Sector supply-chain guidance – wind energy

European Bank
for Reconstruction and Development

1. Introduction

This note focuses on actions a project sponsor or developer of a wind power project can take to help manage the social and environmental risks associated with assembling key components of wind turbine generators (WTGs). The project sponsor may be an EBRD client to which the Bank is providing direct finance or a sub-borrower of one of the Bank's financial intermediaries (FIs). It can also be an investee company of a fund in which the EBRD is investing.

In some cases, a project sponsor will contract an engineering, procurement and construction contractor to build the wind power facility and it, in turn, will procure modules from a WTG supplier. Alternatively, particularly in the case of medium-sized wind deals, a project sponsor will contract a WTG supplier directly and it will be responsible for construction, operation and maintenance. The WTG supplier may be a vertically integrated original equipment manufacturer (OEM) or may assemble components manufactured by sub-suppliers.

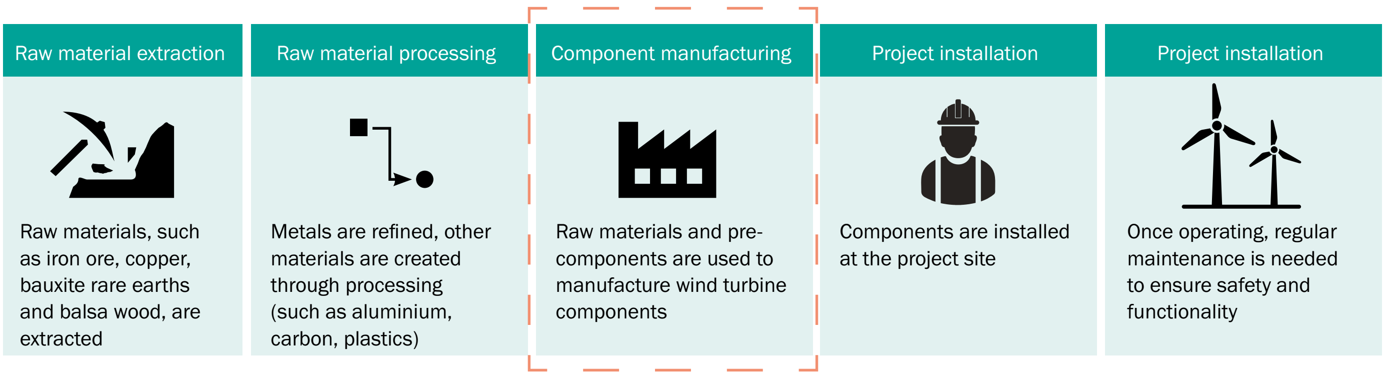
There are, therefore, multiple parties involved in the contracting chain for wind power projects and multiple parties involved in the WTG manufacturing supply chain. This guidance focuses on practical actions a project sponsor can take to improve the visibility and management of social and environmental risks in the WTG manufacturing supply chain.

Note, too, that investments in WTG may take various forms. As standalone energy generators, wind farms can contribute to the grid. However, they can also supply energy directly to businesses of different sizes, as well as to (municipal) infrastructure. The principles outlined in this guidance also apply to these projects, where wind energy is a material component of the project.

1.1. Overview of the WTG manufacturing supply chain

The WTG supply chain can be broken down into various stages from the mining of raw materials to the operation and maintenance of wind turbines. Of the various supply-chain stages, component manufacturing is the core supply chain and, thus, the focus of supply-chain due diligence. Specifically, this includes the 25 WTG core components listed in Figure 1.

Figure 1. Overview of the WTG supply chain and core components



Rotor	Nacelle		Rotor
Rotor blade	Main shaft	Yaw system	Tower
Pitch bearing	Main bearing	Generator	Foundation and
Pitch system	Main gearbox	Power converter	foundation adaptor
		Transformer	

Source: International Electrotechnical Commission and Certification Body Subcommittee (n.d.).

The production of key components requires a large volume of different raw materials.

