



re-sourcing

Renewable Energy Sector

**Roadmap for Responsible Sourcing of
Raw Materials until 2050**

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Contents

Abbreviations.....	3
Executive Summary.....	4
1 Introduction	6
1.1 The RE-SOURCING Project.....	6
1.2 The Renewable Energy Sector.....	7
1.3 Methodology: The Roadmap Process.....	9
1.4 Vision	11
2 Pathway.....	13
2.1 Target 1: Circular Economy & Decreased Resource Consumption	15
2.1.1 Recommendations for Policy Makers	17
2.1.2 Recommendations for Industry	27
2.1.3 Recommendations for Civil Society, Academia & Research Institutions	34
2.2 Target 2: Paris Agreement & Environmental Sustainability	35
2.2.1 Recommendations for Policy Makers	37
2.2.2 Recommendations for Industry	45
2.2.3 Recommendations for Civil Society, Academia & Research Institutions	51
2.3 Target 3: Social Sustainability & Responsible Production	52
2.3.1 Recommendations for Policy Makers	53
2.3.2 Recommendations for Industry	57
2.3.3 Recommendations for Civil Society.....	63
2.4 Target 4: Responsible Procurement	64
2.4.1 Recommendations for Policy Makers	64
2.4.2 Recommendations for Industry	71
2.5 Target 5: Level Playing Field & International Cooperation.....	76
2.5.1 Recommendations for Policy Makers	77
2.5.2 Recommendations for Industry	81
2.5.3 Recommendations for Civil Society.....	81
2.5.4 Role of International Organisations (UN/OECD/IFC).....	82
3 Conclusion	83
4 Publication bibliography.....	85

Figures

Figure 1: Roadmap Process for the RE-SOURCING Project.....	9
Figure 2: Webinar series for roadmap development.....	10
Figure 3: Vision for the renewable energy sector (based on Kügerl and Tost (2020)).....	12
Figure 4: Depictions of the three sustainability pillars - social, environmental and economic (Purvis et al. 2019)	14
Figure 5: Doughnut Economics - combining social and planetary boundaries (DEAL 2021).....	15
Figure 6: Milestones towards a circular economy and decreased resource consumption by 2050	16
Figure 7: Possible reductions of final energy demand in 2050 in the low energy demand scenario proposed by Grubler et al. (2018).....	19
Figure 8: (left) Coscieme et al. (2019) compare the GDP to the Happiness score to illustrate the Easterlin paradox; (right) A comparison of subjective wellbeing (SWB and GDP per capita by Inglehart et al. (2008)	24
Figure 9: Predicted recycling potential of neodymium from EoL permanent magnets for (computer, wind turbine, and automotive industries) (Yang et al. 2017).....	31
Figure 10: Circular business model for solar PV modules as envisaged by the CIRCUSOL project (Tsanakas et al. 2020)	32
Figure 11: Carbon emissions abatements under IRENA's 1.5°C scenario by 2050 (IRENA 2021b).....	35
Figure 12: Milestones to reach the Paris Agreement and Environmental Sustainability by 2040	36
Figure 13: Co-use of land by renewable energy and agriculture at Austria's largest solar PV plant (Wien Energie 2020)	41
Figure 14: Holistic policy framework for a successful energy transition (IRENA 2020).....	43
Figure 15: Milestones to reach Social Sustainability & Responsible Production by 2030.....	53
Figure 16: Recordings of attacks on human rights defenders in 2020 (Business & Human Rights Resource Centre 2021)	54
Figure 17: Levels and impacts of public participation (IAP2 Canada 2018).....	59
Figure 18: ICMM's skills initiative for mining companies to support community resilience (ICMM 2021b).....	60
Figure 19: Milestones for Responsible Procurement by 2040.....	64
Figure 20: Milestones for a Level Playing Field by 2030.....	76
Figure 21: Historical and projected primary copper production compared to projected demand (Nickless 2018).....	79
Figure 22: Roadmap for the renewable energy sector until 2050.....	83

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

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); providing recommendations for EU policy makers, international industry, and civil society organisations on achieving a vision for a sustainable renewable energy sector.

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:

- 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 the three stakeholder groups addressed, 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.

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. Policy makers in particular, need to ensure economic viability of recycling and create a market for secondary raw materials.

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:

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

1 Introduction

1.1 The RE-SOURCING Project

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

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

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

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

The RE-SOURCING project actions will:

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

RE-SOURCING will deliver:

- For EU and international business stakeholders:
 - increased capacity of decision-makers for implementing responsible business conduct;
 - better understanding and awareness of RS in three sectors of renewable energy, mobility, and electric and electronic equipment; and
 - facilitated implementation of lasting and stable sectoral framework conditions for RS.
- For EU policymakers:
 - increased capacity for RS policy design and implementation;
 - innovative ideas on policy recommendations for stimulating RS in the private sector; and

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

1.2 The Renewable Energy Sector

The 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 2020b). 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 found¹, 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 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.

1.3 Methodology: The Roadmap Process

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

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

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

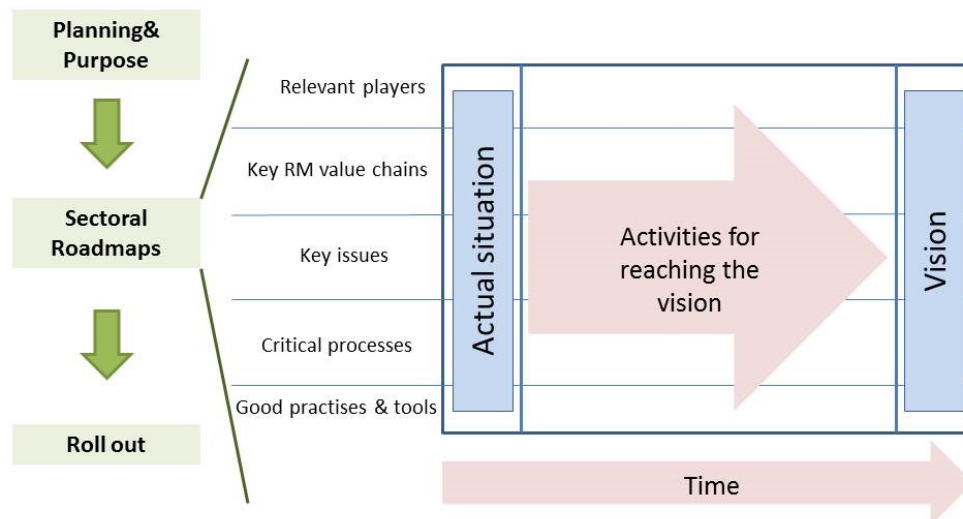


Figure 1: Roadmap Process for the RE-SOURCING Project

An important aspect is the open approach to problems in the supply chain. Only through open communication can problems be uncovered and solved in a joint effort. The RE-SOURCING project supports a risk-based approach. This means ‘activities associated with higher risks will require more intensive due-diligence and monitoring activities’ (OECD 2021).² No stakeholder should be excluded because of prevailing issues, but rather be supported in solving them. These issues and the current situation, including sustainability challenges, actors, and initiatives along the supply chains for wind and solar PV modules were identified in the [State of Play and roadmap concepts: Renewable Energy Sector](#) (see chapter 1.2 for a short summary of the results).

The State of Play report was developed with input from the Platform Steering Committee during two online consultation meetings and further written feedback, as well as a Roadmap Workshop, involving key stakeholder groups from the renewable energy sector; to identify and prioritise issues, challenges, and frameworks to address them. Informed through these consultations, a Vision 2050 for the renewable energy sector was drafted.

The next step was the detailed development of the roadmap, including providing recommendations for industry, policy makers and civil society to achieve the RE-SOURCING project’s vision by 2050. For the roadmap development, three consultations, via online webinars, took place. Initially, the draft roadmap was presented to the Project Consortium, the Platform Steering Committee, and the Advisory Board. At the second stage, a webinar with external experts was hosted, whilst ensuring a balanced representation of stakeholder groups and regions. In the third and final webinar, experts from the second consultation as well as the project’s Platform Steering Committee and Advisory Board were consulted again to finalise the roadmap (Figure 2).

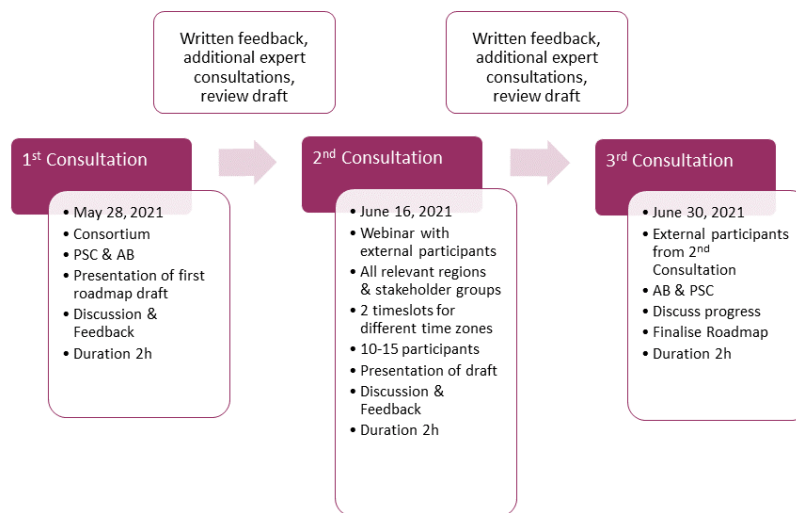


Figure 2: Webinar series for roadmap development

² For more information on a risk-based due diligence process see the OECD’s five-step framework OECD 2016.

A secondary contribution to the development of the roadmap for the renewable energy sector was the preparation of a Guidance Document for policy makers and industry based on specific case studies from the renewable energy sector. Four case studies were presented: (i) a multi-stakeholder consultation process for the Chilean National Mining Policy Development, (ii) Antofagasta Minerals' development of a cohesive corporate sustainability policy, (iii) auditing for responsible sourcing using the example of Wacker Chemie AG and Together for Sustainability Supplier Assessments, and (iv) First Solar's circular business model. Further information on the case studies and the Guidance Document can be found at: [Case Studies](#) & [Guidance Document](#)

The European Green Deal

In December 2019 the European Commission presented the European Green Deal with the aim of making 'Europe the first climate-neutral continent by 2050' (European Commission 12/11/2019). While the RE-SOURCING project's roadmap for the renewable energy sector supports the goals of the Green Deal, the authors also believe that more ambitious targets are required. This roadmap integrates many aspects of the Green Deal, especially from the strategies on sustainable industry (European Commission 2019b), clean energy (European Commission 2019a) and circular economy (European Commission 2020a). However, these aspects are mostly included with a shorter timeframe – e.g., 100% renewable energy by 2040.

1.4 Vision

The horizon considered for the roadmap of the RE-SOURCING project is 2050. The vision for the renewable energy sector (Figure 3) was developed based on the underlying concepts of planetary boundaries³ and strong sustainability⁴ 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.

³ For further information on planetary boundaries, please refer to Rockström et al. 2009 and ; Steffen et al. 2015.

⁴ An explanation of the strong sustainability concept is provided by Ekins et al. 2003; and Dedeurwaerdere 2014.

