and are addressed in this roadmap (Fig. II):

- Circular Economy & Decreased Resource Consumption;
- Paris Agreement & Environmental Sustainability;
- Social Sustainability & Responsible Production;
- Responsible Procurement; and
- Level-Playing Field & International Cooperation.

Each target is further subdivided into recommendations for industry, with corresponding milestones and necessary actions for short (2025), medium (2030 and 2040) and long-term (2050) timeframes. The numbering of the targets does not imply any priority. All five targets are interlinked and must be pursued simultaneously to achieve the vision for the renewable energy sector.

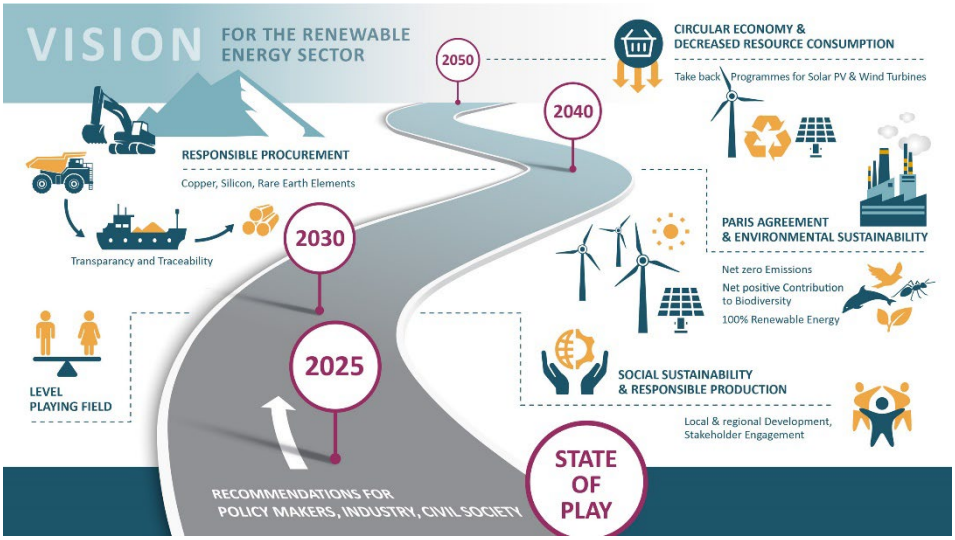

Fig. II: Roadmap for the renewable energy sector until 2050

Target 1 'Circular Economy & Decreased Resource Consumption' addresses the need for changes in behaviour and the economic system to stay within planetary boundaries. A transition to renewable energy sources without improvements in energy efficiency and decreased demand will not be possible or enough to mitigate climate change. Additionally, end-of-life wind turbines, solar PV modules, and related equipment need to be seen as strategic source of raw materials, with collection and recycling systems strengthened.

Target 2 'Paris Agreement & Environmental Sustainability' focuses on the expansion of renewable energy itself, the reduction of GHG emissions, biodiversity conservation, etc. within the supply chain stages of mining, manufacturing, and recycling. We encourage the EU to take a lead role in the transition and speed up the renewable energy expansion, while highlighting the need for improved environmental conservation.

In Target 3 'Social Sustainability & Responsible Production', the fair distribution of benefits and burdens is the main objective. This includes considerations such as occupational health and safety standards specifically for the renewable energy sector, meaningful stakeholder engagement, or the introduction of social life cycle assessments in production processes.

All issues addressed in targets 1-3 are also included in Target 4 'Responsible Procurement'. Rather than focusing on an organisation itself, this considers the entire supply chain of said organisation.

Recommendations include transparency as a prerequisite for supply chain due diligence, the support for sustainable development, as well as the development of resilient and risk-proof supply chains.

Finally, Target 5 'Level Playing Field & International Cooperation' aims at harmonising requirements for companies operating and trading across the value chain, in and with the EU. Raw materials or products that are produced with lower standards should be disadvantaged in the future or no longer be imported. However, creating a level playing field also implies supporting companies, regions, and countries in improving their practices and achieving the required standards.

Keywords:

Industry Recommendations; Renewable Energy Sector; Wind Turbines; Solar PV; Responsible Sourcing; Sustainability; Transition Minerals

1 Introduction

1.1 The Renewable Energy Sector

The work on the renewable energy sector started with the State of Play report which was published in October 2020. The aim of this report was to investigate the current state of the renewable energy sector and the value chains of wind and solar PV energy respectively. The RE-SOURCING project focuses its efforts on the supply chains of copper, rare earth elements and silicon to produce wind turbines and solar PV modules. The supply chain stages that are assessed in more detail are mining of these minerals, manufacturing of wind turbines and solar PV panels, and their recycling. The standards and initiatives addressing sustainability challenges in these supply chain stages are discussed.

The following provides a brief overview of the main findings of the State of Play report. For details see: State of Play and roadmap concepts: Renewable Energy Sector

Copper is an essential raw material for numerous applications, including all types of wiring for electric energy supply (European Commission 2020). The majority of supply is produced by large-scale mining (LSM) companies in Chile, providing more than 28% of the world's supply in 2018. However, artisanal and small-scale mining (ASM) mainly in the 'African Copperbelt' in the DR Congo (6% of global supply in 2018) and Zambia (4% of global supply 2018) play an important role in copper production (Reichl and Schatz 2020). The existence of both LSM and ASM in the same area are often cause for conflict. LSM operations potentially deprive local communities of their livelihoods as they depend on income from ASM. Informal ASM is also exposed to risks such as child and forced labour. In regions with weak democratic institutions, corruption is also an issue (Maiotti et al. 2019; Sweetman and Ezpeleta 2017). Additionally, mining operations in the Copperbelt cause significant environmental pollution, including water pollution through effluent discharge leading to health issues, food insecurity, etc. (Kügerl and Tost 2020). The Environmental Justice Atlas also reports other issues related to copper mining projects. A major issue is the disrespect of indigenous lands, for example in Canada and Alaska (Environmental Justice Atlas 2015).

The most important supplying country of **Rare Earth Elements** (REE) is China, accounting for more than 73% of global supply in 2018 (Reichl and Schatz 2020). REE are crucial for the production of permanent magnets, which are used in certain types of wind turbines among others.

For mining and processing of REE, potential environmental pollution is one of the main challenges that need to be considered. There are numerous risks during this process that can lead to significant pollution with chemicals, heavy metals, and radioactive elements. Especially small illegal mines in China pose a threat, as they are not equipped with the necessary treatment facilities, causing serious environmental damage and health hazards (Kügerl and Tost 2020). Furthermore, an important aspect of REE production is resource efficiency, or the lack thereof. For instance, at the mining stage, the cut-off grade needs to be taken into consideration to ensure a sustainable use of the available resources. This continues at the processing stage, where Chinese floatation plants only achieve recovery rates of approximately 40-60% (Schüler et al. 2011).

Silicon for the use in solar PV modules is mined as quartz. While no major issues in mining operations were found[1], the processing of quartz to high-purity silicon (polysilicon) needs to be considered in more detail. One issue is the vast amount of energy required for the purification process. Moreover, the most important producer of polysilicon for the solar PV industry is the Chinese Xinjiang region, which is subject to allegations of human rights abuses and forced labour (Copley 2020).

For the **renewable energy technologies manufacturing** stage of the supply chain, both wind turbine and solar PV manufacturers show a lack of commitment to human rights principles, including respect for land rights, indigenous people rights and gender equality (Business & Human Rights Resource Centre 2020; Kiezebrink et al. 2018). Moreover, both production processes are very energy intensive, especially the production of materials used. **Wind turbine manufacturing** also needs to consider occupational health and safety. On the one hand, during production employees are potentially exposed to epoxy resins, fibreglass, noise, dust, etc., and on the other hand working in heights and confined spaces pose a risk. **Solar PV modules** use silicon wafers that require large amounts of energy, water, and chemicals in their production. Moreover, the resource efficiency in the production of the wafers is of concern as high material losses occur (Kügerl and Tost 2020).

The **collection and recycling** of wind turbines and solar PV modules already shows high technical recyclability. Both show a technical recyclability of approximately 90%. For wind turbine blades innovations are required to ensure the efficient reuse of the composite materials, especially considering the increasing waste streams of the coming years. In general, there currently is a gap between collection and recycling possibilities and the expected large waste streams of the future.

1.2 Vision

The horizon considered for the roadmap of the RE-SOURCING project is 2050. The vision for the renewable energy sector (Figure 1) was developed based on the underlying concepts of planetary boundaries[2] and strong sustainability[3] and will be incorporated in the definition of responsible sourcing that is developed towards the end of the project. Further information on the RE-SOURCING project's vision for the renewable energy sector can be found in the State of Play report.

The remainder of this report outlines five key target areas for achieving the RE-SOURCING Vision 2050 (Renewable Energy Sector):

- Circular Economy & Decreased Resource Consumption;
- Paris Agreement & Environmental Sustainability;
- Social Sustainability & Responsible Production;
- Responsible Procurement; and
- Level-Playing Field & International Cooperation.

The discussion of each area considers targets and milestones, followed by specific recommendations for three key stakeholder groups: Policy makers, industry, and civil society. This document only includes recommendations for industry (for the other stakeholder groups see here).

[1] This means that during the preparation of the State of Play report, no reports on sustainability challenges in quartz mining were found. The authors do not wish to rule out the existence of such challenges in quartz mining operations in general.
[2] For further information on planetary boundaries, please refer to Rockström et al. 2009 and ; Steffen et al. 2015.
[3] An explanation of the strong sustainability concept is provided by Ekins et al. 2003; and Dedeurwaerdere 2014.

