Opportunities for trade integration in clean energy value chains

Nearly 40 per cent of anthropogenic GHG emissions are caused by burning fossil fuels to produce electricity (IEA, 2022b). Decarbonizing electricity generation is a critical step toward achieving net zero goals. Target 7.2 of the UN Sustainable Development Goals (SDGs) calls for a substantial increase in the share of renewable energy in the global energy mix by 2030 (UN General Assembly, 2015).

According to the International Energy Agency (IEA), renewables[1] accounted for 90 per cent of the global growth in electricity capacity in 2022 (IEA, 2023h). Global solar photovoltaic (PV) capacity increased by around 340 GW, a new annual record.

Renewable energy capacity is expected to grow by 85 per cent over the next four years, at a pace nearly two-thirds faster than that witnessed between 2015 and 2020. Renewables are on track to become the largest source of electricity generation by early 2026, at a pace vastly exceeding that predicted in all major studies (IEA, 2022e), and by 2050, renewables are projected to generate nearly 95 per cent of the global electricity supply (see Figure 3.1).

The pace of deployment of renewable energy is not consistent globally. IRENA estimates that China, the European Union and the United States accounted for 75 per cent of renewable energy capacity additions in 2022 (IRENA, 2023a). In contrast, Africa continues to account for less than 3 per cent of the world's installed renewables-based electricity generation capacity (IRENA and AfDB, 2022). This gap is particularly significant in the context of solar power generation – as reported by the IEA, 60 per cent of the world's best solar resources are in Africa, yet the continent only accounts for 1 per cent of installed solar PV capacity (IEA, 2022j).

Accelerating the rate of renewable energy diffusion promises economic benefits. One study projects that a 1 per cent increase in renewable energy consumption is expected to generate 0.07 per cent, in the short run, and 1.9 per cent, in the long run, of African economic growth (Qudrat-Ullah and Nevo, 2021). A clean energy transition would help to lower energy costs, increase energy access, stabilize energy prices, reduce import dependency, create value-added potential and generate additional employment opportunities.

Expanding domestic clean energy infrastructure can offer direct trade benefits. This was one of the key messages of the WTO's 2022 World Trade Report (WTO, 2022b). The report noted that international trade in renewable energy and electricity could help to compensate for an uneven geographical distribution of clean energy sources. For example, the report highlighted the potential for solar energy production in many economies in Africa, Asia, Latin America and the Middle East. By using this natural asset as a factor for comparative advantage, these economies could generate and export surplus electricity to regional and international partners in which domestic power generation creates a higher cost burden. These energy exports could take place in different forms, such as through undersea cables, pipelines or in related physical consignments (e.g., transporting hydrogen in the form of ammonia).

Achieving net zero goals will also depend on whether the production and trade of clean energy technologies and services can be expanded rapidly enough to match rising demand. This growth in demand presents new trade integration opportunities for developing economies and LDCs. Seizing these opportunities will require concerted action by developing economies, LDCs and their development finance partners. This action should explore areas beyond technology diffusion, to support the creation and engagement of these economies in clean energy markets.

Aid for Trade is helping developing economics to seize opportunities for trade integration, created in both the domestic and the international space. In particular, Aid for Trade is supporting economies in expanding their productive capacity in sectors that feed into value chains for the production and deployment of clean energy technologies. Sectors broadly fall into three "horizontal" value chain phases that are common to each clean energy technology, i.e.: i) the supply of critical minerals and metals, ii) machinery and equipment manufacturing and iii) services value chains.

3.1 Supply of critical minerals and metals

The availability of critical minerals and metals underpins a clean energy transition. The production of clean energy technologies requires larger quantities of these inputs than those necessary for fossil-fuel based power generation. The IEA estimates that the average quantity of minerals needed for power generation has risen by 50 per cent since 2010, in line with the accelerated diffusion of clean energy technologies. As a speci c example, an onshore wind plant requires nine times more mineral resources than a gas- red power plant (IEA, 2022h).

Given their critical role in the clean energy deployment,

FIGURE 3.2 Revenue from select minerals and coal (2020-40)

BOX 3.1 Copper and a clean energy transition

Copper is often termed the “metal of electri cation”. This is due to its extremely high electrical conductivity potential, which allows for an ef cient transmission of electricity over long distances. As a result, it is an important raw material in the manufacture of many electrical appliances.

Copper is a crucial input in the manufacturing of renewable energy generation technologies. It is required to produce conductive grid lines, interconnections and busbars for solar technologies. Copper is utilized in the windings of electric generators in wind turbines, enabling the conversion of wind energy into electricity. Copper also is a key component in electric vehicle manufacturing, where it is required in large quantities to produce batteries, motor windings and charging infrastructures.