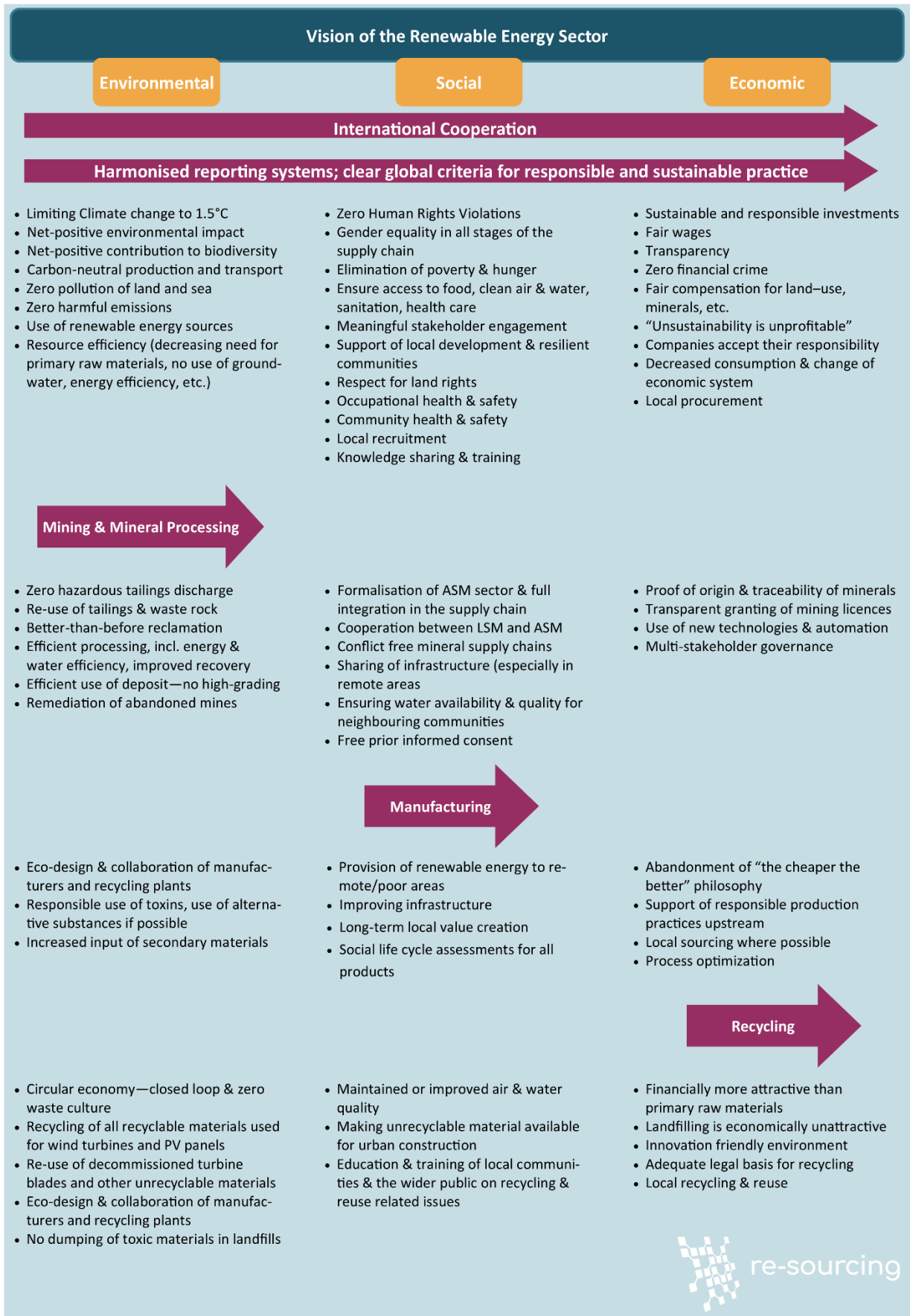


Figure 3: Vision for the renewable energy sector (based on Kügerl and Tost (2020))

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.⁵ 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, 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. 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).

⁵ 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 4), 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.

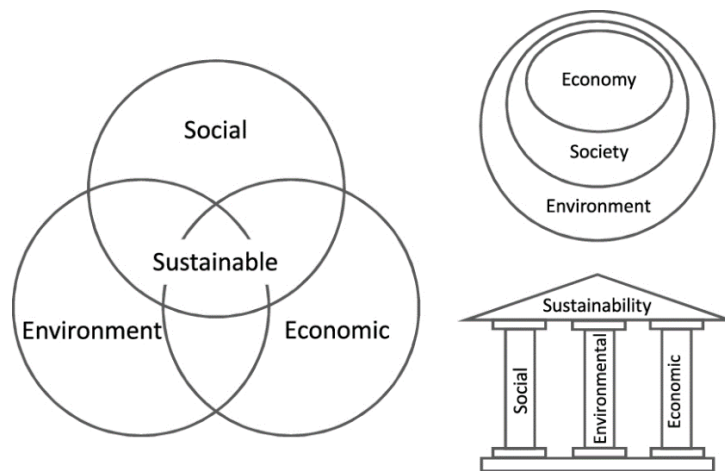


Figure 4: Depictions of the three sustainability pillars - social, environmental and economic (Purvis et al. 2019)⁶

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.

⁶ 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).

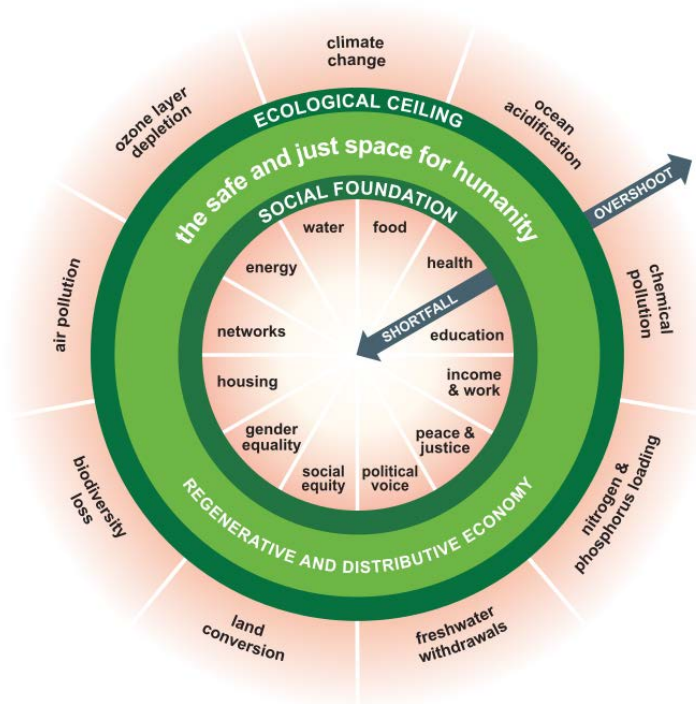


Figure 5: Doughnut Economics - combining social and planetary boundaries (DEAL 2021)

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 6 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 are outlined further. As mentioned earlier, the recommendations presented here are aimed at EU policy makers and internationally operating companies and CSOs. 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 6: Milestones towards a circular economy and decreased resource consumption by 2050

2.1.1 Recommendations for Policy Makers

Milestones 2025

- Policies for Sustainable Consumption & Production
- Resource efficiency & waste policies, including
 - legal basis for recycling
 - supporting measures for waste prevention and circularity
 - classification and management guidelines for hazardous waste
 - reporting guidelines for companies
 - technology specific waste policies for wind turbines (similar to WEEE Directive for Solar PV)
- Adoption of EU energy efficiency directive & ambitious targets for lowering energy consumption

General Considerations

Recommendations

Implement the 10-year framework of programmes on sustainable consumption and production (SDG 12)

Ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature (SDG 12)

Changing consumption patterns and promoting sustainable consumption also requires a discussion of material and energy 'needs' which is a prerequisite for changes in the economic system.

Adopt policies for increasing energy efficiency including ambitious targets for lowering energy consumption

Include necessary behavioural changes in policies and strategies– energy intensity can only be reduced with the support of citizens (inform and educate and involve!).

Ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development (SDG 4).

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

Include considerations such as employment in expansion and efficiency improvements of energy system (IEA 2021)

Consider policies to support employment and businesses that will be asked to move out of polluting and fossil fuel industries – the no one left behind principle.

Examples for necessary behavioural changes are provided by the IEA report ‘Net Zero by 2050’: Reduction of water and space heating temperatures (average 19-20°C), increase of space cooling temperatures (av. 24-25°C by 2030), increase of building lifetime (20% by 2050), etc. (IEA 2021) However, while it is important to increase the lifetime of buildings or infrastructure, it is also essential to consider the construction materials used. A building made of wood might not achieve the same lifetime as a concrete building, yet it can be more sustainable.

While technological advances are certainly necessary to improve energy and resource efficiency, this must not be the only “point of attack”. Without behavioural and consumption pattern changes, the rebound effect or Jevons paradox is likely to occur and potential savings by technological progress are offset by increased consumption (Coscieme et al. 2019). Jackson (2017) emphasises the need to question the role of policies and institutions that influence behaviour and consumption. He states, ‘Perhaps the most critical task to hand is to identify (and correct) those aspects of this complex social structure that provide perverse incentives in favour of a materialistic individualism and undermine the potential for shared prosperity’ (Jackson 2017, p. 203). In his view the notion of public goods plays a vital role in reducing consumption and fostering social ties and community engagement. Policy makers need to create viable alternatives for consumerism, by investing in public amenities and spaces. Trading standards need to protect social and environmental standards along the supply chains, and address the durability, lifetime and reparability of products.

Community-based businesses need to be supported to shorten supply chains and deliver local value by providing services such as education, maintenance, repair, recreation, etc.

‘ZOE.’ the Institute for future-fit economies also provides concrete policy recommendations to ‘shift from unsustainable to sustainable patterns of consumption’, including incentives for sharing economies, regulations to decrease the total demand for goods and services or to decrease the rebound-effects (for more information and concrete examples for policies, see ZOE. Institute for future-fit economies (2021)).

Grubler et al. (2018) developed a low energy demand (LED) scenario building on five main drivers:

- (i) quality of life (including higher living standards, clean local environments and accessibility of services and technologies);
- (ii) urbanization;
- (iii) novel energy services (more accessible, cleaner, and higher quality);
- (iv) diversification of energy end-user roles (from consumer to producer, trader, community member, etc.); and
- (v) information innovation (improvements of information and communication technologies).

These drivers generate five crucial elements for achieving the LED: granularity (small-scale, low-unit-cost technologies), decentralisation of energy generation, distribution and end-use, move towards a sharing economy and multi-purpose services (away from ownership of single-purpose goods), digitalisation and rapid transition driven by pressure of consumers and technology innovations. With these measures, they deem the following reductions of global final energy demand as possible (Figure 7).

Table 2 | Impact of the LED scenario on final energy demand in 2050

	Region	% change in activity levels (2020-2050)	% change in energy demand (2020-2050)	Activity levels in 2050	Energy demand in 2050 (EJ)	Total energy demand in 2050 (EJ) (GJ capita ⁻¹)	
End-use services	Thermal comfort	North	6	-74	47 × 10 ⁹ m ²	8	16 (1.8)
		South	63	-79	218 × 10 ⁹ m ²	8	
	Consumer goods	North	79	-25	67 × 10 ⁹ units	13	41 (4.5)
		South	175	54	186 × 10 ⁹ units	28	
	Mobility	North	29	-60	25 × 10 ¹² passenger km	16	27 (3.0)
		South	122	-59	73 × 10 ¹² passenger km	12	
	Contingency reserve						8
Upstream	Public and commercial buildings	North	49	-64	35 × 10 ⁹ m ²	5	8 (0.9)
		South	77	-82	68 × 10 ⁹ m ²	3	
	Industry	North	-42	-57	1.0 × 10 ⁹ t	26	107 (11.7)
		South	-12	-23	5.4 × 10 ⁹ t	82	
	Freight transport	North	109	-28	31 × 10 ¹² tkm	11	27 (3.0)
		South	75	-12	51 × 10 ¹² tkm	17	
	International aviation and shipping (bunker fuels)						10
Total	North ^a		-53		82	245	
	South ^a		-32		153		

All sub-totals and totals are rounded (lower integer at numerical values <0.5, to upper integer ≥0.5). ^aContingency reserve of 8 EJ is allocated equally to the global North and global South. Bunker fuels are reported at the global level only, consistent with current energy balances and emission accounting frameworks.

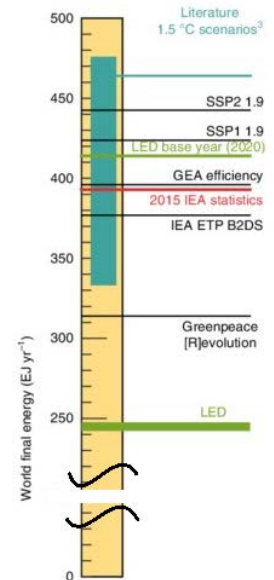


Figure 7: Possible reductions of final energy demand in 2050 in the low energy demand scenario proposed by Grubler et al. (2018)

Mining

Recommendations

- Update mining policies to include resource efficiency considerations and requirements for companies.
- Bring uniformity in national mining policies and legislation to level the playing field within Europe.
- Include responsible mining pre-requisites in trade and investment agreements with other countries.

Explanation

The mining industry is already subject to numerous voluntary standards of varying degrees of comprehensiveness, with some covering all three sustainability pillars. Resource efficiency considerations are also covered by few standards. Kickler and Franken (2017) found in their comparison of mining standards, that IFC Environmental and Social Performance Standards are most comprehensive considering water, energy and material consumption and recycling efficiency. A multi-stakeholder approach is taken by the Initiative for Responsible Mining Assurance (IRMA)⁷. IRMA is currently the most comprehensive standard with some of the highest requirements for mining sites. Especially their guidelines for water can be considered as supporting strong sustainability – part of the vision this roadmap wants to achieve (Tost et al. 2018). The requirements provided by these standards should also inform new regulations and policies and provide a common base among EU member states.

Policy makers also need to recognise that the mining industry will struggle to achieve resource efficiency and energy reduction targets in the absence of significant changes in consumption. The mining industry has to reduce their own carbon footprint while producing minerals and metals to reduce other people’s carbon footprints; consumption is the only lever to address this gap.

⁷ The IRMA standard will be part of the Flagship Cases for the Mobility Sector of the RE-SOURCING project, where the standard itself, as well as the benefits for companies will be evaluated (forthcoming in 2022).