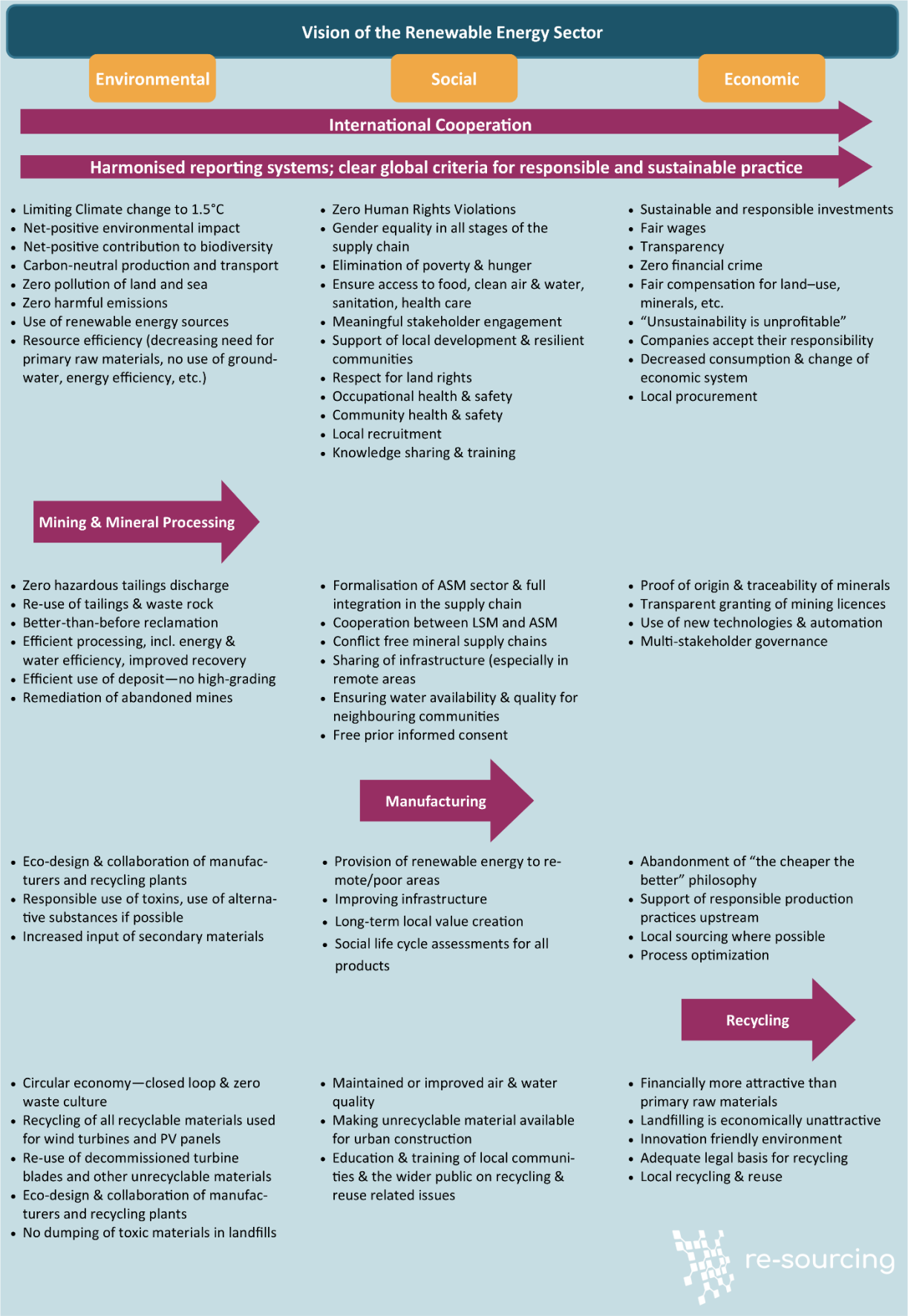

Figure 1: Vision for the renewable energy sector (based on Kügerl and Tost (2020))

2 Pathway

Scope

The RE-SOURCING project provides a roadmap, encompassing recommendations for actions. It does not propose new standards or guidelines, nor does it attempt to 'reinvent the wheel'. For many areas, appropriate standards have already been developed and the first and most important step is to successfully implement these. Implementation of these standards is part of the roadmap's recommendations - before we start thinking 'outside the box', it is important to have the foundation in place. There is ample evidence of companies that for example, are not respecting basic human rights, or governments that are failing to address the sustainability principles for protecting local communities.[4] Existing standards address these issues. However, it is also acknowledged that it is crucial to harmonise these standards, by promoting alignment and cohesion, to avoid confusion for adopters and customers in their implementation.

The State of play report is considered the baseline and the pathway provides concrete recommendations for policy makers, industry (included in this document), and civil society for moving ahead from this baseline to the RE-SOURCING project's vision for 2050. The recommended actions for policy makers focus on the EU, whereas recommendations for industry and civil society can be considered on a global level. For the other stakeholder groups, consult the full roadmap, or policy and civil society excerpts on the project's homepage. The RE-SOURCING project recognises the important role of investors, insurance, logistics providers or other business service providers. However, they are out of scope for this roadmap as they are relevant for all three sectors (Renewable Energy, Mobility, and Electric and Electronic Equipment) included in the RE-SOURCING project. Therefore, recommendations for these businesses will be provided in a separate briefing document at a later stage in the project.

As with the State of Play report, the roadmap focuses on the raw materials copper, REEs and silicon; the technologies wind and solar PV energy; and the supply chain stages mining, manufacturing, and recycling. This scope was defined as part of the consultation process for the State of Play report. There are, of course, numerous other minerals and metals that are essential for the energy transition, and many of the recommendations listed here can also be applied to other raw materials. (Information on other relevant mineral raw materials can be found in the IEA's report on The Role of Critical Minerals in the Clean Energy Transition (World Energy Outlook 2021) or the World Bank's elaborations by Hund et al. (2020)).

Assumptions and limitations

The RE-SOURCING project's renewable energy sector roadmap takes technological advancements as a given and does not specifically address this issue, apart from the continuation of these advancements and the required support by public and private sectors. Further information on the technological aspects can be found in various reports, such as SolarPower Europe and LUT University (2020) or European Climate Foundation (2010).

[4] For further information on sustainability challenges in the renewable energy sector supply chains, as well as existing standards and initiatives, please refer to the State of Play and Roadmap Concepts report for the renewable energy sector.

Conclusions from the consultation process note that it is not currently possible to set specific goals for secondary raw material input, circularity rate, etc. because the necessary research has not been undertaken fully at this time. This aspect will be highlighted in the relevant sections of the report; however, we note this as a limitation in the pathway discussion here.

Structure

The pathway differentiates between targets and milestones. **Targets** define the desired end points and are kept at a high and aggregated level. They can be medium (2030 and 2040) or long-term (2050). Targets are defined for the three pillars of sustainability: social, economic, and environmental (Figure 2), and developed during a consultation process with the project's Platform Steering Committee and Advisory Board, as well as the Roadmap Workshop with participants from all stakeholder groups of the renewable energy supply chain.

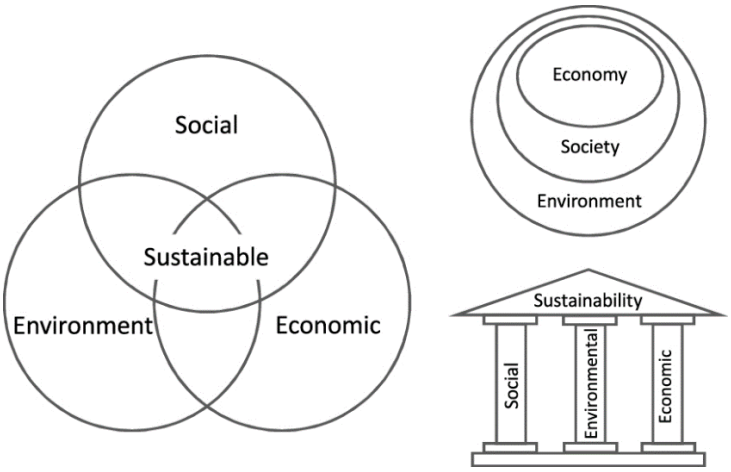

Figure 2: Depictions of the three sustainability pillars - social, environmental and economic (Purvis et al. 2019)[5]

Milestones are points along the desired trajectory from baseline to target and are supposed to help track the progress. They can be short (2025), medium (2030 and 2040) or long-term (2050). While 2025 milestones may appear as short-term considerations, they refer to the achievement of commitments already made, or set the direction for future goals. Wherever possible, milestones are specified according to desired quantity, quality and/or time (Capacity4dev Team 7/8/2016). Milestones also include already existing and agreed upon goals, such as the Sustainable Development Goals (SDGs) by the United Nations (UN) and the Paris Agreement. However, the RE-SOURCING renewable energy sector roadmap only includes targets that are relevant for this sector. Targets that are not mentioned here are therefore not considered irrelevant but go beyond the scope of this roadmap.

The classification of the milestones and actions into categories is also based on the authors' preference and should not be regarded as absolute. The timeframe for the achievement of milestones and targets shows the latest deadline, however, earlier completion is strongly encouraged.

[5] Please refer to the report The International Responsible Sourcing Agenda for more information on sustainability and responsible sourcing approaches.

The roadmap for the renewable energy sector of the RE-SOURCING project does not consider the term 'responsible sourcing' as a simple supplier - manufacturer business transaction. The term, within this project, represents the idea that responsible sourcing engages all stages of the supply chain and should be understood as a joint effort to make each stage more sustainable. Hence, the recommended actions and milestones that follow do not merely focus on procurement, but also touch upon sector specific issues.

2.1 Target 1: Circular Economy & Decreased Resource Consumption

Access to energy is a prerequisite for economic and social development and is embedded in the Sustainable Development Goals (SDGs) as Goal 7 'Ensure access to affordable, reliable, sustainable and modern energy for all' (Brand-Correa and Steinberger 2017). However, energy systems (including electricity, heat and transportation) are the largest source of manmade greenhouse gas (GHG) emissions (76% in 2018) (Climate Watch 2021; US EPA 2015). While the transition from fossil-fuel based energy generation to renewable energy sources is associated with positive effects, the negative impacts of the ever-increasing energy demand cannot be ignored. A 100% renewable energy system will certainly decrease GHG emissions and have positive environmental effects. However, continuing with business-as-usual consumption patterns can be described as a 'low-carbon destruction of planetary resources' (Swilling 2020, p. 101). New systems for both consumption and production are required to satisfy human needs and universal well-being while staying within planetary boundaries (Brand-Correa and Steinberger 2017; Raworth 2017; Swilling 2020).

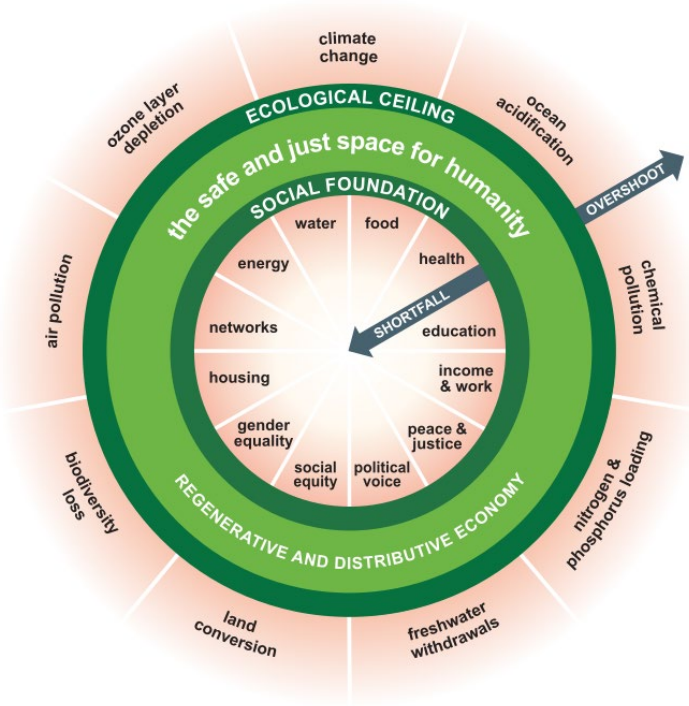

Figure 3: Doughnut Economics - combining social and planetary boundaries (DEAL 2021)

Absolute decoupling of economic growth, resource consumption and environmental impact is one of the proposed measures to tackle price shocks, resource scarcity and halt environmental degradation (UNEP 2014). Decoupling relies on decreasing resource consumption by improving resource efficiency through technological improvements, substitution of non-renewable by renewable resources, waste prevention through reuse and recycling, etc. The concept of decoupling also faces a lot of criticism and research has not agreed on whether absolute decoupling of economic growth, consumption and environmental impact is in fact possible (Parrique et al. 2019; Strand et al. 2021; Wiedmann et al. 2020). Similarly, 100% circularity of resources within an economy will not be possible, due to physical and economic constraints and in some cases not desirable due to the high negative environmental impacts of recycling processes (Moss 2019; UNEP 2013).