- **Support structure:** The foundation is usually made of steel and/or concrete and the tower is made of either steel or cement.
- **Nacelles:** Generators contain iron and rare earth elements, such as neodymium, dysprosium, praseodymium, boron and terbium. For the magnetic field of the generators, a copper coil is required for geared turbines, while permanent magnets are installed in direct-drive turbines. Where permanent magnets are used, these also contain rare earth elements. The gearbox is made of stainless steel, containing chromium, manganese, selenium, molybdenum and niobium.
- **Rotors** are made of balsa wood, carbon, glass fibre and epoxy resin.

2. Supply-chain mapping and traceability

2.1. Production and supply-chain context

The wind supply chain is currently highly globalised, with a strong focus on China. China dominates the manufacturing of wind energy components (50-80 per cent of global capacity for most individual components)[1] and wind turbine installation (about 66 per cent of global manufacturing capacity in 2022).[2]

Table 1. Wind component production capacity, 2023

Wind turbine		Rotor blades		Nacelle		Tower		Foundation (offshore)	
Market share	Country/ region	Market share	Country/ region	Market share	Country/ region	Market share	Country/ region	Market share	Country/ region
60%	China	61%	China	60%	China	53%	China	76%	China
19%	Europe	13%	Europe	19%	Europe	18%	Europe	16%	Europe
9%	USA	9%	South America	9%	USA	11%	North America	5%	Asia Pacific[3]
7%	India	8%	India	7%	India	7%	India	2%	India

Source: Global Wind Energy Council and Boston Consulting Group (2023).

Mining for the most important raw materials for WTG component manufacture – such as iron, zinc and copper – is heavily centralised in a small number of countries. The largest producers of copper are Chile, Peru and the Democratic Republic of the Congo. The largest iron ore producers are Australia, China and Brazil. China produces by far the greatest volumes of zinc, followed by Peru and Australia.[4] The refining of critical rare earth minerals for wind turbine permanent magnets is done almost exclusively by China,[5] which is also responsible for nearly 70 per cent of all rare earth element extraction.

Balsa wood is mainly produced in Latin America – particularly Ecuador (which accounts for over 90 per cent of exports) and, increasingly, Peru – typically in secondary forest that originates from fallow agricultural areas on indigenous community and smallholder farmer lands.[6]

Table 2. Key control points

Raw material refiners	Refiners play a key role in most raw material value chains. While many mining companies are often involved, there are usually only a few refiners. Consequently, they have a large market share, so are key players in providing traceability to mining level.
Wind turbine manufacturers	Wind turbine manufacturers have different levels of vertical integration, resulting in some components being manufactured in house while others are supplied externally.

2.2. Traceability

While there are several certification schemes in place for the technical quality of wind power projects, these currently offer very limited supply-chain traceability and transparency capabilities.

However, a supply-chain risk assessment should capture all risks, including at the raw-material stage. The traceability of mined minerals is a challenge that is only starting to be addressed by industry actors. For individual raw materials, chain-of-custody standards have been set by certification organisations such as the Initiative for Responsible Mining Assurance (IRMA), the Aluminium Stewardship Initiative (ASI) and Copper Mark. However, due to the low market share of certified materials, the reach of these traceability schemes is still very low. As non-certified materials are mostly blended throughout the supply chain, it is frequently not possible to determine the origins of raw materials included in any product. As the WTG supply chain is usually only a comparatively small consumer of raw materials, cooperation across sectors may be necessary to increase leverage.

Key resources on traceability

- IRMA chain of custody draft standard
- ASI chain of custody standard
- Copper Mark chain of custody standard

[1] See IEA (n.d.) and Global Wind Energy Council and Boston Consulting Group (2023). [2] See EnerData (2024). [3] Asia and Pacific, excluding China and India. [4] See US Geological Survey (2024). [5] See Global Wind Energy Council and Boston Consulting Group (2023). [6] See Forest Policy Trade and Finance Initiative (2022).

2.3. Overview of potential actions to improve mapping and traceability

The crucial first step in improving supply-chain mapping is understanding the structure of the WTG supply chain to the level of the component manufacturer. This entails the following for each key component (see the list of key components in Figure 1):

1. Indicate all sources of the component being produced/that will be produced for the project:
   a. company's own manufacturing and assembly facility
   b. tier 2 suppliers/vendors (indicate the number of suppliers).
2. Specify whether wind turbine components are fully traceable:
   a. own manufacturing and assembly facility (indicate country, where the facility/plant is based)
   b. tier 1 suppliers/vendors (indicate the legal name of the supplier/manufacturer, country and region, where the facility/plant is based).