Manufacturing

Recommendations

- Introduce eco-design policies for solar PV and wind turbines (finalise EU Eco-label for solar PV).*
- Evaluate the feasibility of introducing requirements regarding increased durability and service life for wind turbines and solar PV modules.*
- Support of R&D in material efficiency considerations (e.g., material losses of polysilicon in Solar PV production need to be improved significantly).*
- Adopt policies to create a market (i.e., demand) for secondary raw materials on EU level*
 - Conduct research on applicable secondary material content and reuse targets
 - Set specific targets for recycling, reuse and circularity on EU level (Milios 2021).
- Increase data disclosure on ESG metrics of manufactured products.*

Explanation

Examples for policies to increase recycling rates and create a market for reuse and secondary raw materials include tradable recycling credit scheme (Söderholm and Ekvall 2020), i.e. requiring a specified share of secondary raw materials in production, increasing the level over time, or the introduction of circular economy and product reuse targets, including measuring and monitoring mechanisms (Milios 2021). The American NSF/ANSI 457 standard for solar PV modules awards additional points for the achievement of certain recovery rates (e.g. $\geq 90\%$ metals – 2 extra points awarded) and recycled content (e.g. $\geq 10\%$ recycled semiconductor material – 1 additional point) (NSF/ANSI 457-2019).

The battery passport of the EU already provides a good example of regulatory measures to increase recycling and a similar framework should be evaluated for wind turbines and solar PV modules. Due to the stationary use of these technologies and limited secondary market, the targets should be set at a more ambitious level. However, further research is required to assess the useable amount of secondary raw materials and a decreased resource consumption without impacting the PV module efficiency or the durability of wind turbines.

Recycling

Recommendations

Review waste definition in the context of secondary resources on member state level in line with the EU Waste Framework Directive

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

Adopt DIN SPEC 4866⁸ for the dismantling and recycling of wind turbines and support the development of a similar norm for solar PV (possibly project ReSi-Norm will deliver the results needed).

Create the legal basis for reuse of unrecyclable materials in other sectors, e.g., wind turbine blades in urban construction

Reusing materials in other applications needs to be carefully considered. This should only be an option if recycling is not possible. E.g., many metals from complex products end up in infrastructure today and are essentially 'locked in' for a long time.

Unification of waste stream classification across EU member states and adoption of uniform recycling targets (Bobba et al. 2020).

Support the recycling activities by introducing recycling subsidies, e.g. by directly supporting the implementation of recycling programmes, or lower costs for collection of end-of-life products, etc. (Söderholm and Ekvall 2020).

Enable transport of waste to recycling facilities with suitable import/export policies.

Make landfilling economically unattractive by introducing taxes.

Explanation

Streamlining of waste legislation is crucial to make it less complex and reduce administration. The clarification of waste definitions and EoL criteria, as well as the removal of internal and external policy conflicts will help navigate companies through legal requirements (Milios 2021).

For both solar PV and wind turbines the technologies for recycling are mostly already available. The issue is with the economic viability of recycling processes (e.g., high labour costs work against economic recycling) and demand for recycled materials (e.g., primary raw materials are often cheaper). Thus, policies need to create a market for secondary raw materials (e.g., with financial incentives). This is a prerequisite for the achievement of recycling and circularity goals. However, incentives for the use of secondary raw materials should be carefully considered. The example of gold shows that the higher prices for recycled gold lead to primary gold being falsely recycled to be able to sell it at a higher price. An assessment of policy tools and their potential effects is provided in the report 'Mapping support for primary and secondary metal production by the OECD (McCarthy and Börkey 2018).

⁸ For more information see DIN 2021.

Milestones 2030

- Circular Economy – Closed loop & zero waste culture⁹
 - Min. rate of circularity for solar PV and wind turbine manufacturers of 90%
 - Achievement of SDG 12 - Ensure sustainable consumption and production patterns
- All new buildings are zero-carbon-ready (IEA 2021)
- Increase of energy efficiency by >45% (Petroula et al. 2018; WWF 2020)¹⁰
- Decrease energy consumption by¹⁰
 - > 37% final energy consumption
 - > 41% primary energy consumption
- Achievement of the SDGs
 - 4 - Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
 - 6 - Ensure availability and sustainable management of water and sanitation for all
 - 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
- Policies for changes of the economic system

General Considerations

Recommendations

Develop innovation friendly environment.

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

Incorporate IFC EHS Guidelines in policies

Increase public awareness, foster resource saving attitude and behaviour (Swilling 2020); provide a clear direction and achievable targets for future developments to reduce uncertainty around investments and remove bias against decoupling (UNEP 2014)

Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production (SDG 12)

Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-year framework of programmes on sustainable consumption (SDG 8)

Introduce policy tools to support recycling (e.g. tax breaks for recycling activities and use of secondary raw materials, a resource or virgin material tax system) (UNEP 2014; Söderholm and Ekvall 2020; Swilling 2020). Impacts of these policies on resource dependent developing countries need to be kept in mind and negative consequences mitigated by actively supporting long-term sustainable development in raw material supplying countries.

Enhance policy coherence for sustainable development (SDG 17).

⁹ Keeping physical (i.e., technological efficiency, loss of properties, etc.) and economic limitations (long lifetime of wind turbines or solar PV installations) in mind.

¹⁰ Current EU Energy Efficiency target for 2030 is 32.5%, and required energy consumption reduction is based on this target, see European Commission 2020c.

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).

Continuously increase energy efficiency and decrease energy consumption

Improvements of -4.5% energy intensity per year (2020-2030) (IEA 2021)

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

Develop and introduce policies for changes of the economic system.

Explanation

The EU is already active in supporting innovative projects, e.g., in Horizon 2020 or EIT funding schemes. However, it is important to further improve the collaboration between research institutions and industry, to avoid innovations that are irrelevant for mass production and ensure the uptake of innovations. In particular, wind turbines, but also solar PV modules are subject to intensive research efforts focusing on new technologies, improved efficiency, material substitution, and improved recycling processes. Policy makers need to ensure that this research can contribute to improvements of the industry. For example, the cross-sectoral project ZEBRA (Zero waste Blade ReseArch) brings together companies and research partners to ensure technical, economic and environmental relevance of the results (IRT Jules Verne 9/22/2020).

The IFC provides various guidelines relevant for energy and resource efficiency. These guidelines should inform policies and can support the development of a common basis for all EU member states. Examples are: General EHS Guidelines 1.2 Energy Conservation, 1.4 Water Conservation, 1.6 Waste Management.

Adding new policies without considering existing regulations or cooperating with other sectors increases the risk of implementing contradictory or unimplementable goals. For example, when introducing a new mining strategy, it is essential to harmonise this strategy with other policies, such as climate, environment, or land-use policies.

The cooperation between governmental agencies and institutional coherence is crucial. Considering the complex challenges of today, new institutional structures might be needed to address them appropriately. For example, the expansion of renewable energy should go hand in hand with energy efficiency considerations, to decrease the pressure on raw material supply (UNEP 2014).

The current economic system is built on the premise that continuous economic growth and consumerism are necessary to address poverty and foster wellbeing (Coscieme et al. 2019). However, studies show that an ever-growing GDP/income per capita does not necessarily contribute to a societies' wellbeing at all. After a certain threshold level has been achieved, GDP and wellbeing do not grow at the same rate (i.e., "Easterlin Paradox"). On the contrary, further GDP growth might lead to a deterioration of the quality of life and of the environment (Jackson 2017; Max-Neef 1995).

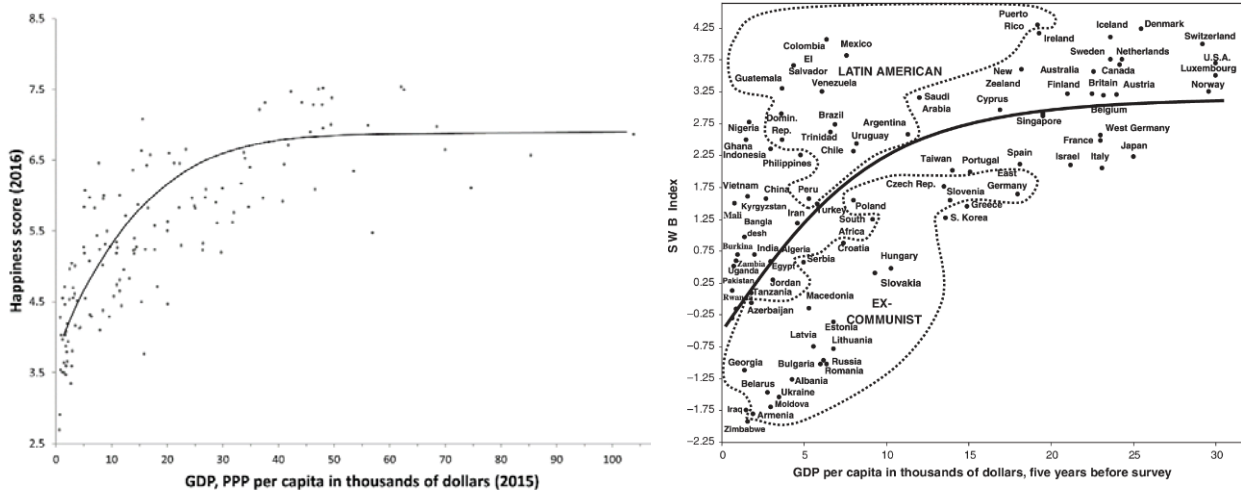


Figure 8: (left) Coscieme et al. (2019) compare the GDP to the Happiness score to illustrate the Easterlin paradox; (right) A comparison of subjective wellbeing (SWB and GDP per capita by Inglehart et al. (2008)

For developed countries, such as EU member states, it is crucial to start rethinking mainstream economics now, in order to increase resource efficiency and decrease consumption.¹¹ The five countries Finland, Iceland, New Zealand, Wales and Scotland are already in the process of implementing a wellbeing economy.¹² Even though, their economic plan still includes the aim for GDP growth, they have also introduced wellbeing indicators to guide cross-policy decisions. In Iceland, societal indicators include for example mental health or work-life balance; environmental indicators include air quality and climate, as well as recycling (Prime Minister's Office Iceland 2019). This is an important step towards an economy that has the wellbeing of the people at heart and is addressing the need for environmental protection and staying within planetary boundaries at the same time.

¹¹ We recognise the need for developing countries to continue their growth to bring people out of poverty and increase wellbeing in line with SDG8. Especially in countries with a low GDP (below approximately 20,000 \$) happiness or subjective wellbeing still increase significantly with only small increases of the GDP (as illustrated in Figure 6) (Jackson 2017).

¹² For more information on the Wellbeing Economy Governments, see Wellbeing Economy Alliance 2021.

Manufacturing

Recommendations

- Introduce policies and support innovation to improve resource efficiency in production processes.*
- Implement sector specific energy efficiency targets for wind turbine and solar PV module production.*
- Support research for the substitution of critical raw materials and/or the development of sustainable sourcing strategies.*

Explanation

Especially in the production of silicon wafers for solar PV modules material losses (so-called kerf losses) of more than 50% can occur and this material is currently not reused. The development of economically viable recycling processes needs to be supported and appropriate targets for the reduction of kerf losses implemented. The ITRPV anticipates kerf loss to decline to below 50 µm by 2031 with the continued use of diamond wire sawing technology (Fischer et al. 2021). The potential of kerfless cutting needs to be investigated in the long run.

Both the production of wind turbines and solar PV modules is very energy intensive. Energy payback time for the entire life cycle of the technologies needs to be improved.

Considering the planned increase of offshore wind energy capacity, development of alternatives for rare earth permanent magnets need to be supported and sourcing strategies implemented to support more sustainable rare earth supply chains (see chapter 2.4 Target 4: Responsible Procurement).

Wastewater recycling in PV plants is already standard. Currently approximately 40% recycling rate can be achieved. Achieving a further increase in the wastewater recycling rate requires a design change of manufacturing plants and needs to be considered when setting up new plants.

Recycling

Recommendations

- Make reuse/recycling financially more attractive than consuming primary raw materials and disposal.*
- Support the development of new high-value recycling facilities in Europe.*
- Support R&D for efficient recycling processes, new technologies, reuse, etc.*
- Facilitate communication and collaboration along the supply chain.*
- Prevent export of recyclable materials outside the EU (=loss of strategic material source!), provided that appropriate collection and recycling infrastructure is available in the EU.*
- Prevent export of waste outside of the EU – unless it will be recycled/handled properly.*

Explanation

When setting circularity targets, policy makers need to keep potential downcycling in mind. Currently downcycling already achieving circularity rates of 90%. However, it is important to consider the raw materials from renewable energy technologies as strategic source of materials for the sector and keeping it within the sector should be fostered (by providing the necessary regulatory framework, supporting R&D, development of recycling facilities, etc.). While recycling alone will not be able to provide sufficient amounts of raw materials for the renewable energy sector, it is still important to avoid over-dependency on other nations and geopolitical tensions, as well as to address enormous levels of current and future waste. Investments in cutting edge research is required for the EU to become a global leader and innovator in recycling. Furthermore, the recycling industry needs to be considered as an important employment source, especially considering a likely loss of jobs from the fossil fuel sector.