This roadmap follows a two-pronged approach for the renewable energy sector: on the one hand, increasing resource efficiency, recycling and reuse rates are a prerequisite for achieving the energy transition and cover the growing demand by a growing population. On the other hand, reengineering the current economic system with a focus on changing existing consumption patterns is necessary. These considerations are addressed by the Doughnut Economics Principles of Practice: 'think in systems' – aim for continuous improvements; 'be regenerative' – the 6R of sustainability (reduce, reuse, recycle, repair, rethink and refuse); 'aim to thrive rather than grow' (DEAL 2021).

Figure 4 provides an overview of the milestones for supporting the target of a circular economy and decreasing resource consumption. To achieve these milestones, a set of recommendations for actions for industry are outlined further. The authors recognise the importance of inclusive green growth for both developing and advanced countries, to achieve a sustainable standard of living. Hence, the inclusion of SDG 8 for sustainable growth in milestones. It is important to rethink consumption patterns and consider material and energy needs in the development programmes of all countries.

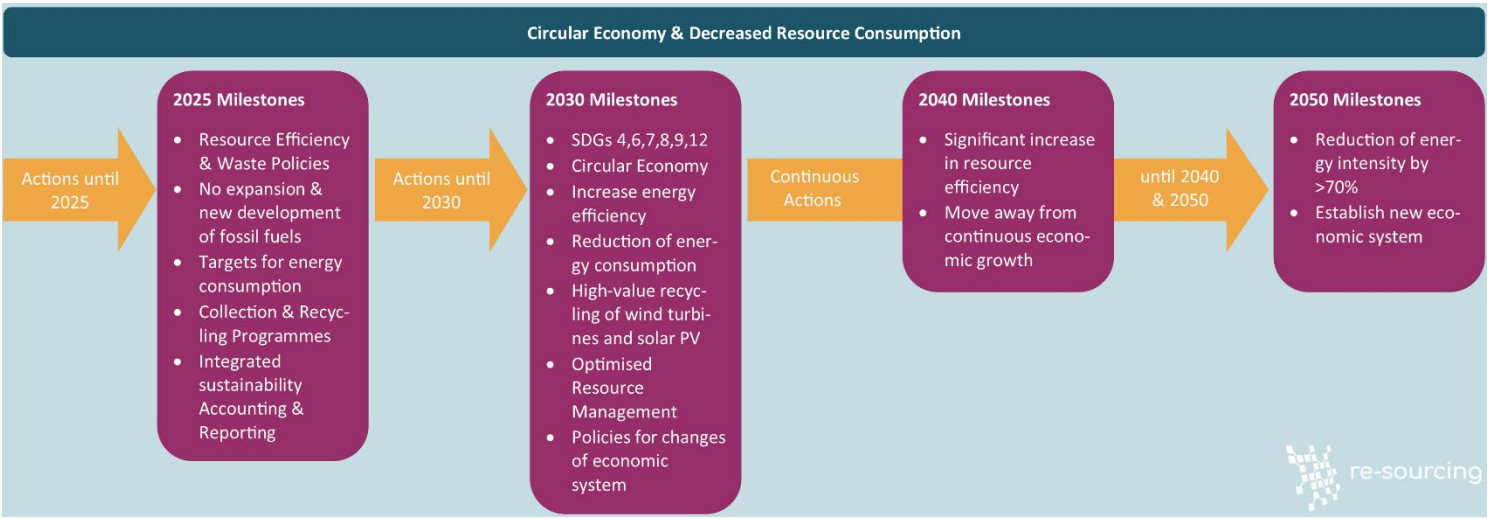

Figure 4: Milestones towards a circular economy and decreased resource consumption by 2050

Milestones 2025

- Implementation of collection and recycling programmes for solar PV modules and wind turbines
- Cooperation with research and academia
- Implement sustainability accounting and reporting
- Support the achievement of sustainable consumption patterns

Recommendations

General Considerations

Companies need to contribute to the achievement of the SDGs

Substantially reduce waste generation through prevention, reduction, recycling and reuse (SDG 12)

Adopt sustainable practices and to integrate sustainability information into reporting cycle (SDG 12).

Support the development of sustainable consumption patterns.

Explanation

Considering the necessary reduction of resource and energy intensity, as well as waste prevention, requirements from SDG 12 (ensure sustainable consumption and production patterns) need to be integrated in management and operation.

Companies can do their part in changing consumption patterns. Considering energy providers, incentives systems could be investigated. An example is provided by Marks & Spencer's encouraging their customers to reduce their carbon footprint by offering store vouchers to customers who reduced their energy consumption by 10% (Nagappan 2009).

Another interesting example from the energy sector is E.ON partnering with the Global Action Plan International. E.ON has not only introduced energy audits and green travel but is also encouraging its employees to contribute to the environmental performance of the company. Sites participating in this 3 year project reached out to 1,000 students educating them on energy consumption and efficiency, achieved energy savings of € 23,000 per year and avoided 2,000 tonnes of CO_2 (GAP 2020).

Recommendations

Mining

Implement strategies to improve resource efficiency.

Strengthen cooperation with research and academia.

Continuous fleet modernization (incl. automation and digitalisation) for electrification and decreased energy intensity.

Explanation

Mining companies need to implement policies for improving efficiency and resource use in their operations, e.g., based on IFC Environmental and Social Performance Standards, these policies should include: (i) Implementation of management plan for sustainable use of the entire deposit. (ii) Optimization of existing mining plan considering energy efficiency (incl. schedule, drilling and blasting, layout, etc.); and (iii) Energy optimization and increase of renewable energy use in processing.

Additionally, mining companies should strengthen cooperation with research and academia to foster the development of new mining and processing technologies to increase raw material recovery and sustainable use of deposit. This can also aid the management of tailings and waste heaps. Research projects with a focus on decreasing environmental impact and possible recovery with future technologies should be supported by mining companies.

Recommendations

Manufacturing

Optimize production processes:[6]

- Decrease material losses during production
- Improve energy efficiency.

Explore new business models with the goal of increasing resource efficiency.

Strengthen cooperation with research and academia, as well as other sectors with the focus on

- new business models
- resource efficient production processes
- new technologies with increased lifetime, eco-design, etc.

Implement a global collection and recycling program for all new and already deployed solar PV modules and wind turbines (either company owned or in cooperation with recycling providers).

Eco-Design considerations for all new products.

Incorporate resource efficiency considerations in product development processes.

Explanation

Silicon wafer production for solar PV in particular, needs to be optimised to decrease kerf losses; replace slurry-based wafering by other cutting technology (e.g. Diamond Wire Sawing reducing silicon consumption by 15% (Arora et al. 2018)) suitable recycling methods still need to be developed on a commercial scale and implemented. The EU's SIKELOR project developed a prototype for such a recycling process possible providing a model for industrial application (SIKELOR 2021). Li et al. (2021) provide a further overview of existing methods reviewing benefits and drawbacks.

In solar PV recycling another major challenge is the large variation of cell and module structure between different types and manufacturers creating problems in the extraction of components. Standardisation of modules would significantly increase recyclability (Tao et al. 2020).

[6] No specific targets for the roadmap's raw materials and technologies can be set at the time of the report. Further R&D to improve efficiency of production processes is required and needs to be supported by policy makers.

Further research on the reduction of REE use in permanent magnets for wind turbines needs to be conducted. The EU funded NEOHIRE project investigated different types of permanent magnets to decrease the REE demand of the EU. The new concept for bonded NdFeB magnets allows the reduction of REE use by 30% and at the same time the project also developed recycling methods for this new type of magnet. Environmental impacts of both manufacturing and recycling could be reduced, compared to the sintered magnets that are currently in use (NEOHIRE 2020). Industry needs to actively support such projects and be prepared to adopt new insights provided by them.

By incorporating resource efficiency considerations from the very beginning of product development, significant efficiency improvements can be achieved. A possible method for the assessment and subsequent reduction of resource use over the lifetime of a product is a combination of MIPS (Material Input Per Service) concept with and general resource efficiency parameters. Other reductions potentials that need to be explored further are the use of new lightweight materials and high- and ultrahigh-strength steel (Rohn et al. 2014).

When developing new products, eco-design considerations need to be included from the very beginning of the process. Cooperate with recycling facilities to improve future recovery of raw materials, also revise existing products according to this aspect.

Good Practice Recommendations for implementing a life cycle-based business model[7]

Consider the life cycle assessment approach to determine the reduction in primary material use, replacing it with secondary materials. Incorporate secondary materials use as part of the product design process and the manufacturing process.

To ensure secure access to secondary materials, consider setting up recycling facilities at manufacturing sites at a commercial scale that allows requisite materials to be recycled. Consider further improving the products carbon footprint by incorporating renewable energy and water efficiency within the recycling process.

Offer customers and clients fully costed recycling options, that are based on realistic, clear commitments and are backed up by funds that will continue to be available even if the firm is no longer in operation.

To support the case for high value recycling, firms should calculate the cost and benefits associated with decommissioning of solar panels. These calculations are more likely to indicate an economic as well environmental benefit for the firm.

[7] For more information on the implementation of a life cycle assessment business model and a good practice example, please refer to Farooki et al. 2021 '[Meeting the Milestones in the Responsible Sourcing Roadmap Good Practice Guidelines for the Renewable Energy Sector]'.

Recycling

Recommendations

Strengthen cooperation with research and academia, as well as other sectors with the focus on

high-value recycling technologies

new reuse opportunities.

Improve collection and recycling of copper, REEs and silicon.[8]

Implement ISO/TC 298 Rare Earth Standard.

Explanation

Given the long lifetime of wind turbines and solar PV modules of approximately 20-30 years, waste volumes are still rather low. Infrastructure and technologies for increased waste streams need to be implemented now to be prepared for future higher volumes. Especially considering planned capacity increases of renewable energy technologies, recovering materials from End-of-life (EoL) recycling needs to be seen as a strategic source of raw materials. While copper already shows relatively high EoL collection and recycling rates (65% and 45% respectively in 2011 (Glöser et al. 2013)), REEs and silicon still lag behind significantly (both EoL-RR <1%) (Graedel et al. 2011; EL Latnunussa et al. 2020). Copper can be recycled without any loss of performance or qualities compared to primary copper (Copper Alliance 2014). The only limitations are therefore physical limits of recycling processes (currently overall recycling efficiency rates of 60% are achieved (Glöser et al. 2013)) and economic limits (lifetime of products).

Apart from resource efficiency considerations, recycling of REEs is also crucial considering the EU's import reliance on China for REEs and permanent magnets. Given the likely increase of permanent magnet demand for offshore wind turbines, ambitious recycling targets need to be implemented. In particular, the large permanent magnets from wind turbines can be recycled manually and the REEs recovered, whereas automated recycling processes are currently not applicable due to high REE losses of up to 90%. However, even with efficient recycling processes, the recovered REE amount will not be able to replace primary raw materials until 2030 (Figure 5) (Yang et al. 2017).

Direct magnet-to-magnet recycling is investigated by various projects, e.g. the H2020 funded project SUSMAGPRO – Sustainable Recovery, Reprocessing and Reuse of Rare Earth Magnets in a European Circular Economy (Susmagpro 2019). Generally, permanent magnets from EoL wind turbines can be reused in their current shape and form (limited by availability due to lifespan of turbines) (Karavida and Nõmmik 2015).