Demand for copper is expected to increase rapidly as the pace of clean energy adoption accelerates. The scale of copper requirements was highlighted in a report by S&P Global (2022), according to which solar and offshore wind require two to ve times more copper per MW of installed capacity than power generated using non-renewable sources. Meanwhile, electric vehicle manufacturing requires 2.5 times as much copper as an internal combustion engine vehicle. As a result, the demand for copper could nearly double to 50 million metric tons by 2035, and could reach 53 million metric tons by 2050. To put this gure in perspective, this is more than all the copper consumed in the world between 1900 and 2021.

Future spikes in copper demand require long-term strategic planning, due to the extensive lead time required to initiate mining projects. The IEA (2022h) estimates that between 2010 and 2019, it took an average of 16 years to develop projects from discovery to rst production, more than 12 years to complete exploration and feasibility studies, and four to ve years for the construction phase. These long lead times need to be considered if demand were to pick up rapidly and if it becomes necessary to ramp up output.

Several Aid for Trade projects have been initiated to help developing economies reduce production lead times and assess export market needs. For instance, the World Bank’s Climate Smart Mining Facility provides technical assistance to accurately assess mineral endowments and construct sustainable extraction methods that help enhance export potential.

Lithium, central to the production of batteries, is another critical metal essential for a clean energy transition (see Box 3.2). Demand for lithium in clean energy production has

BOX 3.2 Minerals in battery production

Philippines and the Paci c region. In addition, the IEA notes that, collectively, minerals account for over 30 per cent of annual export value in 23 African economies (IEA, 2022h).

One challenge in expanding the extraction of such minerals is the environmental footprint of related operations. Another is in ensuring that the sydde708.6vactiounoplTex(I)-42 (EAons. 2h095 GS01 Tc 9n, LDCe3937080 538 f)40

Launched in 2019, the World Bank's Climate-Smart Mining Facility[3] aims to assist developing economies and LDCs in responding to the growing demand for minerals to manufacture clean energy technologies. By means of technical assistance and investments, the Facility supports the extraction and processing of minerals and metals used for producing solar and wind power. Resource-rich developing economies can therefore bene t from supplying the increasing mineral demand, while creating a minimal environmental and climate footprint.

The Climate-Smart Mining Facility was established as a multi-donor trust fund. Partners include Germany, the Netherlands and several private sector companies. Assistance worth US$ 50 million is being

Supporting the integration of renewable energy into mining operations, given that the mining sector accounts for up to

How can Aid for Trade help unlock trade opportunities?

Aid for Trade projects are encouraging developing economies to enter the manufacturing space in clean energy supply chains. One example cited in the 2022 Aid for Trade M&E questionnaire was the partnership between Australia and Indonesia to produce grid-scale batteries (see Box 3.5). Initial scoping for the project is currently underway under the "Katalis" programme backed by Australia to promote the bilateral partnership.

Another example of multilevel coordination is the "Africa-EU Green Energy Initiative", which is a forum for political dialogue, knowledge sharing and peer connection between EU and African stakeholders in renewable energies[5]. Leveraging p3r57 368m2al partn93

Africa's clean energy manufacturing potential was highlighted in a recent study by Sustainable Energy for All (SEAL) (2023). The study analysed continental manufacturing prospects by considering key factors such as domestic demand, infrastructure, manufacturing scale, policies, trade relations, infrastructure and the ability to export.

Economies identi ed as viable manufacturing hubs for renewable energy, particularly solar PV manufacturing, included:

EGYPT

Egypt's large domestic market and export base, as well as its speci c domestic laws promoting renewable energy and manufacturing make it ideal for renewable energy manufacturing. Its close trade ties with the Middle Eastern region lends for a favourable regional export strategy.

MOROCCO

A strong manufacturing track record, reliable infrastructure and institutional support for clean energy production make Morocco well-suited for renewable energy manufacturing and exporting. Morocco's strong trade ties with the European Union and China provide a conducive environment for strong export and inward investment potential.

to boost employment in the renewable energy sector in Africa substantially. The number of jobs in the renewable energy sector is expected to increase from around 0.35 million 2020 to over 4 million by 2030.

Clean energy services spanning the entire value chain were identi ed by IRENA and the WTO in a study analysing solar PV trade (WTO and IRENA, 2021). Highlighted services in each value chain node include:

Project planning

Adopting circular economy mechanisms can also enhance the value of service sector operations. For instance, product-service systems, which provide access to a service for a certain period, could operate as a model to stimulate resource ef ciency and reduce waste.[11] The European Commission's "Circular Business Models for the Solar Power Industry" ("CIRCUSOL")[12] is an example of such an initiative. The initiative seeks to develop and promote solar product management, both through the re-use, refurbishment and remanufacturing of these products, and by developing value-added new product-services for residential, commercial and utility end-users.[13]

Governments are already investing in reskilling workers in the energy sector. For example, the United States Agency for International Development (USAID) is supporting Egypt in introducing new renewable specializations through its Workforce Improvement and Skills Enhancement (WISE) project. To date, 75 new occupational standards have been de ned under WISE (Bouchene et al., 2021).