Milestones 2040

- Significantly increase resource efficiency¹³
- Continuous reformation of the economic system moving away from the growth paradigm

Milestones 2050

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

Continuous Actions until 2040 & 2050

General Considerations

Recommendations

Facilitate the implementation of innovative business models (car sharing, etc.).

Continue energy efficiency improvements

Annual energy intensity improvements of approx. -3 % (2030-2050) (IEA 2021).

Explanation

Implement IEA's 25 energy efficiency recommendations (OECD and IEA 2017). Energy efficiency policies need to be coordinated across policy areas and with existing policies and EU targets; often goals accumulate and don't provide a clear path (Kern et al. 2017). Energy efficiency considerations need to become part of energy access policies (OECD and IEA 2017).

Support off-grid systems in remote areas paired with super-efficient appliances to maximise efficient utilisation and affordability (OECD and IEA 2017) and utilize the energy efficiency potential in buildings (account for 40% share of energy use in Europe) (Kern et al. 2017).

Sharing economy (SE) business models often struggle with the lack of policy, regulations, insurance and licensing (Hossain 2020). Policy makers can support SE by implementing respective policy changes and offering local government support (Mi and Coffman 2019). Additionally, also appropriate EHS regulations and taxation schemes are required, to ensure that existing traditional businesses adhering to high European labour, safety, etc. standards are not penalised (e.g. Uber vs Taxi) (Hossain 2020).

¹³ 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 resource efficiency is required and needs to be supported by policy makers.

Manufacturing & Recycling

Recommendations

Support R&D into new technologies for lower material needs and reuse of secondary materials.
Prohibit landfilling of recyclable materials.

Explanation

Landfilling of recyclable materials from wind turbines and solar PV needs to stop being a viable option. By this time, high value recycling facilities will have been set up and economic, socially, and economically friendly collection and treatment of EoL materials is conducted. Research to increase resource efficiency needs to continue and be supported by policy makers. Cooperation between all stakeholder groups should be fostered.

2.1.2 Recommendations for Industry

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

General Considerations

Recommendations

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 CO₂ (GAP 2020).

Mining

Recommendations

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.

Manufacturing

Recommendations

Optimize production processes:¹⁴

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.

¹⁴ 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.

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).

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 model¹⁵

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.

Recycling

Recommendations

Strengthen cooperation with research and academia, as well as other sectors with the focus on high-value recycling technologies and new reuse opportunities.

Improve collection and recycling of copper, REEs and silicon.¹⁶

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).

¹⁵ 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](#)'.

¹⁶ 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.

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 9) (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)..

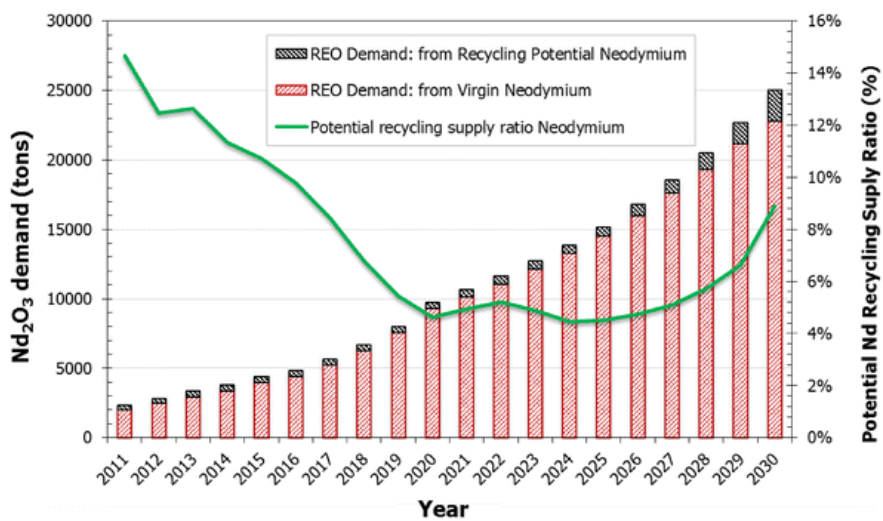


Figure 9: Predicted recycling potential of neodymium from EoL permanent magnets for (computer, wind turbine, and automotive industries) (Yang et al. 2017)

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).

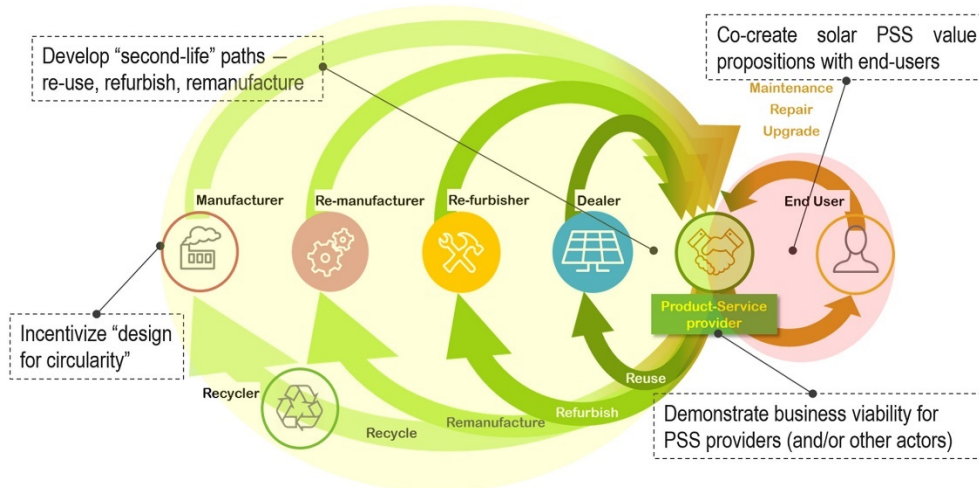


Figure 10: Circular business model for solar PV modules as envisaged by the CIRCUSOL project (Tsanakas et al. 2020)

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.

2.1.3 Recommendations for Civil Society, Academia & Research Institutions

The recommendations for CSOs are not subdivided and sequenced in the same way as for policy makers and industry, as we consider their role to be overarching. This means that CSOs play an important (supporting) role in the achievement of all goals and milestones and this role is not temporary.

CSOs are already important contributors to the achievement of sustainability in the supply chain of wind and solar PV power. For the target of decreased resource consumption, we especially want to highlight the role of advocacy NGOs (both local and international), industry associations and research institutions.

NGOs can make an important contribution to increasing resource efficiency and reducing energy demand. An important element of this contribution is to increase awareness and inform citizens about the impact of consumption patterns and possible alternatives. For example, increase awareness of issues such as the impact of buying a new mobile phone every year, what raw materials are needed for it, where they come from and their environmental and social impacts. Consumers need to be better informed about the consequences of continuing their current consumption patterns. In this area, the necessary and desirable cooperation with policymakers should be emphasised. On the one hand, this "educational work" is necessary at the political level, on the other hand, political measures to increase resource efficiency can be developed and communicated to the population together.

Research and academic institutions are challenged in two ways: (i) they have a primary role in developing new technologies and advancing existing ones to reduce both the resources and the energy used in their production. It is also important, in terms of recycling, for them to pay attention to the subsequent reuse and recovery of materials when designing products. When developing new technologies in the future, attention must be paid from the very beginning to the raw materials used. Interdisciplinary cooperation should be significantly strengthened and expanded for this purpose. Direct cooperation with industry needs to be intensified to effectively develop viable new products. (ii) Interdisciplinary cooperation should be strengthened not only in the technical field regarding the use of raw materials, but also interdisciplinary cooperation between engineering, social sciences, ecology, sustainability research etc. Environmental and social impacts have to be considered, for example in the form of (social and environmental) life-cycle assessments, in product development from the start of a project.

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 2019c). 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).

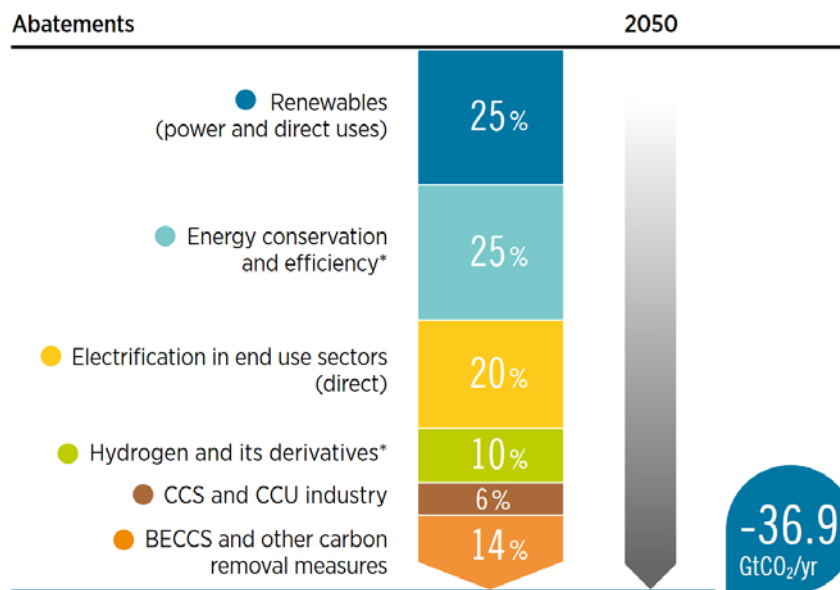


Figure 11: Carbon emissions abatements under IRENA's 1.5°C scenario by 2050 (IRENA 2021b)

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

2.2.1 Recommendations for Policy Makers

Milestones 2025

- Appropriate waste & land use policies
- Achievement of Aichi Targets
- Introduction of reporting criteria on climate & environment-related disclosures
- Require environmental impact assessments for mining, manufacturing & recycling

General Considerations

Recommendations

Integrate environmental sustainability considerations in policy making across fields

Including waste and pollution prevention, biodiversity conservation, water use, etc.

Regulations need to be harmonised among EU members; again, a common basis could be provided by IFC Performance Standards, incl. Standard 3 on Resource Efficiency and Pollution Prevention and Standard 6 on Biodiversity Conservation and Sustainable Management of Living Natural Resources

Waste Classification needs to be harmonised and the disposal of toxic materials carefully regulated (including the export of waste – receiving countries need to have similar standards in place)

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)

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, in particular from land-based activities, including marine debris and nutrient pollution (SDG 12)

Ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements (SDG 15)

Promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally (SDG 15)

Combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world (SDG 15)

Update/include requirements for environmental and climate impact assessments for all included sectors in sustainability policies.

Biodiversity Conservation needs to be improved across the EU

Most 2020 Aichi Targets by the Convention on Biological Diversity have not been met in time, throughout the EU. This requires urgent attention and improvement (Convention on Biological Diversity 2021; Earth.Org 2020).

The Convention on Biological Diversity is elaborating a Post-2020 Biodiversity Framework, this development needs to be supported and guidance integrated in policies. The Aichi Targets have been criticised because progress is difficult to measure due to their format and countries were not required to report on the measures taken to achieve them. These issues need to be addressed in the following programme with support from policy makers, industry and civil society (Nature 2020; Bennun et al. 2021).

Ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development (SDG 15)

Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and protect and prevent the extinction of threatened species (SDG 15)

Integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts (SDG 15)

Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems (SDG 15).

Develop and set reporting criteria on climate and environment-related disclosures.

Explanation

For the mining sector, but also in the construction of wind and solar PV farms, deforestation is an important issue to consider (Bennun et al. 2021; Dai et al. 2015; Turney and Fthenakis 2011). Regulations to prevent deforestation along the supply chain and in the installation of wind and solar PV farms are required, so as not to offset positive impact of the renewable energy technologies on GHG emissions. The New York Declaration on Forests has been adopted by the EU and its Goals 3 and 4 provide guidance for 'reducing deforestation from infrastructure and extractive developments' and 'support alternatives to deforestation driven by basic needs'. Progress towards achieving these goals both from governments and industry is slow and efforts need to be increased drastically (NYDF Assessment Partners 2020, 2021).

The Task Force on Climate-related Financial Disclosures (TCFD) provides reporting recommendations to organisations around climate-related risks and opportunities. These recommendations provide a good guidance for policy makers on what to include in reporting directives for companies, as well as providing a common approach for EU member states (TCFD 2021). Additionally, the Task Force on Nature-related Financial Disclosures (TNFD) is currently developing a framework for reporting guidance on nature related risks (TNFD 2021a).

Mining

Recommendations

Update mining regulations based on existing (voluntary) certification schemes

- New mines need to include regular auditing processes into their development plan to be approved
- Plans for new mines need to include mine closure plans and allocated funds for reclamation to be approved
- Implement ESG considerations in mining policies
- Harmonise EU mining regulations.

Transparent granting of mining licences and support of responsible EU mining projects.

Stop investment in and approval of new coal mines and coal mine extensions (IEA 2021).

Investment in increasing sustainability in mining

- Training and Education of experts for the extractives sector
- Financing of R&D and technical innovation.