The ISO Technical Committee 298 under the lead of the Secretariat China is currently developing standards for 'rare earth mining, concentration, extraction, separation and conversion to useful rare earth compounds/materials (including oxides, salts, metals, master alloys, etc.) which are key inputs to manufacturing and further production process in a safe and environmentally sustainable manner' (ISO/TC 298 - SAC 2021a). Six standards have already been published by this committee, including ISO 22450:2020, ISO/TS 22451:2020 and ISO 22453:2021 on the recycling of REEs, including requirements on providing and exchanging information on and methods for measuring REEs in industrial waste and end-of-life products. Seven further standards are under development (on mining, separation and processing, traceability in supply chains, NdFeB magnet scraps, etc.) (ISO/TC 298 - SAC 2021b)..

[8] At the time of the roadmap development, data was insufficient to set specific targets. Further R&D is required by all involved parties to foster collection and recycling and set ambitious targets.

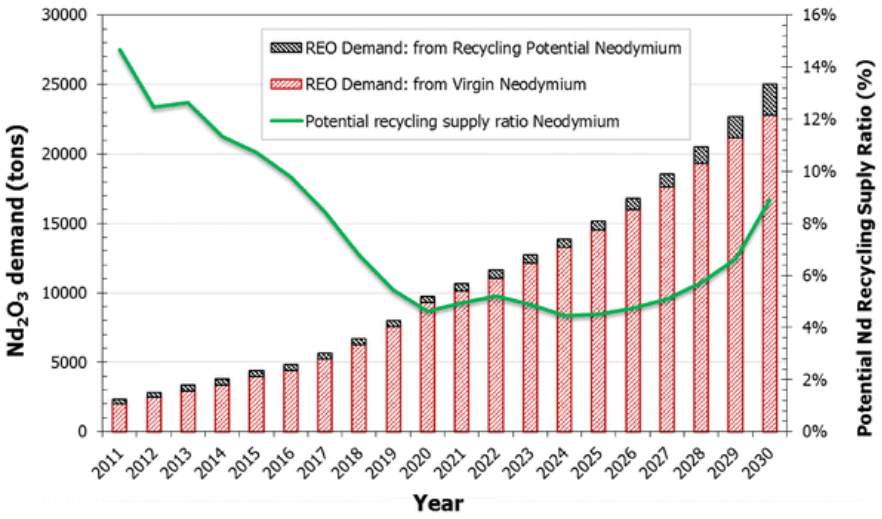

Figure 5: Predicted recycling potential of neodymium from EoL permanent magnets for (computer, wind turbine, and automotive industries) (Yang et al. 2017)

According to Bobba et al. (2020) silicon metal is currently not recovered from post-consumer waste, but recycling of silicon metal from EoL solar PV applications would be possible. Potential for reuse is mainly within the solar PV industry itself.

The WEEE Directive of the EU sets targets for solar PV material recovery and reuse (85% and 80% respectively) from 2019 onwards. The CIRCUSOL project (funded via Horizon 2020, 2018-2022) is assessing possibilities for the formalisation of recycling, repair/refurbish and re-use segments of the solar PV value chains. The project is also aiming at providing regulatory frameworks for these segments, as well as technical standards.

Their preliminary results show that approximately 50% of solar PV modules can be diverted from the recycling path, as repairing and refurbishing is possible and should be preferred (Tsanakas et al. 2020; CIRCUSOL 2021).

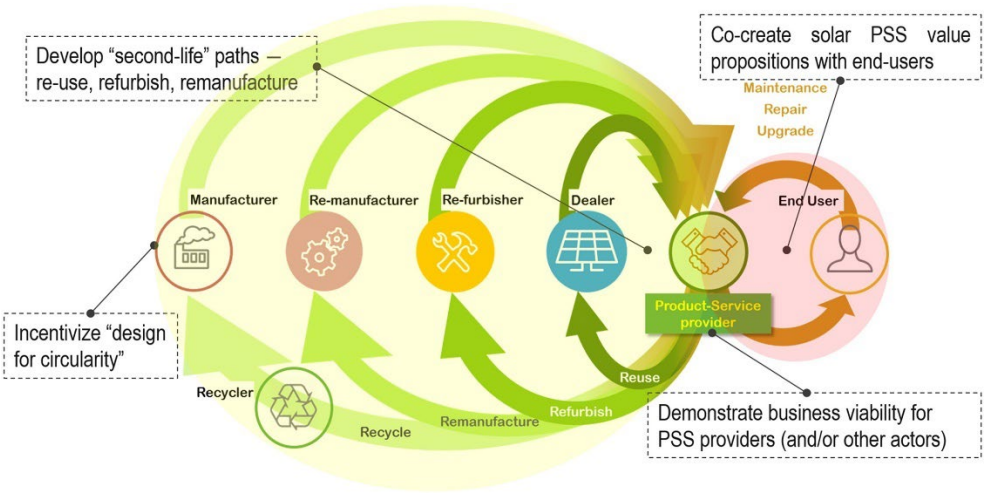

Figure 6: Circular business model for solar PV modules as envisaged by the CIRCUSOL project (Tsanakas et al. 2020)

Milestones 2030

- Support the achievement of the SDGs
  - 7 - Ensure access to affordable, reliable, sustainable and modern energy for all
  - 8 - Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
  - 9 - Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
  - 12 - Ensure sustainable consumption and production patterns
- Implementation of Circular Business Models
- Reduction of energy intensity by 30% (IRENA 2021a)
- Implement high-value recycling processes for all new and deployed solar PV modules and wind turbines with at least 95% recovery rate
- Implement optimized resource management

Milestones 2040

- Significantly increased resource efficiency

Milestones 2050

- Reduction of energy intensity by >70% (IEA 2021)
- Establish new economic system

Continuous Actions 2030-2050

General Considerations

Recommendations

Double the rate of improvement in energy efficiency (SDG 7).

Improve resource efficiency in production processes in accordance with the 10-year framework of programs on sustainable production (SDG 8).

Upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes (SDG 9).

Achieve the sustainable management and efficient use of natural resources (SDG 12).

Manufacturing

Recommendations

Collaboration of manufacturers and recyclers, research, and academia to substitute unrecyclable or environmentally problematic materials (e.g., Zebra project for wind turbines).

Implement innovative business models based on usage rather than ownership (e.g. sell light as a service rather than lamps, see Case Study Philips and Turntoo (Ellen MacArthur Foundation 2017) – Selling light as a service and Philips Circular Lighting Modelling (Philips 2017).

Recycling

Recommendations

Continue the setting up of efficient, high-value recycling processes in cooperation with manufacturers of solar PV modules and wind turbines.

Support the research into materials' substitution for better recyclability.

Explanation

Available technologies already allow for high recovery rates, both for solar PV modules and wind turbines. For c-Si solar PV modules PV Cycle achieved a recycling ratio of 96%, First Solar for their CdTe modules 95%. High-value recycling processes such as these need to become standardised by 2030. For wind turbines the recovery rate from the blades and permanent magnets needs to be increased, or suitable reuse business models implemented.

2.2 Target 2: Paris Agreement & Environmental Sustainability

The roadmap for the renewable energy sector of the RE-SOURCING project aims to assist stakeholders achieving the Paris Agreement's +1.5°C target. For this to happen, the speed required in which necessary transitions are conducted is still under debate. EU policy targets aim at net zero emissions by 2050 including a power sector 'that is based largely on renewable sources' (this is stated in the EU green deal, a revision of the targets is currently under way) (European Commission 2019). This is also reflected in the IEA Net Zero Emissions by 2050 report, which incorporates 88% renewables in electricity generation by 2050. However, this report also acknowledges a 50% probability that this path will not help achieve the 1.5°C target without overshoot (IEA 2021). In their report the IEA (2021) addresses the increased importance of electricity for the future. While the electricity demand will increase due to electrification advances, it is even more important that this sector also achieves the net zero target as soon as possible. According to the IEA, this should be achieved by 2035 in advanced economies and 2040 globally. Other studies highlight the importance of drastically increasing renewable energy supply to 100% renewable energy by 2050 (Teske et al. 2015; Jacobson et al. 2017; European Climate Foundation 2010) or 2040 respectively (SolarPower Europe and LUT University 2020). This is also reflected by many companies and countries some of which set even more ambitious targets (see RE100 (2021) and REN21 (2021)).

Based on the consultation process, this roadmap recommends the achievement of 100% renewable energy and net zero emissions by 2040. The RE-SOURCING consortium believe the EU should take a clear lead and push for a global shift to renewable energy. However, as already discussed in the previous chapter Target 1: Circular Economy & Decreased Resource Consumption this has to be accompanied by energy efficiency improvements and demand reduction (of overall energy demand, not electricity). An important aspect highlighted in many recently published reports, such as IEA (2021) or IRENA (2021b).

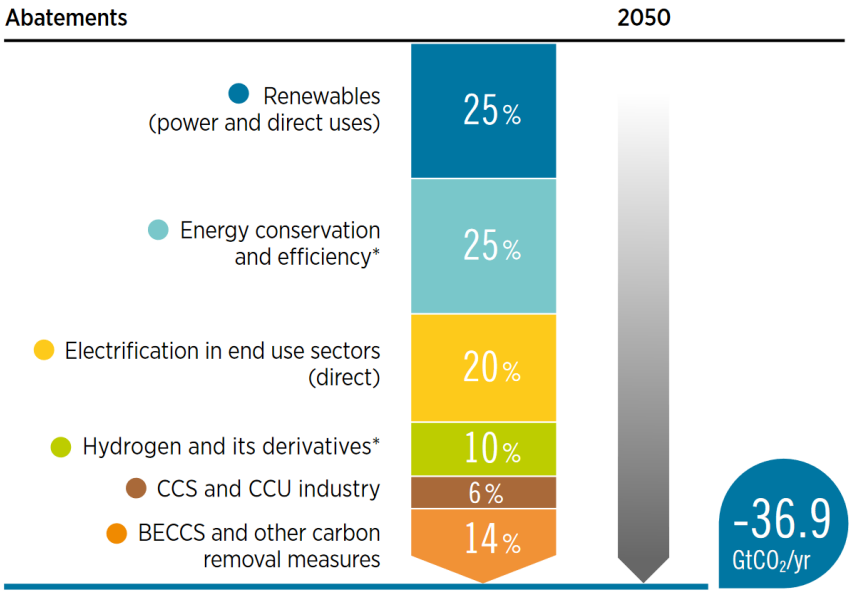

Figure 7: Carbon emissions abatements under IRENA's 1.5°C scenario by 2050 (IRENA 2021b)

The recommendations in this chapter focus on the expansion of the renewable energy system. This is equivalent to phasing out thermal coal. The RE-SOURCING project recognises the importance of coal for certain industries (e.g., the production of silicon metal for solar PV, steel manufacturing or the chemical industry). Nevertheless, R&D into the substitution of coal in these industries is a crucial aspect for decarbonising the economy and reaching the target of net zero emissions (according to the ECF (2021) a 100% renewable energy system is not enough for heavy industries to be compatible with the Paris Agreement). While the authors want to highlight the importance of the phasing out of coal as a feedstock, it is out of scope to go into more detail for this report.

Apart from climate related considerations, this chapter also addresses issues such as biodiversity loss and land-use related to renewable energy supply. In their Guidelines for project developers for mitigating biodiversity impacts from wind and solar energy, the IUCN highlights the importance of biodiversity considerations in project development. Biodiversity must be taken into account from the very beginning of the planning process to successfully identify and manage risks. The choice of location plays a major role in this regard. With the correct placement, not only can risks to biodiversity be avoided, but also regulations and expectations of investors and consumers can be met more easily (Bennun et al. 2021).