3 Supply-chain risk identification

3.1. Child labour

Child labour is not reported to be a significant risk in the **manufacturing of WTG components.** Due to the nature of mining activities, child labour in the extraction of key raw materials used in WTG supply chains is likely to constitute the **worst form of child labour.**[7]

3.2. Forced labour

In China's north-western Xinjiang province, there are persistent concerns over labour transfer schemes.[8] The United Nations has expressed serious concern about the coercive measures being used.[9] This is relevant to the wind turbine supply chain because China is the uncontested global leader in mineral refining capacity, and many such processing sites are located in Xinjiang. There is also a high concentration of manufacturing of **wind turbines** and **wind turbine components in this region.**

In terms of other key raw materials used in WTG supply chains, there are some reported forced-labour risks in relation to extraction and mining. In the Democratic Republic of the Congo and Zambia, cases of forced labour have occurred in artisanal and small-scale mining (ASM) sites. where combined **cobalt** and **copper** mining occurs.[10]

3.3. Deforestation

Although far less relevant than agriculture, mining is the fourth-largest driver of deforestation worldwide,[11] particularly bauxite and **iron ore** mining.[12] Intense logging of **balsa wood** in Ecuador has led to high rates of deforestation. The **construction, installation and maintenance** of wind projects has only been associated with forest loss on a small scale.[13]

Sources on deforestation in raw material extraction and processing

- Balsa wood: Forest Policy Trade and Finance Initiative 2022, The Economist 2021, Mongabay 2023
- Bauxite: European Commission 2021, National Committee of the Netherlands 2023, Mining Magazine 2023, Mongabay 2023
- Cobalt: The Metals Company 2023, SOMO 2016, World Bank 2013, Guardian 2022
- Copper: Mongabay 2018, Material Flows n.d.
- Iron ore: Reuters 2022, Flora and Fauna International 2020
- Limestone: AP News 2021
- Nickel: GIZ 2022, Satya Bumi 2023, Climate Rights International 2024: 64-68, Business and Human Rights Resource Centre 2023
- Rare earths: Environmental Justice Atlas 2023, WWF n.d.

3.4. Risk of harm

The manufacture and repair of wind turbine components pose similar safety risks to other industrial jobs (for example, automotive or aerospace), such as handling heavy machinery, electrical hazards and noise. However, in the wind industry, the risks related to hazardous substances are greater, particularly fibre-reinforced plastics and epoxy resin. Without proper care, fugitive emissions and splashes in the manufacturing and repair processes can lead to significant health risks, such as skin diseases, negative reproductive effects, throat and eye issues, and dizziness.[14]

During **project installation and maintenance**, workers are exposed to electrical hazards, burns, crush injuries, arc fires, noise and vibration. As wind turbines are designed to be installed at the levels of greatest wind intensity, workers are at high risk of falling from great heights.[15] Offshore wind farms generally have higher risks due to added noise levels (such as helicopters) and additional levels of stress based on working in rough conditions at sea.[16] As workers often need to operate at great heights, the provisions and usage ~~of~~ training on appropriate protective equipment is extremely relevant.

All **extractive industries carry inherent risks to physical safety and health** in producing countries when it comes to the supply chain of raw materials. The more informal a mining operation, the more pronounced the risk to life and limb, generally speaking. Particularly in ASM and highly informal sectors, such as **cobalt, ASM copper, nickel** and **rare earths**, the severe injury and death of miners is commonplace.[17]

[7] See ILO (n.d.), US Department of Labor (2023a) and US Department of Labor (2023b). [8] See US Department of Labor (2023c). [9] See UN OHCHR (2022). [10] See US Department of Labor (2023a) and US Department of Labor (2023b). [11] See Chatham House (2020). [12] See WWF, WU Vienna and Satelligence (2023). [13] See Murray (2023). [14] See European Agency for Safety and Health at Work (2013) and German Federal Ministry of Labour and Social Affairs (2023). [15] See European Agency for Safety and Health at Work (2013), US Department of Labor (n.d.) and Canadian Centre for Occupational Health and Safety (n.d.). [16] See Karanikas et al. (2021). [17] See Innotech (2023).