Explanation

As mentioned in chapter 2.1, a plethora of mining standards have already been developed, differentiated by the processes deployed for their drafting, the type of mines and minerals they focus on and how comprehensive they are. For large-scale mining (LSM) the Initiative for Responsible Mining Assurance (IRMA) is a major mining standard that has been developed based on a broad multi-stakeholder process.

According to Kickler and Franken (2017) and Tost et al. (2018) IRMA is the most comprehensive standard currently available, especially considering its guidelines for water and biodiversity management moving towards strong sustainability (see chapter 1.4 Vision). IRMA can therefore provide a common basis for harmonising mining regulations and a starting point for auditing of mining operations to evidence responsible mining. IRMA has been developed in a consensus based multi-stakeholder approach.

However, many companies already adhere to or are certified under other standards, e.g., the ICMM Mining Principles (for all minerals and metals) or The Copper Mark (a relatively new standard for copper production only). A more detailed description of available standards and initiatives can be found in the [State of Play](#) report. If a company is already certified by a third-party auditor according to one of the other available standards, this needs to be recognised as well. Aspects missing, relative to IRMA should be subjected to supplementary audits. This will meet the interests of both miners and customers and aid the harmonisation of standards and requirements. Additionally, this prevents mining companies from being constantly forced to obtain new certifications because a new system is published.

EU mining policies need to be harmonised, and the approval of responsible new mining projects made possible. Access to raw material deposits needs to be ensured to provide critical raw materials for the energy transition and achievement of the SDGs (Nickless 2018). Various authors emphasise the necessity of developing international guidelines and governance for responsible minerals extraction to ensure access to responsibly sourced raw materials. More details in chapter 2.5.

Coal is still an important raw material for production of other products, e.g., silicon metal or steel. Alternatives are not yet ready for commercial production and further R&D is required. However, the pathway provided by the IEA to net zero by 2050 requires no further expansion of coal production, as it needs to be phased-out for energy production to achieve the Paris Agreement.

While the mining industry has a large environmental impact, it is still important to invest in the sector to develop new technologies and further sustainability ambitions. Divestment is a serious risk for responsible mining practices. This is also particularly relevant when it comes to educating the next generation. The extractives industry is struggling with an ageing workforce and very little interest from young people to work in the sector. It is important to set measures to ensure the availability of environmental and OHS inspectors in the future, as well as experts for sustainability considerations in mining operations. Firstly, policy makers need to inform the public better on the necessity and positive aspects of mining to increase interest. Secondly, high-quality study and training programmes need to be ensured, even with low numbers of participants.

Manufacturing & Recycling

Recommendations

Require Life Cycle Assessments (LCAs) for all new technologies/products.

Develop and implement environmental regulations for wind turbine and solar PV manufacturing and recycling.

Facilitate the transition to renewable energy sources in manufacturing/recycling plants.

Recycling Plants need to fulfil similar EHS guidelines as manufacturing plants.

Emissions (gas/water) need to be carefully regulated, especially considering toxic materials such as Cd-compounds in CdTe Solar Modules).

Revise land-use policies with focus on construction of renewable energy plants.

Explanation

Responsible or clean production guidelines should not only cover manufacturing itself (regarding use of renewable energy, chemicals, waste, etc.) but also at the entire life cycle of a product – from mining to recycling. The aim is to move from managing environmental impacts to ‘prevention at the source before environmental effects occur’ (Ceylan and Aydin March). An LCA provides an overview of all environmental impacts of a product, a service or a process and helps to identify stages with optimisation potential. This supports the development of product design with minimised environmental impact (Bongaerts 4/14/2021). A framework for LCAs is provided by ISO 14040:2006 Environmental management – Life cycle assessment – Principles and framework (ISO 2006).

At the time of the State of Play report, environmental standards or guidelines for wind turbine and solar PV manufacturing had not been developed. The American Wind Energy Association, now part of the American Clean Power Association (ACP), was working on a standard on environment, health and safety for wind turbines. However, no updates on this standard could be found.

Most existing standards focus on performance, design requirements, testing and monitoring, etc. Only the IFC provides Environmental, Health and Safety Guidelines for on- and offshore wind energy facilities for their entire lifecycle including some recommendations on the decommissioning of wind parks (International Finance Corporation IFC 2015). This should inform requirements and regulations for the sector in the EU.

Standards for solar PV modules mostly focus on technical aspects as well. The EU’s eco-design, energy label and ecolabel standards that are still under development, will hopefully provide further guidance on environmental aspects in solar PV manufacturing. The introduction of an emissions label for renewable energy technologies should be considered.

Considering recycling standards, solar PV modules are covered under the WEEE directive. The German Institute for Standardization (DIN) developed the standard DIN SPEC 4866 in cooperation with various companies, experts and government representatives for dismantling and recycling of wind turbines. This can provide a basis for an EU wide regulation.

Many companies are already very active in transitioning to renewable energy sources and are setting themselves ambitious targets. These efforts need to be supported by policy makers, e.g., by subsidies, or higher taxes for companies that still rely on fossil fuel energy systems.

Land-use policies for solar PV need to be revised and a solar rooftop programme developed (currently 90% of European rooftops are unused) (SolarPower Europe and LUT University 2020). The co-use of agricultural land and solar PV or wind farms needs to be facilitated and considered from the beginning of project planning; as the example of Austria's largest solar PV plant shows, which is also home to 150 sheep (Wien Energie 2020). Impacts on undeveloped lands from renewables needs to be taken into account (deforestation, land erosion, biodiversity loss, etc.) and the further development of unused green spaces for solar and wind farms should be largely prevented.



Figure 13: Co-use of land by renewable energy and agriculture at Austria's largest solar PV plant (Wien Energie 2020)

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 2030

- Reducing GHG emissions by >60% (from 1990 levels) (SolarPower Europe and LUT University 2020)
- Increase renewable energy capacity to 80% (Matthes et al. 2018)
- Net positive contribution to biodiversity
- Achievement of the 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
- Mandatory EHS Auditing for all stages of the Supply Chain

Milestones 2040

- Comply with Paris Agreement 1.5°C target¹⁷
 - 100% renewable energy
 - Net-zero emissions
- Increased electrification of industry to 40% (IRENA 2021b)¹⁸

¹⁷ According to SolarPower Europe (2020) 100% Renewable Europe, 100% renewable energy and net-zero emissions need to be achieved by 2040 in order to reach the Paris Agreement 1.5°C target

¹⁸ IRENA targets an electrification rate of industry up to 40% by 2050 (including indirect electrification). Due to the more ambitious targets of the RE-SOURCING renewable energy sector roadmap, this target is set for 2040.

Continuous Actions until 2030 & 2040

General Considerations

Recommendations

Significantly increase the share of renewable energy deployment and reduce GHG emissions, this includes the achievement of SDG 7 - Ensure access to affordable, reliable, sustainable and modern energy for all and cooperation with developing countries to support their energy transition

- Ensure universal access to affordable, reliable and modern energy services (SDG 7)
- Increase substantially the share of renewable energy in the global energy mix (SDG 7)
- Expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support (SDG 7)
- Support the electrification of industry
- Facilitate the uptake of new business models to improve the affordability of off-grid solutions (OECD and IEA 2017).

Mobilize significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation (SDG 15).

Explanation

Wind and Solar PV are seen as the two main technologies (next to Bioenergy and Hydropower) carrying the energy transition (IEA 2021; IRENA 2021b; Matthes et al. 2018). However, rather than setting specific targets for wind and solar PV capacities, the roadmap only sets a target for renewable energy capacity increase in general. This is done to ensure that new technologies and innovations can still enter the market and a competition between technologies is enabled.

IRENA (2020) emphasises the importance of coordinated deployment, integration and enabling policies for the transition to renewable energies.

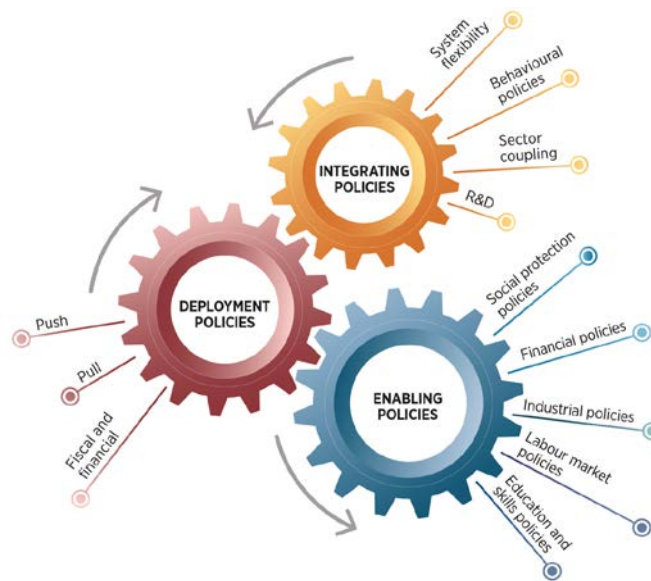


Figure 14: Holistic policy framework for a successful energy transition (IRENA 2020)

Balancing the need to foster the energy transition with the need for taxation, policy makers need to ensure that the brunt of the taxes and costs does not fall on the shoulders of the ordinary households, small companies, or energy cooperatives. Justice and equity need to be built into a new tax system, otherwise the population is likely to reject an energy transition, which would hamper the EU's climate targets.

IRENA (2021b) foresees an electrification of industry to nearly 40% by 2050 (including indirect electrification) up from 26% in 2018. However, further electrification of industry requires new developments to have improved economic feasibility. Policy makers need to support R&D in this area, as well as ensure feasibility by adjusting energy prices accordingly. For example, in Germany, a major challenge for realising the electrification potential of the industry are lower gas prices compared to electricity. (Bühler et al. 2019; Gruber et al. 2015).

Mining

Recommendations

Regulations for mining need to advance from responsible mining to sustainable mining

- Develop and implement guidelines for sustainable mining
- Introduce mandatory third-party audits.

Explanation

Auditing becomes mandatory for both currently operating and new projects. Former voluntary third-party certifications are incorporated in regulations as minimum requirements and continuous improvement and review are imperative. Regulations need to support the achievement of sustainability in the mining sector. The H2020 SUMEX project is elaborating a guidance for 'Sustainable Management in the Extractive Industries'; aiming at offering a toolkit and validated good practices and principles to companies and operations (SUMEX 2021).

2.2.2 Recommendations for Industry

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 2021b). 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 TFCFD. 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.

Mining

Recommendations

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 policy¹⁹

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 sourcing, 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 bringing 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.

¹⁹ 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 ²⁰
- 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

²⁰ 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.

Manufacturing

Recommendations

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.

Recycling

Recommendations

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.

2.2.3 Recommendations for Civil Society, Academia & Research Institutions

CSOs already play an important role in identifying bad practice cases and holding industries and supply chains to account. This monitoring and reporting function of CSOs, especially local and international NGOs, will continue to be essential in achieving the RE-SOURCING projects' targets. Advocacy focused NGOs provide important data for assessing and evaluating environmental and social impacts. It is essential that this work continues, as often this data provides crucial support for policy development. NGOs need to drive policy makers towards stringent environmental regulations for mining and production, as well as for the construction of wind or solar PV farms.

As already mentioned in Target 1, advocacy focused NGOs are important transmitters of information to the population. People need to be aware of the impact their personal behaviour has on the environment and climate, and this is a function NGOs can perform as independent third parties.

Key functions relevant for climate related and environmental as well as social issues include:

- Monitoring and reporting of violations of standards to governments, companies, and the public
- Support closure and remediation of the reported incidents
- Capacity building of small businesses
- Empower CSOs to train, monitor and support small businesses
- Solution providers! – help governments to make due diligence laws feasible and impactful, suggest accompanying measures to the law that make compliance possible for businesses and make monitoring of compliance for CSOs and governments possible

(Small) community associations are required to gather and consolidate the concerns of the community and communicate them through one channel to companies and governments. Particularly, in remote areas such as Chilean copper mining regions, where the water use in copper mining can have a significant impact on communities and the environment and other organisations supporting the interests of the communities are not as present. Local NGOs can support these efforts and provide important local expertise in finding solutions between communities, companies, and governments. In the preceding chapters, companies are encouraged to seek the expertise of local CSOs when setting up or improving operations. We see this as an important role of local NGOs or community-based organisations that do not have NGO status²¹. Local knowledge is crucial for impact assessments and successful mitigation plans. This cooperation is also a prerequisite to build resilience of communities against the effects of climate change. While many NGOs are working with mining companies to increase sustainability of operations, there remains a lot of resistance from other CSOs against mining in general. While environmental impacts certainly need to be minimised, it is also important for NGOs to acknowledge the necessity of mining for the renewable energy transition as well as our everyday lives.

²¹ NGO status refers to the recognition of NGOs by the UN and/or governments which creates an associated legal framework for their work; see for example NGO status by the UN: Edmund Rice International 2021, or NGO status in Austria: BMEIA 2021.