Considerations on deep sea mining and legacy issues of abandoned mines will be incorporated in a separate briefing document at a later state of the RE-SOURCING project, as these issues are relevant for all three sectors included in the project.

Figure 8: Milestones to reach the Paris Agreement and Environmental Sustainability by 2040

The role of Industry Associations

Industry associations have the task of mediating between their members in industry and politics. It is important that laws and regulations are in fact implementable. The aim is not to reduce important climate or environmental targets to secure maximum profit for the companies, but to realistically reflect the feasibility in laws. For example, in the area of recycling - regulations on the use of secondary raw materials are not effective if these raw materials are and will not become available due to physical or economic limitations.

It is also important that industry associations promote cooperation among their members. Many of the environmental and social standards will be difficult to implement, especially for small and medium enterprises (SMEs), as they require high investments. This is where these associations can intervene and encourage joint R&D, group certification to a certain standard, the purchase of new equipment that can possibly be shared between companies, etc.

Milestones 2025

- Full integration of environmental and climate impacts in company strategy
- Integrate product life cycle approach in business strategy

General Considerations

Recommendations

Implement Environmental and Climate Reporting

Implement GHG accounting and reporting system for entire value chain and product life cycle (e.g., GHG Protocol).

Support local development by sharing infrastructure.

Achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment (SDG 12).

Prevent and significantly reduce marine pollution of all kinds, particularly from land-based activities, including marine debris and nutrient pollution (SDG 14).

Assess companies' impacts on ecosystems, develop mitigation plan accordingly (e.g., utilise WRI The Corporate Ecosystem Services Review or WBCSD Guide to Corporate Ecosystem Valuation)

Implement ecosystem and biodiversity accounting and management tool (WBCSD Eco4Biz provides an overview of existing tools, e.g., Ecometrica Biodiversity Metric).

Integrate ecosystem services in impact assessment (e.g., using WIR Step-by-Step Guidance).

Use data of local data providers or NGOs to assess companies impact on forests, e.g., Global Forest Watch.

Protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes (SDG 6).

Support and strengthen the participation of local communities in improving water and sanitation management (SDG 6).

Improve water quality by reducing pollution, eliminating dumping, and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally (SDG 6).

Evaluate companies' impacts related to water use and discharge (e.g., using GEMI Local Water Tool, or Veolia True Cost of Water Toolkit, or Water footprint network)

Implement integrated water resources management at all levels, including through transboundary cooperation as appropriate (SDG 6)

Implement respective reporting (e.g., GRI 303: Water and Effluent Standard; for mining and metals sector GRI G4 Standard).

Advance best practice in water resource management (e.g., in Cooperation with Aqueduct Alliance).

Explanation

One key requirement of the industry is to provide complete and reliable data on their environmental and climate related performance. Transparency is crucial for building trust with the public and enable a fast and sustainable transition to renewable energy. A framework for reporting on mainly climate related issues is provided by the Task Force on Climate-related Financial Disclosures. It provides guidance on 'disclosing clear, comparable and consistent information about the risks and opportunities presented by climate change' (Irish Funds 2020, p. 2). The goal is to achieve a re-allocation of capital to support the transition to a sustainable and low-carbon economy. The Taskforce on Nature-related Financial Disclosures is in the process of preparing a framework on reporting of all environment-related issues. Financial flows should shift from supporting nature-negative outcomes to nature-positive outcomes (TNFD 2021). The GRI provides a reporting framework with a broader ESG-related focus, concentrating on a business' contribution towards sustainable development in general (Irish Funds 2020; The Value Reporting Foundation 2021a). Recently, the IIRC and SASB decided to join forces and created the Value Reporting Foundation. Their reporting standard aims to complement the GRI framework and increase coherence with other initiatives such as TFCD. The standard joins three existing frameworks together – the Integrated Thinking Principles (guidance on decision-making and planning to create value), the Integrated Reporting Framework, and the SASB Standards (guidance on industry-specific topics and metrics relevant for disclosure to inform investors) (The Value Reporting Foundation 2021a, 2021b).

To improve both environmental and social impact of industry, companies should actively engage with communities in infrastructure developments. For example, the transition to renewable energy sources by a project can be beneficial for neighbouring communities as well, provided the company is willing to share their energy system (also in line with SDG 7 - expand infrastructure and upgrade technology to sustainable energy systems). Apart from environmental and health benefits, this can help build trust in and acceptance of the company. This also applies to other infrastructure developments - especially in remote regions, it is desirable that water and sanitation infrastructure is also shared. Companies need to take this into account from the beginning of future projects, renovations, and expansions, and involve communities in planning and implementation.

Recommendations

Mining

Develop a holistic sustainability policy, incorporating environmental and social impacts (see Good Practice Guidance below).

Implement environmental mitigation measures according to a comprehensive mining standard (see previous chapter).

Develop a strategy for automation, digitalisation, and update of equipment to save energy and decrease environmental impact.

Good Practice Recommendations for creating a holistic sustainability policy[9]

Through internal and external discussions, articulate a vision for the company that is clear and meaningful and does not rely on vague or overly ambitious sustainability terminology.

In considering areas of strategic focus to support a company vision, consider pillars that are relevant across all operating units and company processes. At this stage avoid a silo approach by focusing on single business process. Ensure that the strategy pillars are not too opaque or vague and refer to a concrete set of factors relevant to the company.

The definition of objectives is an important task – these need to be clearly outlined and balance between being too open and too narrow. An objective should outline the outcome expected and not the means/process to achieving it – this is done at a later stage.

At this stage, objectives can also benefit from consultations with external experts, business partners (including communities) and be informed by standards and guidelines from industry initiatives. These objectives should be contextualised within the company's structure and operating framework.

Taking a bottom-up approach for target and action setting is recommended, incorporating individual nodes of business operations – these targets/actions do not need to be uniform across the business, but reflect the context of the area being targeted.

It is important that decision making, and responsibility for responsible souring, is taken by the highest managerial levels i.e., the Board of Directors. However, 'buy-in' from middle and junior level staff is essential and internal company communications needs to focus on brining all employees and sub-contractors on to the same page. Assigning individual and collective responsibilities is not sufficient, responsibility for monitoring performance within the firm also needs to be assigned.

With the emerging concerns around green washing by companies, it is considered good practice for extractive companies to report their actions according to an internationally accepted reporting template (GRI is one example). In addition, the information being reported carries more weight and relevance where it has been assured/audited by an independent third-party.

[9] For more information on the implementation of a life cycle assessment business model and a good practice example, please refer to Farooki et al. 2021 'Meeting the Milestones in the Responsible Sourcing Roadmap Good Practice Guidelines for the Renewable Energy Sector'.

Milestones 2030

- Support the achievement of SDGs
  - 6 - Ensure availability and sustainable management of water and sanitation for all
  - 7 - Ensure access to affordable, reliable, sustainable and modern energy for all
  - 12 - Ensure sustainable consumption and production practices
  - 14 - Conserve and sustainably use the oceans, seas and marine resources for sustainable development
  - 15 - Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
- Reduction of GHG emissions by >60%
- Net positive contribution to biodiversity & environment [10]
- Increase electrification of operations
- Full integration of ecosystem impacts in companies' impact assessment & performance management of companies
- Optimisation of production processes & use of best available technologies

Milestones 2040

- 100% renewable energy
- Electrification of production
- Zero harmful air emissions
- Zero pollution of land, air & sea
- Net zero GHG emissions

[10] See Net Positive Project by the Forum of the Future, WWF, and the Climate Group: https://www.forumforthefuture.org/net-positive

Continuous Actions until 2030 & 2040

General Considerations

Recommendations

Decrease GHG emissions by >60%

Increase the electrification of all sectors

Increase the use of renewable energy sources for all operations (SDG 7).

Support the achievement of the SDGs

Support R&D in the substitution of environmentally harmful substances, substitute wherever possible, responsible use of toxins

Expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling, and reuse technologies (SDG 6).

Substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity (SDG 6).

Apply regular audits/assessments to evaluate sustainable water management (e.g., Alliance for Water Stewardship Standard).

Explanation

To decrease the industries' CO2-emissions, it is important to advance electrification of production processes. To drive the electrification, further developments are required for electric technologies to become economically feasible. Additionally adjustments of energy prices are crucial (Bühler et al. 2019). Gruber et al. (2015) investigated the power-to-heat potential of the German industry and found a significant electrification potential; thus, enabling a potential reduction of energy consumption by 6-13%. However, they also highlight the challenges hindering electrification. The two major issues are lower gas prices compared to electricity and the requirement for reconstruction of production plants to accommodate process changes. The latter needs to be considered when setting up new production sites and older plants will need to be reconstructed gradually. For the raw materials and technologies considered in this roadmap, further research is required to first, evaluate the electrification potential and second, develop new technologies and processes.

Mining

Recommendations

Avoid the use of groundwater and implement desalination plants in arid regions.

Use of best available technologies to avoid environmental pollution from tailings

Avoidance of tailings and waste rock by efficient reuse

Zero hazardous tailings discharge.

Increase the electrification and automation of equipment.

Explanation

Copper mining and processing is known for its intense water usage. Especially in arid regions, such as the Chilean copper mining regions this can cause significant problems and conflicts with neighbouring communities. Both ASM and LSM mining operations for Copper in Africa (Copperbelt region in Zambia and DR Congo) and REEs in China, cause significant water pollution through effluent discharge. To avoid such issues mining companies are already implementing desalination plants, water treatment and recycling systems for their operations (see e.g. BHP implemented a desalination plant for its mines 'Minera Escondida' (Copper Alliance 2018b) or Anglo American's water conservation programme (Copper Alliance 2018a)). By 2030 these developments need to be implemented and in operation on a much wider scale. Additionally, it is important that companies share this infrastructure with the local communities to decrease water scarcity and support livelihoods based on farming, etc.

Tailings dams are another potential source of pollution and need to be managed correctly. While standards, such as the Global Tailings Review provide important guidance on how to safely manage 'tailings facilities, towards the goal of zero harm' (Global Tailings Review 2021), it is also crucial to investigate reuse possibilities in parallel.

Recommendations

Manufacturing

Significantly increase electrification of manufacturing processes and increase share of renewable energy use.

Automation and use of best available technologies.

Explanation

Various manufacturers of renewable energy technologies have already announced changes to their energy systems to become 100% renewable by 2030 or even sooner. E.g. JinkoSolar by 2025 (JinkoSolar Holding Co., Ltd. 8/6/2020), First Solar by 2028 (First Solar, Inc 8/6/2020); Vestas is relying on 100% renewable energy since 2013 (RE100 2021). Industry is already advanced in this regard, and it is important that these goals are pursued vigorously, and more companies take similar initiatives.

Recommendations

Recycling

Recycling of all recyclable materials – significantly increase recycling rates and optimise processes.

Significantly decrease energy and water use in recycling processes

Implement wastewater recycling facilities.

Avoid land filling of unrecyclable materials

Cooperation with other sectors to enable reuse, e.g., wind turbine blades can be reused in urban construction

No dumping of toxic materials.