Sources on harm in raw material extraction and processing
• Bauxite: Forests & Finance 2022, German Federal Ministry of Labour and Social Affairs 2023: 24 • Cobalt: Washington Post 2023, NYU Stern Center for Business and Human Rights and Geneva Center for Business and Human Rights 2023, BGR 2019: 39-42, 2021: 47-49 • Copper: BGR 2019: 39-42, 2021: 47-49, MoLSA 2023: 34. Kitenge et al. 2022 • Iron ore: Forests & Finance 2022, Mining.com 2021, MoLSA 2023: 39 • Nickel: GIZ 2022, Müller/Reckordt 2017, TrendAsia 2023, Forests & Finance 2022 • Rare earths: Global Witness 2022, China Labour Watch 2022: 53-62

3.5 Overview of potential risk identification actions

Table 3. Potential actions to identify risk

Examples of foundational actions	Examples of intermediate actions	Examples of leading practices
Define supply-chain structure for a specific project Map WTG supply chain **Risk-screen** supply chain	For the designated WTG vendors, complete a **labour audit:** • International labour consultant audits WTG vendor's designated facility(ies) Review WTG vendor's supply-chain management and corrective measures agreed (as necessary)	**Risk-screen tier 2 suppliers** by: • undertaking a media search for (in English, Chinese, other major languages) any linkages to forced labour or associated programmes/schemes • checking physical presence in high-risk areas • checking sanctions for grave labour/human rights violations Check linkages with other supply-chain risks

4. Risk mitigation

Effective risk mitigation for the raw-materials stage is likely to include participation in industry certification schemes and multi-stakeholder initiatives. For the WTG core supply chain, a set of more specific due-diligence measures is required.

4.1. Multi-stakeholder initiatives and certification schemes

4.1.1. Raw materials

At the raw-material level, multi-stakeholder initiatives aim to bring together brands, supply-chain actors, civil society and public actors. They can serve to facilitate dialogue between downstream expectations and upstream pushbacks, as well as between local communities and large corporate entities. Ideally, multi-stakeholder initiatives can lead to more stringent requirements at the mining and processing level and a greater willingness to adopt these requirements by upstream companies. Most of these operators have also established certification or assurance models. These vary in terms of governance, ambition with regard to requirements and the scope of materials included.

- The Initiative for Responsible Mining Assurance (IRMA) standard: IRMA is widely recognised as industry leader in responsible mining assurance because of its multi-stakeholder governance, extensive sustainability requirements, transparency and wide scope, encompassing all mined materials.[18] It is one of the most ambitious and far-reaching standards on mined minerals. At the same time, its four achievement levels allow mine sites at any stage of their journey to use IRMA to drive continuous improvement.
- Other credible MSIs and certification schemes include the Responsible Minerals Initiative, Aluminium Stewardship Initiative Performance Standard (ASI) and the Responsible Steel International Standard.

Key resources on raw materials certification systems

- BGR 2022: Sustainability Standard Systems for Mineral Resources
- Lead the Charge 2024

4.1.2. Component and wind turbine manufacturing

There are no global standards to address the manufacturing of components or wind turbines. However, in both the Netherlands and Germany, multi-stakeholder platforms exist to facilitate dialogue between the renewable energy industry (including wind), trade unions, civil society and government actors on responsible sourcing. These are the Dutch Responsible Business Conduct Agreement for the Renewable Energy Sector and the German Energy Sector Dialogue.

4.2. Core supply-chain mitigation actions

Specific risk mitigation actions should be based on the results of mapping and risk identification. Based on the overall risk profile of wind energy, the key focus area is likely to be labour issues linked to extraction activities and the risk of harm associated with component manufacturing.

Key resources on mitigation actions

- OECD (2017): Practical actions for companies to identify and address the worst forms of child labour in mineral supply chains
- OECD (2013): OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas
- Re-sourcing (2021): Renewable Energy Sector: Roadmap for Responsible Sourcing of Raw Materials until 2050
- Re-sourcing (2021): Identifying Challenges & Required Actions for Responsible Sourcing in the Renewable Energy Sector

[18] See German Federal Institute for Geosciences and Natural Resources (2022), Lead the Charge (2024) and US Department of State (2022).

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