The scientific community should continue to inform governments and businesses on the state of environment and climate change. They need to develop models on the effectiveness of measures, outlining what needs to be achieved and by when, or the impact of inactivity. An important task is also to prepare scientific findings so that they can be understood by the ‘common person’. A lot of scepticism about climate change and the associated effects can be remedied through clear and understandable information. Additionally, the support of industry in conducting research on and developing new technologies with smaller environmental impacts (including emissions reductions, replacement of coal in production processes, etc).

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 15: Milestones to reach Social Sustainability & Responsible Production by 2030

2.3.1 Recommendations for Policy Makers

Milestones 2025

- Gender & Racial Equality
- Procedural & Distributive Justice
- Integration of Social-Life cycle assessment (LCA) & Life cycle planning (LCP)

General Considerations

Recommendations

- Review land-use policies and tenure rights to appropriately cover, cultural heritage, land acquisition, etc.*
- Incorporate meaningful stakeholder involvement in policy and strategy development processes.*
- Establish guidelines for companies on grievance mechanisms and stakeholder engagement processes.*
- Incorporate requirements for companies on support for local development and added value in production regulations as well as community health and safety.*
- Ensure the creation of decent jobs in new sectors.*
- Ratification of new International Labour Organization (ILO) labour standards.*
- Protect human rights defenders and support capacity building by CSOs.*

Explanation

Land-use policies need to consider aspects such as free-prior informed consent and fair compensation; this might require a review of tenure rights in some EU countries. The goal of establishing an EU wide system (or at least a common basis) should be pursued. IFC Performance Standards 5 on Land Acquisition and Involuntary Resettlement, 7 on Indigenous Peoples and 8 on Cultural Heritage can provide a basis for harmonised EU policies.

When expanding the renewable energy and recycling sector governments should consider the creation of decent jobs as alternative for workers losing their jobs in the fossil fuel industries. This also includes the provision of training opportunities.

The EU has ratified the core ILO conventions and is committed to participating and implementing ILO standards. However, new conventions such as the C190 on Violence and Harassment or the C189 Domestic Workers Convention have not been ratified by all EU member states. It is important to continuously update labour and social regulations and implement these technical guidelines. This will also support the harmonisation of regulations throughout the EU (ILO 2012, 2017).

In the mining and renewable energy space, human rights defenders, communities and other CSOs are increasingly exposed to dangers and threats (Figure 16). The Business and Human Rights Resource Centre highlights the importance of ‘mandatory human rights and environmental due diligence in the EU’ as key ‘to ensure that European companies respect human rights and prevent attacks on HRDs throughout their operations, supply chains, and investments’ (Business & Human Rights Resource Centre 2021). In neo liberal democracies where a deregulation of companies is common, CSOs are often expected to act as an extra layer of accountability. While this is an important role, CSOs are often under resourced and under capacitated. To ensure this ‘third-party monitoring’ by CSOs, governments need be prepared to support these organisations. CSOs should also be involved in the development of policies and auditing.

For that it is crucial to ensure the disclosure of all relevant data by companies. CSOs cannot provide support or give advice without knowing all the facts.

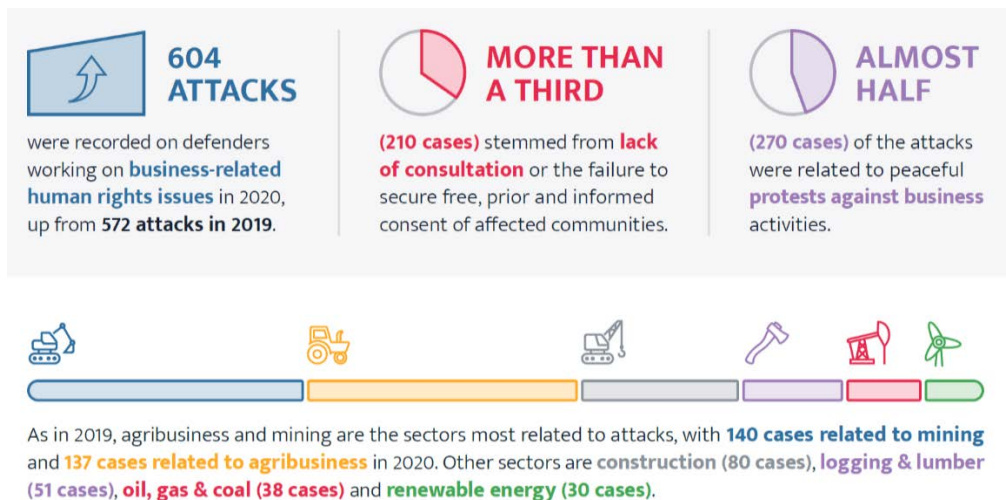


Figure 16: Recordings of attacks on human rights defenders in 2020 (Business & Human Rights Resource Centre 2021)

Mining

Recommendations

Develop and implement a common regulatory framework for all member states to ensure socially responsible mining in the EU.

Ensure and support mining companies contribute to sustainable development.

Explanation

As mentioned for environmental considerations in the previous chapter, mining policies also need to be reviewed considering the social impacts of mining operations. Existing voluntary mining standards can provide a common framework for all EU member states to ensure responsible mining in the EU (see previous chapters and the State of Play report for further explanation).

The UN Economic Commission for Europe (UNECE) provides policy recommendations for ‘Transforming Extractive Industries for Sustainable Development’. This policy brief recognizes the positive impact mining could potentially have on societal development and recommends measures to realise this potential.

Good Practice Recommendations for a consultative approach to designing national mining policies²²

Create a step by step participatory and inclusive approach to establish a vision, goals, and indicators for the mining policy. Draft a live memory/live document that is continuously amended during the consultative stages to keep track of the overall process of the consultation.

Take an approach that is open to input, critique and suggestions and presents an objective way of engaging with different stakeholders and their interests, regardless of background.

The design and use of different participatory formats (round tables, online and territorial consultations, technical working groups) to enable nationwide participation.

Physical multi-stakeholder roundtables aimed at experts as an initial scoping exercise of challenges to be addressed. Ask for written contributions to a shared, ‘living’ document.

Online registration for regional consultations, asking participants to indicate the topics they are most interested in.

Designing online surveys on a national mining policy portal. Holding virtual participatory workshops to allow for maximum participation. Additional targeted workshops to be organised for women, students, and mine workers.

Identify themes (axes) to better understand and contextualize issues and effectively address challenges of sustainability in mining that are relevant to more than one of the four dimensions of sustainability at a time, on which the consultative process should focus on.

²² 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’](#).

Manufacturing & Recycling

Recommendations

Review occupational health and safety regulations to incorporate issues specific to wind turbine and solar PV manufacturing.

Integrate social life cycle assessments in requirements for product development and operations planning

To manage impacts, support sustainability reporting and sustainable investment

To detect burden shifting and enable comparison of alternatives (Mancini and Nuss 2020).

Explanation

Occupational health and safety is an important issue in wind turbine manufacturing, especially in blade production where workers come into contact with epoxy resins and fibre glass (for details see State of Play report). The IFC EHS Wind Energy guidance provides a suitable framework to inform policy reviews. Similar challenges occur in the manufacturing of thin-film CdTe PV modules.

Similar to environmental LCAs, a social life cycle assessment (S-LCA) evaluates socio-economic impacts throughout the supply chain of a product. Guidance on the correct execution of a S-LCA is provided by UNEP (see Andrews et al. (2009) and Life Cycle Initiative (2020)).

The goal is to enable the detection of negative impacts (burdens) on all involved stakeholder groups at each stage of the product life-cycle; to detect burden shifting and to compare alternatives (Mancini and Nuss 2020).

Milestones 2030

- Achievement of 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
- Local & Regional Development
- Corrective Justice

General Considerations

Recommendations

Ensure damages to individuals and communities caused by policy decisions or companies are addressed in a fair and appropriate way, hold companies accountable for environmental and social damages and ensure repair of losses.

2.3.2 Recommendations for Industry

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.

‘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 17). 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.

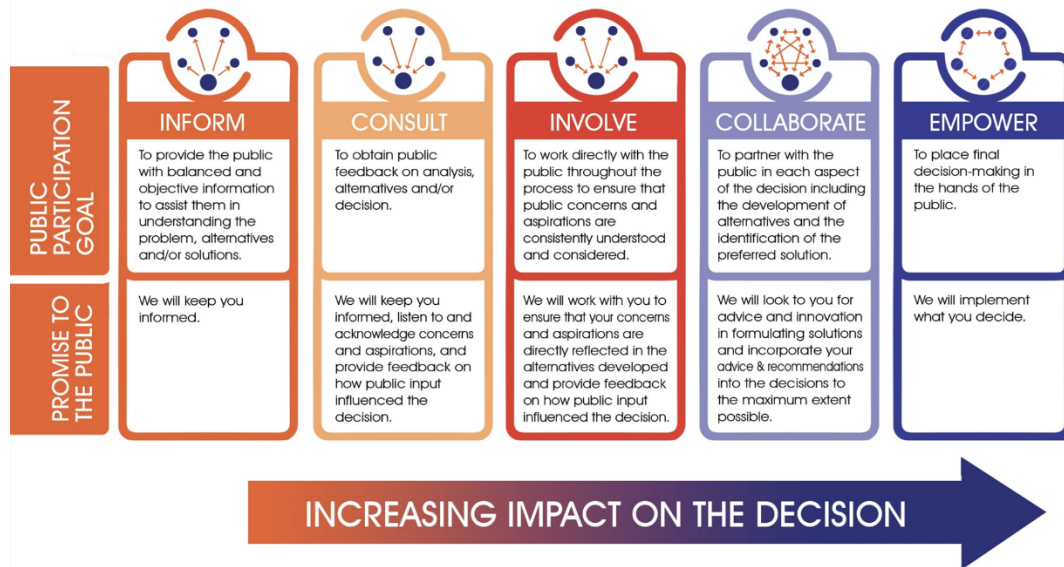


Figure 17: Levels and impacts of public participation (IAP2 Canada 2018)

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 18: 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).

2.3.3 Recommendations for Civil Society

Local NGOs should increasingly take on a mediating role and support a multi-stakeholder approach. This should ensure that, on the one hand, concerns of the local communities are heard, but also that sustainable developments by companies and policy makers are supported and promoted. This role is particularly important in the field of ASM. NGOs that are currently active in areas with a large ASM sector know the conditions and specifics on the ground. Both companies and policy makers need to be supported on what capacity building should look like and how it should be implemented. Capacity building, infrastructure development, etc. should always be done in consultation with the unique context of the local population and their wishes must be part of the decision-making process. Off-the-shelf solutions do not always lead to the desired results. There are various examples of NGO lead initiatives for the acceptance of ASM, however, mostly focused on gold mining. For example, the ARM's Fairmined Standard and CRAFT Code, Impact's Just Gold project, or planetGOLD. These programmes can serve as examples for copper ASM in Africa or South America and aid the transparency of supply chains.

Communities cannot be the primary monitor for practices by companies. This is the responsibility of state regulators. Nevertheless, community-based organisations are important to raise awareness of issues and to ensure that community concerns are heard. Both vis-à-vis governments and companies. International companies often do not know about local cultures and rely on information from local people (information gathering and cooperation with local organisations is included in the recommendations for companies). They can also support local development by aiding the start of cooperatives, other local businesses, or organising training opportunities and basic financial support.

Labour Unions play an important role, particularly in occupational health and safety aspects, worker rights as well as in supporting social sustainability in general. A good practice example is the framework agreement between IndustriALL Global Union and Siemens Gamesa, one of the largest wind turbine manufacturers worldwide. This agreement aims at improving social and environmental sustainability both in Siemens Gamesa's facilities and along the supply chain of the company. Commitments included are the respect for the new ILO Convention 190 on violence and harassment at work, life-long learning and training programmes for employees and supply chain due diligence based on the OECD guidance (IndustriALL 2019). This shows collaboration between labour unions and companies can lead to positive actions to support occupational health and safety of the employees, community health and safety along the supply chain and other major labour issues impacted by a company's operations.

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 19: Milestones for Responsible Procurement by 2040

2.4.1 Recommendations for Policy Makers

Milestones 2025

- Implement a standard for transparent mineral raw materials supply chains
- Include considerations on responsible supply chains in all Trade Agreements
- Resilient supply chains

General Considerations

Recommendations

Develop a standardised framework for supply chain due diligence.

Include IFC Performance Standards explained in previous chapters in supply chain due diligence as well (Cultural Heritage, Indigenous Peoples, Land Acquisition, etc.).

Support developing countries and incorporate international companies to support development along their supply chains to

End hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round (SDG 2)

Increase investment in rural infrastructure and technology development (SDG 2)

Increase Aid for Trade support for developing countries, in particular least developed countries, including through the Enhanced Integrated Framework for Trade-Related Technical Assistance to Least Developed Countries (SDG 8)

Promote and enforce non-discriminatory laws and policies for sustainable development (SDG 16)

Strengthen domestic resource mobilization, including through international support to developing countries, to improve domestic capacity for tax and other revenue collection (SDG 17)

Significantly increase the exports of developing countries, in particular with a view to doubling the least developed countries' share of global exports (SDG 17)

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)

Respect each country's policy space and leadership to establish and implement policies for poverty eradication and sustainable development multi-stakeholder partnerships (SDG 17).