2.3 Target 3: Social Sustainability & Responsible Production

The energy transition is not only meant to mitigate the effects of climate change and address environmental issues, but also socioeconomic concerns. To achieve the often-quoted 'just transition' it is crucial to ensure the just distribution of the benefits and burdens associated with this transition. The concept of a just transition is inter-related with energy justice and both are based on the principles of distributional, procedural and recognition justice (García-García et al. 2020; Carley and Konisky 2020). For the target of social sustainability and responsible production, the roadmap aims at achieving two of the mentioned justice streams – distributional and procedural justice, recognition justice is out of the scope for this roadmap. Additionally, corrective or restorative justice is included as part of the energy justice concept. As cited in Mohai (2018, p. 23) Professor Kuehn, the former Director of the Environmental Law Clinic at Tulane University, defines distributive justice as '*the right to equal treatment, that is, to the same distribution of goods and opportunities as anyone else has or is given*' and procedural justice as *'[…] the right to treatment as an equal. That is the right, not to an equal distribution of some good or opportunity, but to equal concern and respect in the political decisions about how these goods and opportunities are to be distributed […].'* Corrective justice refers to the way in which law breaking and damages inflicted to communities or individuals are addressed and restored (Mohai 2018).

In line with these three justice movements, the main goals of this roadmap are to achieve a fair distribution of benefits and burdens across countries and populations (access to clean and affordable energy, assessment and mitigation of social impacts of production processes, support of local development, etc.); to include affected communities in decision-making processes and that 'energy procedures are fair, equitable and inclusive of all who choose to participate' (Carley and Konisky 2020, p. 570); and avoidance and correction of injustices through intervention by governments or other institutions (transparency and accountability).

Figure 9: Milestones to reach Social Sustainability & Responsible Production by 2030

Milestones 2025

- Gender & Racial equality
- Procedural & Distributive Justice
- Integration of Social & Environmental Life Cycle Assessment and Life Cycle Planning

General Considerations

Recommendations

Develop and implement a human rights management system in your organisation with continual improvement of the system (SolarPower Europe 2021)

Integrate UN Guiding Principles on Business and Human Rights in company policies

Adhere to ILO Labour Conventions

Ensure fair wages and provide insurance for employees

Implement slavery grievance mechanisms (see e.g., WBCSD and UN Global Compact Implementing effective modern slavery grievance mechanisms - A guidance note for business)

Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment (SDG 8) and including access to safe water, sanitation, and hygiene (see WBCSD WASH Pledge).

Integrate children's rights into impact assessments and develop a mitigation plan accordingly (see UNICEF guidance).

Strengthen efforts to protect and safeguard the world's cultural and natural heritage (SDG 11)

e.g., IFC Performance Standard 8 provides guidance on Cultural Heritage.

Ensure procedural, distributive, and corrective justice in all operations

Involving affected communities in decision making processes

Provide all relevant information in an understandable manner

Allow for free prior informed consent

Introduce effective grievance mechanisms (for modern slavery, employees, and local communities) suitable for local conditions.

Continuous education and training of local communities and support local recruitment

Substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship (SDG 4).

Assess gender equality in your company, e.g., using GEP Assessment tool based on Gender Equality Principles, to identify areas that need improvement.

Develop strategies to support local development

Assess companies' impact on sustainable development (e.g., Oxfam and UN Global Compact Poverty Footprint to understand business' impacts, Business and Human Rights Resource Centre Human Rights Compliance Assessment, UN Global Compact Guide to Human Rights Impact Assessment and Management. WBCSD Measuring socio-economic impact) and develop mitigation plans accordingly.

Explanation

'Companies have a moral and often legal imperative to act' (SolarPower Europe 2021, p. 44) to ensure no human rights violations take place in their own operations or their supply chains. Unethical practices can have a serious impact on businesses as consumers are largely unwilling to accept such practices. Especially in the energy transition, it is important that this transition is conducted in a fair manner, as irresponsible practices are likely to delay the transition. The implementation of a human rights management system is crucial to address human rights appropriately within an organisation. The support of external experts (including NGOs, labour unions, etc.) can help establish a suitable system. Human rights considerations should be included in contracts with suppliers and improve the risk assessment in the supply chains (see chapter 2.4.2). Auditing of human rights management systems should be implemented, with regular reassessments and continuous improvements. An example for a certification in this regard is SA8000 Social Accountability Certification, which has been developed based on a multi-stakeholder process. General support for the transition is possible when trust is established, and this can only be ensured through transparency (see chapter 2.4) (SolarPower Europe 2021).

The introduction of effective grievance mechanisms is an important aspect for all considered sectors and supply chain stages. For example, the UN Global Compact provides guidance on designing an effective grievance mechanism against modern slavery (Sjerp et al. 2021); the IFC provides guidance for addressing grievances from project-affected communities (IFC 2009); and the EBRD provides guidance for employee and worker grievance mechanisms (EBRD 2017). All three guidance documents highlight the importance of transparency, impartiality, confidentiality, and accessibility and include examples of ineffective grievance mechanisms. There are also sector specific guidelines provided, for example for extractive operations.

Apart from grievance mechanisms, stakeholder engagement in general needs to be strengthened. The two main frameworks providing guidance on meaningful stakeholder engagement are the UN Guiding Principles on Human Rights (United Nations Human Rights 2011) and the OECD Guidelines for Multinational Enterprises (additionally the OECD Due Diligence Guidance for Meaningful Stakeholder Engagement in the Extractives Sector) (OECD 2020a, 2020b). In practice, stakeholder engagement is dominated by business-led top-down approaches. However, understanding the local context is crucial in effectively addressing communities' concerns, reducing rights abuses and conflicts. Some current approaches to impact assessments can lead to oversight of issues, and this needs to be addressed. Community based bottom-up impact assessments and stakeholder engagement processes can support constructive engagement and community participation in decision-making and implementation processes. Guidance on this approach is provided by 'Getting it Right' (Rights & Democracy) a community based impact assessment tool (Maher and Buhmann 2019).

The International Association for Public Participation defines three pillars for effective public engagement in decision-making processes. First, they require the definition of the public's role in the process, from 'information only' to 'empower' (Figure 10). Second, they identify seven core values for any participation process, including the notion that 'those who are affected by a decision have a right to be involved in the decision-making process' and their contribution will have an impact on the decision. Finally, they developed a Code of Ethics to guide actions of institutions establishing a public participation process (IAP2 2021). This framework provides a suitable guidance on effective participation both for policy makers and industry.

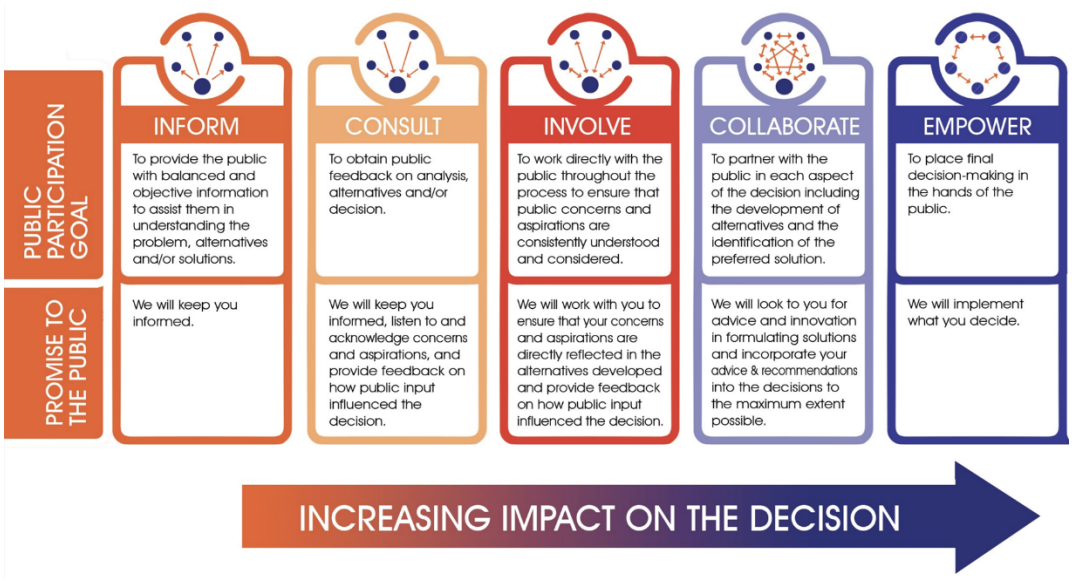

Figure 10: Levels and impacts of public participation (IAP2 Canada 2018)

Companies need to support the region they are operating in and capacity building within local communities has to be an important aspect. The focus should be on long-lasting developments, that support the local community after a company has closed its project. A simple objective is to share a company's infrastructure with the local communities, especially in remote areas (e.g., electricity and water supply, roads, internet, etc.). In remote areas with a lack of health care and educational institutions, support the development of this infrastructure. By actioning local procurement, supporting local businesses and organisations, economic value can be shared, and jobs created

Mining

Recommendations

Mine reclamation to include environmental and social considerations to allow optimal use after the operation, decrease risks and create opportunities for local communities

Include planning for mine closure from the very beginning of project development and set aside funds accordingly, all operational activities must consider continuous and future reclamation.

Facilitate multi-stakeholder governance mechanisms.

Meaningful stakeholder engagement.

Transparent reporting on all environmental and social aspects has to be included in management practices.

Explanation

As mentioned previously, guidance on the social responsibilities of mining companies is provided through various standards, with IRMA being one of the most comprehensive standards, based on a multi-stakeholder initiative.

Guidance on what is expected of mining operations to be made publicly available is also provided by the biannual report of the Responsible Mining Foundation (RMF).

Planning for mine closure both from an environmental and social point of view needs to be included from the very beginning of a mining project. An important aspect is to ensure long-lasting and self-sustaining socio-economic development of the region.

When supporting the local development, mining companies should also consider community resilience in the regions they operate in. Community resilience can be understood as 'having the capacity to respond to negative events' (ICMM 2021a). This includes helping the community prepare for mine closure or other disruptions of operations that may impact the community. ICMM's initiative 'Skills for our Common Future' supports their members to strengthen resilience of communities and host-regions for future challenges, such as economic transitions, climate change and other disruptive events (ICMM 2021b).

Figure 11: ICMM's skills initiative for mining companies to support community resilience (ICMM 2021b)

The World Economic Forum also developed a tool to enhance the understanding of value that can be created by mining and what is necessary to achieve responsible mineral development. (see Mineral Value Management by the Responsible Mineral Development Initiative (Banks et al. 2016)).

Manufacturing & Recycling

Recommendations

Include social life-cycle assessment and life cycle planning in operations and product development.

Develop strategies to support long-term and sustainable local development.

Explanation

Social life cycle assessments are an important addition to LCAs (commonly LCA refers to environmental life cycle assessments) and need to be integrated in a company's product development processes. As the environmental counterpart, they evaluate impacts at each stage of the value chain throughout the life cycle of a product, focussing on social and socio-economic impacts. The S-LCA covers both positive and negative impacts on affected stakeholder groups.

For instance, freedom of association, child labour, fair salary, working hours, equal opportunities, etc. are evaluated for the stakeholder group 'workers'; health and safety, transparency, or feedback mechanisms for consumers (Mancini et al. 2018). The ISO 14040 and 14044 standards focus on environmental LCAs as well. UNEP and the Life Cycle Initiative have also developed guidance based on ISO for social assessments (Andrews et al. 2009).