Enforce high labour standards for international companies along their entire supply chains

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)

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).

Governments need to adopt the same supply chain due diligence standards required by companies

Promote public procurement practices that are sustainable, in accordance with national policies and priorities (SDG 12).

Promote the rule of law at the national and international levels and ensure equal access to justice for all (SDG 16).

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

Broaden and strengthen the participation of developing countries in the institutions of global governance (SDG 16).

Ensure public access to information and protect fundamental freedoms, in accordance with national legislation and international agreements (SDG 16).

Enhance North-South, South-South and triangular regional and international cooperation on and access to science, technology and innovation and enhance knowledge sharing on mutually agreed terms, including through improved coordination among existing mechanisms, in particular at the United Nations level, and through a global technology facilitation mechanism (SDG 17).

Explanation

Undertaking responsible procurement practices by governments or public administrations are equally important as by industry players. In the European energy transformation, large amounts of renewable energy are sourced from outside the EU. While the EU invests in the development of solar farms in African countries for example, many of these countries still live in energy poverty. The energy is exported to the EU and the population in the host countries are unable to fully profit from these developments. Additionally, livelihoods are threatened by land-grabs or large water requirements for solar farms. These practices need to be addressed immediately, and stopped completely, if a balance between local development and EU energy demands cannot be achieved. In the development of new foreign projects, the consideration of procedural and distributive justice is equally important. Local communities should be able to participate in decision making processes, as well as profit from the development of clean energy projects.

Mining

Recommendations

Develop and implement a standard for transparent mineral raw materials' supply chains.

Enable responsible mining in Europe, no more 'burden-shifting'.

Explanation

While the EU has already integrated the OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas in EU law, generally the tracking of minerals and metals is still a big challenge. Current solutions mainly rely on operators at the mining site to enter data into a system (e.g., blockchain). Fingerprinting of minerals, as a tool to cross-check the documented place of origin, have not been developed for copper, REEs and silicon yet (if that is at all possible). IRMA and CERA have both developed a chain of custody standard to make up for technological shortcomings and allow traceability of mineral raw materials from the mine to the manufacturer and the end-consumer. Both standards highlight the importance of compatibility with existing responsible sourcing standards (e.g., ResponsibleSteel or the Aluminium Stewardship Initiative). For the minerals and metals considered in this report, there are different mineral specific initiatives for responsible supply chains. REIA (The Rare Earth Industry Association) focuses on increasing transparency of REE supply chains. The Copper Mark, together with the International Lead Association, the Nickel Institute, the International Zinc Association, and the Responsible Minerals Initiative developed a Joint Due Diligence Standard for Copper, Lead, Nickel and Zinc supply chains. For polysilicon no specific standards or initiatives were identified at the time of the roadmap development. These standards and initiatives can serve as a reference to identify and legislate requirements for companies.

Manufacturing & Recycling

Recommendations

Raw materials and products imported from outside the EU need to fulfil the same sustainability requirements as operations inside the EU.

Explanation

Apart from the transparency of supply chains, companies should also be obliged to carry out risk assessments of their suppliers or supply chains. This should discourage and even exclude negative (social and environmental) practices; whilst promoting the improvement and development of suppliers. An example of such standards is provided by the Together for Sustainability Initiative for the chemical industry (relevant here especially for polysilicon). In the supply chain for polysilicon required for the solar PV industry, forced labour in the Chinese Xinjiang region is a significant issue (Murphy and Elimä 2021). Regulations for transparent reporting on labour practices along the supply chain can be put in place and companies need to be able to prove that those practices are not used in their supply chain to access the EU market.

The US already introduced sanctions on certain solar products coming from Xinjiang region, including metallurgical-grade silicon by Hoshine Silicon Industry (one of the largest polysilicon producers). The UK's Foreign Affairs Committee has also demanded a ban on imports of solar products from the region (Lempriere 2021). For many solar producers it is currently not feasible to move their production or sourcing elsewhere. Governments need to support the industry to develop other suppliers and set up production facilities in Europe.

Milestones 2030

- Supply Chain Due Diligence Law
 - Mandatory for large international players designed with features to ensure due diligence coverage of full supply chains
 - Accompanying measures to assist SMEs' implementation
 - Mandatory non-financial reporting
- Local/Regional Development
 - Incl. Procedural and distributive justice
- Support of the achievement of all SDGs mentioned in previous chapters along the supply chain

Milestones 2040

- Mandatory Supply Chain Due Diligence for all international actors (independent of company size)
 - Incl. control by government agencies
 - Environmental and Social Sustainability
 - Civil liability/accountability

Continuous Actions until 2030 and 2040

General Considerations

Recommendations

Implement supply chain due diligence law in the EU, mandatory for all large international players.

Implement control mechanism for supply chain due diligence measures.

Significantly increase supply chain transparency

Transparent ESG reporting has to be provided by all companies producing and trading in the EU, transparency is a prerequisite for supply chain due diligence

Introduction and implementation of the EU Non-financial Reporting Directive.

Companies wishing to access the European market must provide information on their supply chains (incl. environmental and social practices).

Support the achievement of the SDGs along the supply chains:

Ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance (SDG 1)

Build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters (SDG 1)

Ensure equal access to land (SDG 2)

Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws (SDG 5)

Adopt and strengthen sound policies and enforceable legislation for the promotion of gender equality and the empowerment of all women and girls at all levels (SDG 5)

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

Implement the principle of special and differential treatment for developing countries, in particular least developed countries, in accordance with World Trade Organization agreements (SDG 10)

Encourage official development assistance and financial flows, including foreign direct investment, to States where the need is greatest, in particular least developed countries, African countries, small island developing States and landlocked developing countries, in accordance with their national plans and programmes (SDG 10)

Develop effective, accountable and transparent institutions at all levels (SDG 16)

Ensure responsive, inclusive, participatory and representative decision-making at all levels (SDG 16)

Adopt and implement investment promotion regimes for least developed countries (SDG 17)

Fully operationalize the technology bank and science, technology and innovation capacity-building mechanism for least developed countries and enhance the use of enabling technology, in particular information and communications technology (SDG 17)

Enhance international support for implementing effective and targeted capacity-building in developing countries to support national plans to implement all the sustainable development goals, including through North-South, South-South and triangular cooperation (SDG 17)

Promote a universal, rules-based, open, non-discriminatory and equitable multilateral trading system under the World Trade Organization, including through the conclusion of negotiations under its Doha Development Agenda (SDG 17).

Explanation

Evaluating the German plans for a supply chain due diligence law, the Initiative Lieferkettengesetz (Initiative supply chain law) provides recommendations of requirements to be included in a suitable supply chain due diligence law.²³ Some of their requirements are summarised below:

- Appoint a responsible government agency for supply chain due diligence
- Integrate UN Guiding Principles on Business and Human Rights into supply chain law and requirements for companies and the OECD Guidelines for Multinational Enterprises and OECD Guidance for Responsible Supply Chains of Minerals into supply chain law and requirements for companies
 - Both UN and OECD Guidelines include risk analysis with obligation to investigate, prevention and mitigation measures, grievance mechanism and remediation
- Transparency and documentation of supply chains and operations
- The disregard of due diligence obligations, as well as the non- or incomplete submission of a due diligence plan, should be linked to clear penal consequences under public law
- Companies are liable for human rights violations caused by their failure to comply with due diligence obligations
- Integration of dedicated environmental due diligence obligations to improve environmental standards along global supply and value chains, including the mandatory implementation of environmental management systems by companies (Henn and Jahn).

To further harmonisation of future legal requirements and already existing standards, former voluntary certification schemes for responsible sourcing (e.g., Together for Sustainability (TfS), EcoVadis) should be accepted, provided a certification via third-party audits is available and reviewed on a regular basis. Aspects missing from existing schemes need to be re-audited. Regular third-party auditing and improvements are required. While we recognise the importance of audits and certifications for ensuring sustainable practices, it also needs to be recognised that an audit can only be a snapshot of a specific moment in time. Companies need to be held accountable for what they claim in their sustainability reports or similar. This can be ensured by transparent reporting on their actions to achieve their claims.

Supply chain due diligence also needs to consider local and regional development, by supporting the development of infrastructure, fair payment, etc. Without fulfilling EU standards for responsible production in all stages of the supply chain, trading in the EU should not be possible. However, it is important to emphasize that trade is not a 'one-way street', and the EU has a responsibility to support their partners. Companies or countries that are currently not meeting EU standards need to be supported in their capacity building. It should be recognised that this development takes time and cannot be achieved over night. This means, the EU will need to support trade partners who are willing to improve their practices to meet the standards in time.

²³ For more information on the demands of the Initiative Lieferkettengesetz, see Initiative Lieferkettengesetz 2020 (German only)

Transparency

Transparency is a prerequisite for supply chain due diligence. To understand and manage the impacts of solar PV and wind turbines, their chain of custody, origin of raw materials and the production conditions (as well as support processes) need to be known (SolarPower Europe 2021). While it is important for governments to set regulations for reporting and disclosure, transparency can only be achieved in a joint bottom-up effort of all involved stakeholders.

Especially considering the energy transition that needs to be supported by the broad public, only open reporting on procurement and manufacturing practices can create the necessary level of trust. The collaboration of stakeholders is required to design and implement suitable mechanisms to collect, review and publish data. A suitable control mechanism for the published data needs to be established as well. Policy makers can support this process by setting up working groups involving representatives of all relevant supply chain actors, as well as CSOs and the public.

Generally, the EU non-financial reporting directive and planned sector-specific due diligence laws need to be implemented and address such issues. An example is already provided by the EU battery regulation and should be transferred to the renewable energy sector.

For the extractives sector, the Responsible Mining Foundation (RMF) assesses mining companies and mine sites based on their publicly available documents and reports (or 'evidence-based assessment [...] on environmental, social and governance issues' (RMF 2020)). The requirements provided by this assessment serve as an important guidance for policy makers on what to expect from companies.

Mining

Recommendations

Supply Chain Due Diligence for Mining Sites

Explanation

A supply chain due diligence law needs to recognise, that the supply chain of mineral raw materials does not end at mine gate. Mining companies need to meet the same responsible procurement requirements as downstream businesses, as procurement accounts for a large part of a mining company's economic output. Additionally, organisations tracing material to mine gate, also need to consider the procurement practices of mining companies in their supplier assessments.

2.4.2 Recommendations for Industry

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.

Explanation

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 resources²⁴

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.

²⁴ 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](#)'.

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.

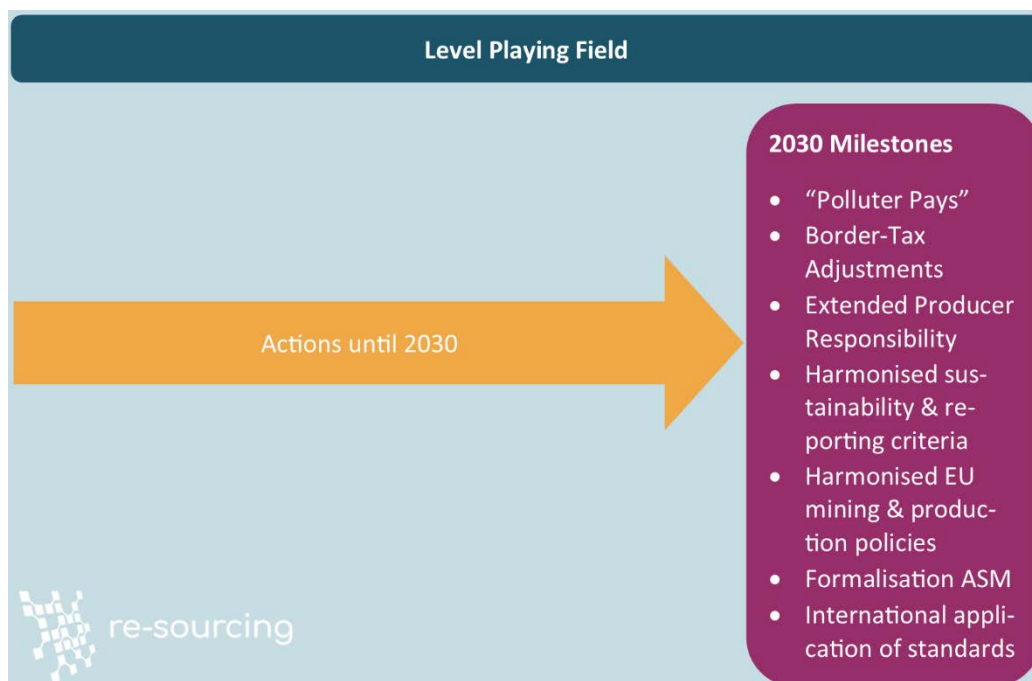


Figure 20: Milestones for a Level Playing Field by 2030

2.5.1 Recommendations for Policy Makers

Milestones 2030

- “Polluter Pays” Principle and Introduction of Border-Tax Adjustments
- Clear global criteria for responsible and sustainable practices
- Harmonised reporting systems
- Harmonised EU mining policies
- Responsible production policies
- Extended producer responsibility
- Formalisation Artisanal and Small-Scale Mining (ASM)
- Achievement of the SDGs 1, 5, 6, 7, 8, 9, 10, 11, 17

General Considerations

Recommendations

Introduction of social and environmental border tax adjustments as a first step towards a level playing field.

Internalisation of external costs (“unsustainability is unprofitable”).

Require companies to apply the same social and environmental standards in all their operations.

Work towards the achievement of the SDGs on a global level with effective international cooperation:

Create sound policy frameworks at the national, regional and international levels, based on pro-poor and gender-sensitive development strategies, to support accelerated investment in poverty eradication actions (SDG 1)

Ensure significant mobilization of resources from a variety of sources, including through enhanced development cooperation, in order to provide adequate and predictable means for developing countries, in particular least developed countries, to implement programmes and policies to end poverty in all its dimensions (SDG 1)

Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women (SDG 5)

End all forms of discrimination against all women and girls everywhere (SDG 5)

Ensure women’s full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life (SDG 5)

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)

Enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology (SDG 7)

Achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value (SDG 8)

Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets (SDG 9)

Promote inclusive and sustainable industrialization and significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries (SDG 9)

Support domestic technology development, research and innovation in developing countries, including by ensuring a conducive policy environment for, inter alia, industrial diversification and value addition to commodities (SDG 9)

Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending (SDG 9)

Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support to African countries, least developed countries, landlocked developing countries and small island developing States (SDG 9)

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)

Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries (SDG 9)

Empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status (SDG 10)

Ensure equal opportunity and reduce inequalities of outcome, including by eliminating discriminatory laws, policies and practices and promoting appropriate legislation, policies and action in this regard (SDG 10)

Adopt policies, especially fiscal, wage and social protection policies, and progressively achieve greater equality (SDG 10)

Improve the regulation and monitoring of global financial markets and institutions and strengthen the implementation of such regulations (SDG 10)

Ensure enhanced representation and voice for developing countries in decision-making in global international economic and financial institutions in order to deliver more effective, credible, accountable and legitimate institutions (SDG 10)

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

Explanation

The introduction of border-tax adjustments to account for differences in the environmental performance and social standards (including occupational and community health and safety, fair wages, etc.) of production processes outside the EU is an important measure to improve competitiveness of European manufacturers. However, border-tax adjustments also need to take capacities of developing countries into account. Many minerals and metals crucial for the renewable energy sector are sourced from developing countries. It is imperative to ensure that their due diligence efforts are supported to achieve the required environmental and social standards for the EU market. The EU needs to assist countries to responsibly manage their natural resources, achieve or maintain high due diligence standards and for them to build their own production capacity (in line with the SDGs). In return for the capacity support, countries are also more likely to agree to guaranteed and balanced access to good quality products and sustainably mined minerals and metals for EU consumers. However, the EU demand should not overrule the national needs of the resource-rich countries and undermine their transition to renewable energies.

European companies are required to apply the same high social and environmental standards in every country they operate, using lower standards in other countries should be penalised. Possibly implement a bonus-malus system, supporting companies adhering to high standards throughout their production locations and supply chains and increasing taxes for companies that do not.

Mining

Recommendations

Strengthen international cooperation to develop harmonised mining standards for responsible extraction.

Support development of new sustainable mining projects in the EU.

Imported raw materials need to fulfil the same standards in their extraction and processing as EU mined raw materials.

Explanation

Nickless (2018) illustrates the limits of current mineral production with the example of copper. If we continue to do business-as-usual, we will be 30 Mt short of copper in 2050. In addition to the absolutely necessary reduction of demand and increased recycling (see chapter 2.1), the exploration and development of new resources is necessary to meet demand.

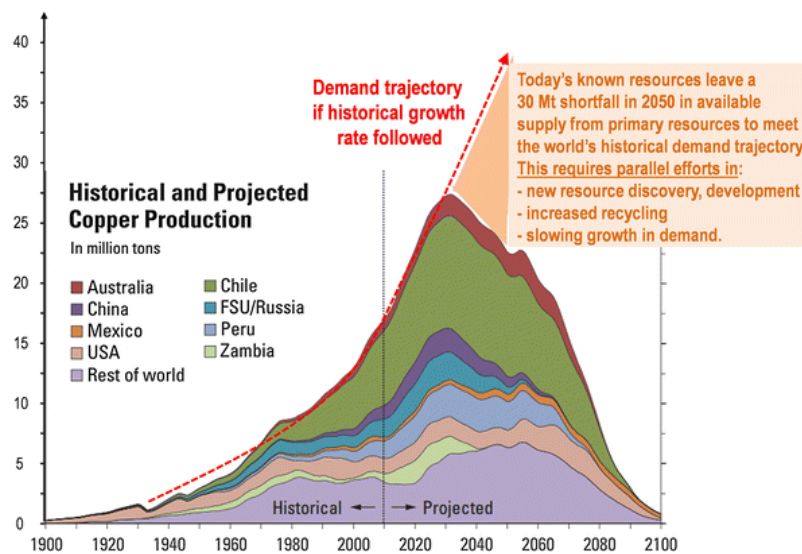


Figure 21: Historical and projected primary copper production compared to projected demand (Nickless 2018)

To ensure a continuous supply of the minerals and metals required for the energy transition, Ali et al. (2017), Mancini and Nuss (2020), and Nickless (2018) highlight the importance of international resource governance mechanisms with focus on responsible and sustainable sourcing. Ali et al. (2017) suggest six measures to be considered: (i) reach consensus on international targets for global mineral production; (ii) monitor impacts of mineral production and consumption; (iii) improve coordination of mineral exploration; (iv) support investment and research into new mineral extraction technologies; (v) harmonise global best practices for responsible mineral resource development; and (vi) develop maps and inventories showing the availability of recyclable metals. The resolution on mineral resource governance by the United Nation Environmental Assembly in 2019 is an important step in this direction and needs to be supported and implemented by all stakeholder groups.

The harmonisation of requirements for raw materials entering the EU is necessary to create a level playing field for companies producing raw materials under the high social and environmental standards in the EU. However, it is important to avoid curtailing ASM’s access to markets as long as sourcing is done in line with the OECD Due Diligence Guidance and continuous improvement over time.

Artisanal and Small-Scale Mining

Formalise ASM operations and ensure easy access to markets.

Cooperate with organisations such as ARM or Impact to support sustainable development of ASM operations.

ASM needs to be supported to build capacity and include environmental and social considerations in their operations, certifications and audits usually require large investments that are not possible for the ASM sector, therefore cooperation between ASM and customers needs to be supported by policy makers, e.g., by reducing taxes for companies engaged in local development of the ASM operations and communities.

To enable capacity building an enabling operating environment is required, i.e., good governance. Chile supports its ASM copper sector via The Chilean National Mining Corporation ENAMI that supplies technical, financial, and other support to ASM and buys their product. This is currently not possible in African copper ASM due to missing governance structures. EU policy makers need to support developing countries in establishing a framework supporting the formalisation of ASM. Considerations include – participatory and inclusive law and policy design, enforcement of laws (incl. fight against corruption and money laundering).

Manufacturing

Recommendations

Apply the same standards for imported goods as for products produced within the EU.

Goods manufactured with higher social and environmental standards should be preferred over others (e.g., lower taxes).

Support small and medium-sized enterprise (SMEs).

Explanation

Policies need to ensure that SMEs and start-ups are supported, and not only large energy companies survive due to increased due diligence costs. A renewable energy sector with a larger number of companies promotes competition and the development of new technologies. Especially, large fossil fuel companies should be prevented from forcing out smaller players when changing their business sector.

2.5.2 Recommendations for Industry

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.

2.5.3 Recommendations for Civil Society

The level playing field will be a difficult goal to achieve, but one that is all the more important for achieving sustainable and responsible global supply chains.

International NGOs can support this development by playing a mediating role between different countries and stakeholders. Especially for countries with conflicting political interests, an independent advisory body is of great importance. Another important step is the harmonisation of reporting requirements and the mutual recognition of legal regulations as well as audits and certifications.

Both local and international CSOs should support information campaigns for the public, around the necessity of the development of raw material projects or the construction of wind and solar farms, etc. The NIMBY (Not In My Backyard) phenomenon is a significant challenge for the energy transition in the EU. People need to understand the necessity of these developments and be willing to compromise in order to maintain living standards. Awareness raising and educating people is an important task for NGOs.

Mining companies are often confronted with rejection and resistance from the general and local populations. Given the EU's aim to promote new projects on its own territory, it is particularly important to bring all stakeholder groups on board. As already highlighted in the industry recommendations, cooperation and involvement of local communities is crucial. In this context, the EU funded project MIREU has developed SLO guidelines and tools for all stakeholder groups. Aspects relevant for civil society are among others, what communities can expect from a mining project in Europe, help identify what SLO level the respective mining project is at, what standards are applicable, etc. A common understanding can help future stakeholder engagements and the development of joint SLO targets (Tost et al. 2021). Organisations, such as Women in Mining in the US, already do important work in educating both its members and the public about the mining and related industries.

Women in Mining also engage in educating students about career opportunities and the importance of mining in our everyday lives (Women In Mining 2021).

In general, professional and labour associations can support efforts for both responsible procurement and the development of a level playing field. Information of members and communities on legal aspects, current industry developments and supporting education and training are only few of the areas where these associations can contribute.

2.5.4 Role of International Organisations (UN/OECD/IFC)

Due to the complex and global structure of the renewable energy sector's supply chains, it is important that international organisations such as the UN and the OECD are strengthened. These organisations have an important contribution to make in shaping the level playing field and harmonising the requirements for companies. The role of the UN's international judiciary should also be extended to companies, so that internationally operating companies can be held more easily accountable for financial offences, as well as crimes against the environment and humanity.

The three organisations, the UN, OECD and IFC, already provide important templates for responsible behaviour by international companies in general. In addition, there are specific guidelines for mining, manufacturing, and responsible sourcing of raw materials, all either specific to or applicable to the commodities under consideration. These guidelines need to be implemented by member states on a mandatory basis and without delay, thereby also supporting an international level playing field.

3 Conclusion

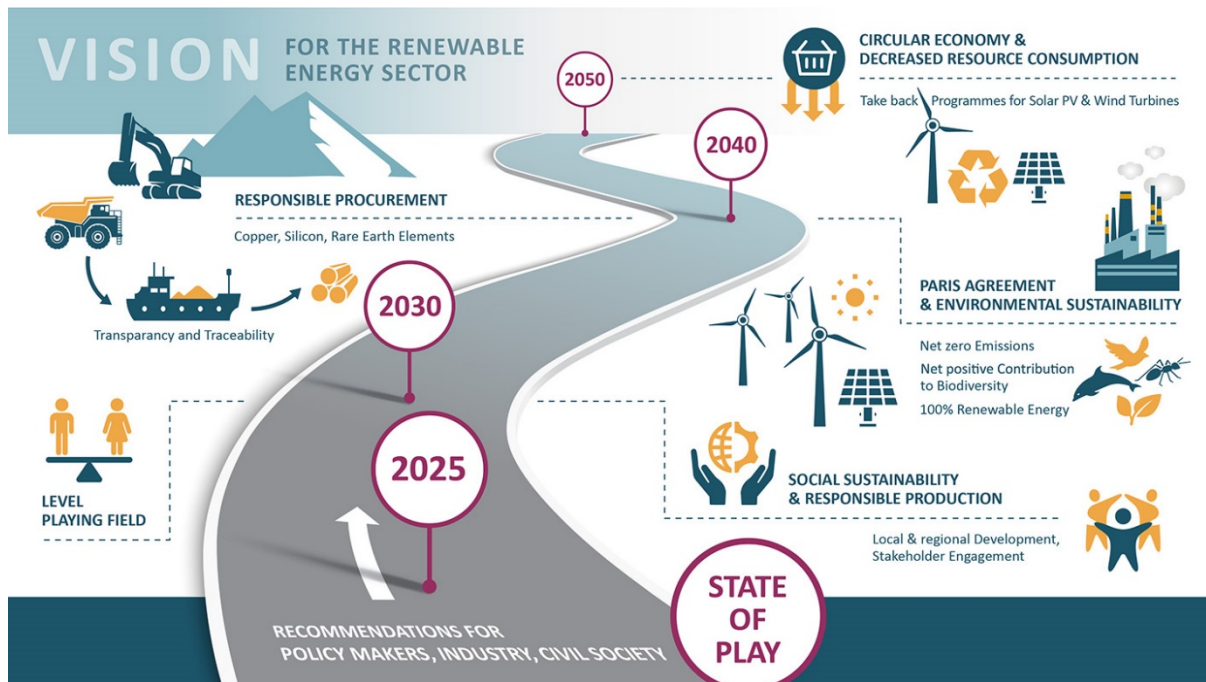


Figure 22: Roadmap for the renewable energy sector until 2050

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 all stakeholder groups, 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 22). 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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