Similar to mining companies, manufacturing and recycling enterprises also need to consider the development of neighbouring communities and regions they operate in. This applies particularly for operations in developing countries, but equally more can be done in Europe, as companies like the solar panel manufacturer Q Cells and the wind turbine producer Siemens Gamesa demonstrate. Q cells together with other companies and the regional government in Sachsen-Anhalt, Germany, provide solar power systems to schools, as well as information and training materials for pupils. They also support the German initiative Solar Energy Foundation by providing funding and trainers for education projects in Ethiopia (Q CELLS 2021). Siemens Gamesa developed programmes for hands-on technological education for school children to motivate students to pursue a career in the STEM subjects (Science, Technology, Engineering and Mathematics). They have a similar project in India, providing vocational training for women, capacity building of community-based businesses, as well as entrepreneurship skill development in the Slums of Surat (Siemens Gamesa 2021a, 2021b). Projects like these need to be incorporated in company strategies with the aim of supporting the achievement of the SDGs.

Milestones 2030

- Support the achievement of the SDGs
  - 1 - End Poverty in all its forms everywhere
  - 2 - End hunger, achieve food security and improved nutrition and promote sustainable agriculture
  - 3 - Ensure healthy lives and promote well-being for all at all ages
  - 4 - Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
  - 5 - Achieve gender equality and empower all women and girls
  - 8 - Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all
- Moderate profit driven production
- Local and Regional Development
- Corrective justice

General Considerations

Recommendations

Local value creation, knowledge sharing and training of local communities

Fair compensation for land use and resources

Develop quality, reliable, sustainable, and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all (SDG 9).

Continuous improvements and use of best available technology (incl. considerations for water and energy efficiency, environmental impacts, automation, etc.).

Moderate profit driven production.

Explanation

The noted practice of moving production to countries with lower environmental and social standards to save production costs has no place in responsible production. International companies need to accept their responsibility and perform according to the highest possible standards whether or not required under a country's regulations.

Currently operations are set up to generate maximum profits for companies and shareholders. However, companies need to accept their responsibility in social and environmental impacts and ensure increased sustainability of their operations to create value not only for their shareholders, but also for communities and regions. This means moving from maximum profit to moderate profit by internalising all external costs (Drebenstedt 2021).

Mining

Recommendations

Improve collaboration between large-scale mining (LSM) and artisanal and small-scale mining (ASM).

Support the development of sustainable livelihoods of AS miners.

Explanation

The State of Play report for the renewable energy sector highlights some of the conflicts between LSM and ASM in the Copperbelt Region in Zambia and the DR Congo. An important step for the formalisation of the ASM sector is the successful co-existence of the two mining sub-sectors. For this purpose, IRMA and the Alliance for Responsible Mining (ARM) have collaborated to achieve a more positive outcome and long-term sustainable development at the interface of the two sectors; and to promote coexistence between LSM and ASM to improve social and environmental practices of all miners (ARM and IRMA 2021).

2.4 Target 4: Responsible Procurement

ISO defines responsible or sustainable procurement as 'the process of making purchasing decisions that meet an organization's needs for goods and services in a way that benefits not only the organization but society as a whole, while minimizing its impact on the environment' (ISO 2017, p. 2). This is exactly what the authors want to achieve with their recommendations – organisations need to consider not only their own impact, but also their impact along supply chains and create value wherever possible. However, responsible procurement does not mean ending business relationships with suppliers or countries that do not adhere to required social and environmental standards, but rather engaging with and supporting them in improving their performance. Forced labour, environmental pollution, or other wilful irresponsible practices at any stage of their supply chain, cannot be accepted from companies that want to do business in the EU.

The recommendation to introduce a supply chain due diligence law is not intended to undermine current efforts by countries to introduce such a law. The timeframe proposed here, as mentioned in the introduction, is only the latest date by which these measures should be implemented. It is also intended to encourage countries that are not yet planning to implement such measures to do so and provide some recommendations on what to include.

Figure 12: Milestones for Responsible Procurement by 2040

Milestones 2025

- Improved supply chain resilience (e.g., considering Covid-19 and other black swan events)
- Strengthened local procurement
- Development & implementation of supplier assessment strategies
- Implementation of supply chain reporting
- Preparation for due diligence standards
- Elimination of forced & child labour in supply chains

General Considerations

Recommendations

Assess and understand strategic vulnerabilities of companies' supply chains (Shih 2020).

Include risk-management in infrastructure planning and development, incl. energy and water supply.

Report on all activities of operations and supply chains related to human rights, energy and water use, biodiversity impact, etc. (e.g., see TCFD, TNFD, or GRI reporting standards).

Take immediate and effective measures to eradicate forced labour, end modern slavery and human trafficking and secure the prohibition and elimination of the worst forms of child labour, including recruitment and use of child soldiers, and end child labour in all its forms (SDG 8).

Commit to anti-corruption programme and assess risks along the supply chain, develop mitigation plan accordingly (e.g., Transparency International Anti-Corruption Toolkit).

Respect regional differences and adapt accordingly.

Implement UN Business and Human Rights Principles and the UN Guiding Principles Reporting Framework.

Implement OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas.

Include Human rights and environmental considerations in business contracts.

Explanation

Contracts with trading partners should always include requirements for human rights and environmental performance. This will not only improve the company's own performance in the supply chain, but also promote the development of its business partners (SolarPower Europe 2021). If partners do not comply with certain standards, the business relationship should not be terminated immediately, but improvements should be supported (provided the business partner is willing to do so).

When operating in or sourcing from other countries, it is important to consider regional differences in standards and capabilities, especially when supporting local procurement and development. Utilise regional expertise to help find suitable solutions within the local context. Local NGOs or other CSOs can provide relevant information and mediate between company and communities. The Danish Institute for Human Rights provides a country specific guidance on human rights issues (The human rights and business country guide).
Local sourcing is important to support local and regional development in the host-country, as well as to improve the resilience of supply chains in case of supply disruptions. Local procurement and sourcing strategies should also include considerations for the increased use of secondary raw materials. Considerations for developing resilience within supply chains, include companies having to develop alternative suppliers (also by accepting higher prices) to decrease their dependence on a limited number of suppliers. Additionally, companies may consider building a safety buffer in their inventories, to safeguard against unanticipated supply disruptions. Long-term purchasing commitments support the development of new suppliers and diversified sourcing. Another alternative to reviewing sourcing strategies is to consider, where appropriate, the creation of regional production centres or units, which in the case of a supply disruption from other regions, have the capacity to step in and carry out the required production processes (Shih 2020).

Mining

Recommendations

Support local procurement.

Apply certification schemes for responsible sourcing and integrate into supplier selection criteria in procurement processes.

Cooperation with downstream customers.

Explanation

Mining companies have significant spending power, which they can and should use to support not only local businesses, but also local development. Most mines spend more money in host countries on procurement than taxes, wages, salaries, and community investment combined. Thus, mining operations can create a large positive economic impact and create additional jobs in the region. A good practice example is the development of Tahltan Nation in British Columbia, Canada, showing the positive impact of community participation and shared economic value on a region. To ensure responsible procurement processes, mining companies need to introduce supplier assessment criteria (as mentioned in the general considerations and increase transparency and public reporting). This will also improve the social licence to operate of mining companies. A framework for reporting on local procurement is provided by the Mining Local Procurement Reporting Mechanism (LPRM). By adhering to this framework, companies can also cover requirements by the RMF assessment or the IRMA standard (Geipel 6/30/2021).

Mining companies should cooperate with their downstream customers to increase transparency of supply chains. With strengthened business relationships, long-term programmes to increase sustainability can be fostered and sustainable supply chains built. For example, the cable manufacturer Nexans and the world's largest copper producer Codelco, teamed up to increase transparency in the copper industry and advance social and environmental sustainability along the copper supply chain. In 2018 they managed to produce the first carbon neutral copper cathode shipment (Copper Alliance 2020).

Manufacturing & Recycling

Recommendations

Take decisive action against modern slavery and forced labour in the supply chains of solar PV and wind turbines.

Cooperation with suppliers and development of shared cost models for certifications.

Consider procurement practices of mining companies.

As elaborated in the State of Play report for the renewable energy sector, the main supplier of polysilicon for the global solar PV market is China, more specifically the Uyghur region accounting for 45% of the global supply. It is known that polysilicon production in this region is carried out using forced labour by the indigenous population (see e.g. Murphy and Elimä (2021)). Manufacturers have to commit to full transparency and conduct mapping to uncover, address and prevent irresponsible practices in their supply chains. Civil society can support such endeavours. Traceability and transparency are a possibility for civil society to monitor practices, adherence to laws, etc. and provide advice on supply chain matters.

Through increased traceability and transparency, it becomes possible for civil society to monitor practices, adherence to laws, etc. and provide advice on supply chain matters. Transparency will create public awareness and pressure by consumers. Consumer pressure can lead to substantial change by requiring companies to adhere to more sustainable production processes. An increasing number of countries are considering the introduction of sanctions against solar products from Xinjiang region. Manufacturers need to diversify their sourcing through supporting capacity building elsewhere, to decrease their dependency on China. In line with development targets of the SDGs, manufacturers need to invest in the long-term development of resource rich countries and if possible, set up their own production facilities for responsible manufacturing.

Currently, many manufacturers expect certain sustainability related certifications from their suppliers, often leaving the suppliers to bear the full costs for the certifications. Given the large number of certifications in the market, this can lead to significant costs for mining companies. The sharing of resources (e.g., a shared database for assessments and audits by suppliers) is one approach to tackle this issue (see Good Practice Case on page 74). Additionally, manufacturers should be open to equivalence between different certifications schemes, such that harmonisation of standards can be achieved (missing aspects could be re-assessed). Manufacturers also need to be willing to develop a shared cost-model for any specific certifications required by them. Particularly in the case of ASM, support by manufacturers is required to make certifications affordable for miners.

When developing responsible sourcing and supplier assessment strategies, manufacturers must not forget to consider the procurement practices of mining companies or mine sites themselves. The supply chain does not end at the mine gate and responsible supply chain management beyond the mining company is important.

Milestones 2030

- Support the achievement of all afore mentioned SDGs along the supply chain
- Supply Chain Due Diligence (mandatory for large companies, accompanying measures to assist SMEs with uptake)
- Zero financial crime
- Local & regional development

Milestones 2040

- All international companies adhere to Mandatory Supply Chain Due Diligence

Continuous Actions until 2030 & 2040

General Considerations

Recommendations

Implement standards for supply chains transparency.

Facilitate conflict free mineral supply chains and implement OECD Due Diligence Guidance for Multinational Enterprises and Responsible Mineral Supply Chains.

Ensure zero human rights violations, gender and racial equality along entire supply chain.

Accept responsibility for environmental degradation and social impact along entire supply chain, conduct risk assessment and develop mitigation plan accordingly.

Support responsible production practices by upstream companies and facilitate capacity building.

Integrate ESG considerations in investment decisions (e.g., apply UN Global Compact Principles for Responsible Investment).

Ensure transparent financial flows (tax payments, investments, etc.) aligned with EU accounting and transparency directive.

Decrease GHG emissions along a company's supply chain by introducing tailor-made climate protection projects (Reisinger 2018).

Support the achievement of the SDGs along the supply chains:

Substantially reduce corruption and bribery in all their forms (SDG 16)

Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on favourable terms, including on concessional and preferential terms, as mutually agreed (SDG 17)

Enhance support for implementing effective and targeted capacity-building in developing countries to support national plans to implement all the sustainable development goals (SDG 17).

Explanation

To improve the transparency of mineral supply chains, IRMA and CERA have developed Chain of Custody Standards, to ensure traceability of the raw material from the mine to the consumer. Transparent supply chains are a prerequisite for companies in adhering to due diligence standards, improving performance along the supply chain, and building trust with their customers.

Responsible sourcing standards such as Together for Sustainability provide a framework for manufacturers to assess their suppliers and ensure their raw materials come from responsible productions. If suppliers do not meet a company's standards, it is important to engage with them in improving practices. Ending a business relationship should only be the last resort in case a supplier is unwilling to improve. Additionally, cooperation with industry peers should be strengthened to develop a joint approach towards responsible sourcing (see Good Practice box below).

Apart from improving a company's own environmental performance, companies should also engage with others in their supply chain. The goal is not to merely reduce a company's carbon footprint, but rather to invest 'in the ecosystem their suppliers depend on to increase their resiliency and provide significant, measurable benefits to communities surrounding the value chain' (Cooper 2018). At the same time, this addresses Scope 3 emission reduction targets.

Good Practice Recommendations for supplier assessment through shared resources[11]

Supplier database should be hosted by an independent third-party to ensure confidentiality of information and avoid conflict of interest between lead firms and between suppliers.

Assessment mechanisms should range from simple assessments (self-reporting) to third-party audits.

The results from assessments should be used to create positive change in performance and not as a pass/fail exercise.

Provide control over assessment information/results to suppliers, addressing how it will be used in the database.

Consultations and engagement with suppliers in drafting the framework for standards and assessment mechanisms.

Ensure the initiative is properly costed and has plan for its financial self-sufficiency.

2.5 Target 5: Level Playing Field & International Cooperation

During the consultation process, it became clear that the development of a level playing field (not only) for the renewable energy sector must be one of the major targets of the RE-SOURCING roadmap. The current system rewards companies that produce the cheapest product, ignoring the way in which the products are produced and their quality or durability. This system encourages companies to move production to countries with low social and environmental standards and encourages a 'throwaway society'. One of the key takeaways from the first RE-SOURCING conference were the two main goals a level playing field needs to achieve: (i) The rules should be similar for all comparable actors. (ii) Those who need more assistance should be provided with the help to achieve implementation to reach common standards (Farooki and Korb 2021). As already mentioned in previous chapters, the RE-SOURCING project follows the idea of a joint effort to reach more sustainable supply chains. Thus, the roadmap not only encourages the introduction of requirements for social and environmental standards to do business in the EU; the recommendations also include the cooperation with and support of companies, organisations or governments that currently do not fulfil those requirements.

[11] For more information on the implementation of a life cycle assessment business model and a good practice example, please refer to Farooki et al. 2021 'Meeting the Milestones in the Responsible Sourcing Roadmap Good Practice Guidelines for the Renewable Energy Sector'.

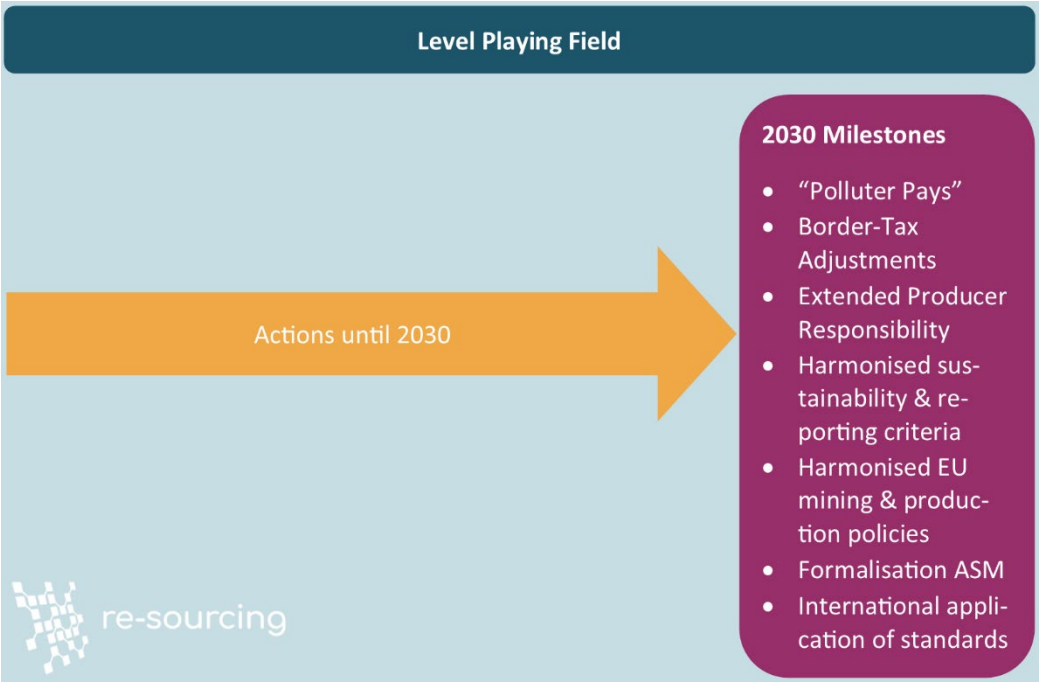

Figure 13: Milestones for a Level Playing Field by 2030

Milestones 2030

Mining, Manufacturing & Recycling

Recommendations

International application of environmental and social standards.

Explanation

Attempting to evade strict environmental and social standards must stop. Companies need to recognise their responsibility and apply the same high standards in all countries of operations. Studies show that companies that have low emissions in countries with strict environmental regulations (on average 29% lower), emit more abroad (Ben-David et al. 2019). In the global fight against climate change, this is unacceptable. Similar issues can be found for social standards, including labour rights, low wages, etc. Companies move their production in low-standard countries, accepting poor working conditions, inadequate safety protocols or forced labour. Here, companies are called upon to show responsibility and put an end to such practices. With the introduction of an EU supply chain due diligence law and border tax adjustments, this will also be necessary for further economic activity in the EU market.

3 Conclusion

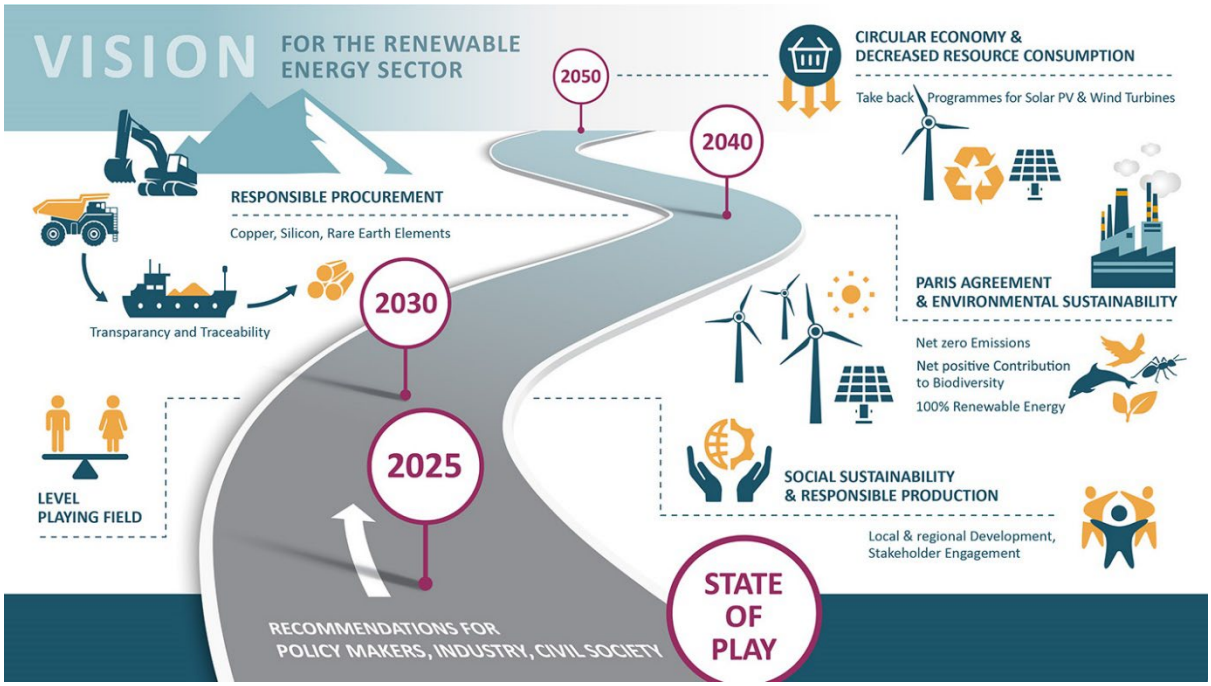

Figure 14: Roadmap for the renewable energy sector until 2050

One of the key findings of this roadmap is the importance of engaging the public in the energy transition. The population must actively support, shape and, most importantly, implement the transition. This not only requires information about the importance of the transition and all processes involved, but above all the trust of the population that this transition will be socially just and environmentally friendly is needed. Decisive and joint action by politics, industry, research, and civil society is needed to create trust and ensure the sustainability of the transition.

In the roadmap, numerous recommendations are made for industry players, both specifically for renewable energies, but also very general recommendations that are valid in mineral raw material value chains of various raw materials and technologies. The rationale behind this is to recognise the systemic nature of many sustainability issues that cannot be specifically attributed to the raw materials and technologies considered in this roadmap, without ignoring their presence in other areas.

Even though the roadmap is designed until 2050, it has become clear that significant changes in procurement, production and energy consumption are needed, now and over the next two decades. This is also reflected in the time scales for the five overarching targets of the roadmap (Figure 14). Both, Targets 3 and 4 (social sustainability, responsible production and the level playing field) need to be implemented by all stakeholders as soon as possible to achieve a fair distribution of the benefits and burdens of the energy transition. The roadmap also sets very ambitious targets for the implementation and achievement of the Paris Agreement and environmental sustainability (Target 2), with 100% renewable energy and net zero emissions by 2040. Target 4 on responsible procurement combines the measures of the other goals with regard to the entire supply chain. Human rights, environmental standards, etc. must be observed not only in a company's own production, in its own country, but in all areas in which a company or government is active and maintains business relations.

Only the goal of a circular economy and decreased resource consumption (Target 1) has a horizon until 2050, as it requires more fundamental, systemic changes to the economic system.

Nevertheless, it is essential to simultaneously address all five targets in a coordinated manner. Falling behind on only one target compromises the achievement of the others. For example, it is impossible to achieve the transition to 100% renewable energy without reducing energy consumption and increasing energy efficiency. Similarly, responsible production cannot be achieved without considering impacts along the entire supply chain.

The roadmap has not only highlighted many current problems and how to address them but has also identified gaps where crucial information is still missing. Critical research on consumption reduction, resource and energy efficiency is urgently needed to set concrete targets and implement measures.

Finally, an important finding of the roadmap is the requirement for the cooperation of all actors along the entire supply chain. Issues need to be solved together by engaging, not by ending relationships. None of the targets can be achieved by one stakeholder group alone.

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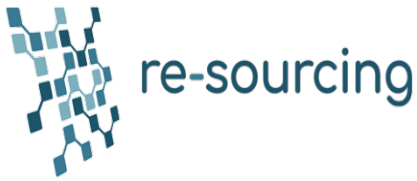

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