BOX 3.6 The Systematic Observations Financing Facility (SOFF)1.8m] st Tq96 -Tm793 -1052 c S Q [2.005 2.00] st T

Accurate weather forecasts and climate data are key to optimize the productivity of clean energy. This is because the operation of clean energy technologies, such as solar PV and wind turbines, is in uenced by uctuations in local weather systems. In this context, weather forecasting systems can considerably increase the resilience of energy systems, provide economies with the ability to locate the best regions for weather-dependent energy systems, and identify when to switch energy sources to ensure stable power supply.

According to the WMO (WMO, 2022a; 2022b), historical climatological data does not offer suf cient granularity for power generation purposes. Hence, in many developed economies, the energy sector is increasingly reliant on sophisticated climate services applications for weather forecasting capacity. Ensuring that these technologies are available to developing economies and LDCs is critical to ensure optimal use of clean energy assets. LDCs and small-island developing states face particularly signi cant weather data gaps because less than 10 per cent of required basic weather and climate forecasting systems are available domestically. Expanding domestic meteorological infrastructure would help to improve clean energy output and, at the same time, ensure timely weather services for other tradable activities that depend on timely weather forecasting. This includes activities in the agriculture sector, a signi cant export earner for many LDCs.

Launched in 2021, the Systematic Observations Financing Facility (SOFF) is a nancing mechanism that aims to address this measurement de cit.[14] Created as a partnership between the World Meteorological Organization (WMO), the United Nations Development Programme (UNDP) and the UN Environment Programme (UNEP), the Facility provides grant nancing and technical assistance for the collection and international exchange of surface-based weather and climate observations for economies lacking infrastructure for accurate data collection.

SOFF works with economies with the most severe shortfalls in observations, prioritizing LDCs and small-island developing states.

In its initial phase, SOFF will support 55 economies improve their weather forecasting services. Activities that are supported include the rehabilitation or establishment of up to 400 data-gathering stations. Initial nancial support has been provided by donors, including Austria, Denmark, the Nordic Development Fund, Norway and Portugal.

areas such as project planning, management, deployment, maintenance and operation of renewable energy systems. Aid for Trade can also be used to support the dismantling and recycling of clean energy technology, in line with circular economy principles. Upskilling service providers in this manner will help to attract more projects and investments, facilitating the expansion of trade in clean energy services.

Leveraging nance to expand aggregate investments in renewable energy services. Aid for Trade can be used to catalyse nancial support, by reducing investment risks for service providers, and to encourage private sector participation.

Supporting trade facilitation measures, simplifying customs procedures, and reducing trade barriers for renewable energy services. This includes streamlining import and export processes, reducing tariffs and addressing non

3.4 Development opportunities through carbon credits and carbon capture utilization and storage

One emerging market opportunity that can help to improve sustainable growth prospects is related to carbon credits. In essence, carbon credits refer to tradable permits that represent that value of emissions that have been reduced, avoided or captured in projects veri ed through credible standards (UNFCCC, 2021). Each carbon credit constitutes the right to emit one metric ton of CO_2 or an equivalent greenhouse gas (GHG) emission. The price of each carbon credit is determined by the interaction between demand and supply in local, regional or international carbon markets (WTO, 2022b).

The use of carbon credits as a form of carbon pricing has received signi cant attention over recent years. It is estimated that more than two-thirds of economies are planning to use carbon markets to meet their nationally determined contributions (NDCS) to the Paris Agreement (World Bank, 2022a). The focus on carbon markets has gained considerable traction since COP26, at which delegates approved Article 6 of the Paris Agreement. This article creates the basis for trading in GHG emission reductions across economies and establishes a mechanism for trading GHG emission reductions between economies (World Bank, 2022b).

Carbon credits are generated in markets when a project reduces or avoids greenhouse gas emissions beyond what is required by law or regulation. For example, each ton of CO_2 that is avoided by energy generation through a clean source such as solar PV (in comparison to a fossil fuel plant) can be sold as a carbon credit to companies or governments that need to offset their emissions. This market structure creates an incentive for all stakeholders to reduce their carbon footprint, either to reduce existing costs or to bene t from a potential income-generating mechanism.

For developing economies, carbon credits can be an important source of revenue and can help nance clean energy projects. The proceeds from the sale of voluntary carbon credits enable the development of carbon-reduction projects across a wide array of project types. For instance, part of the proceeds from carbon credits can be reinvested into renewable energy and energy ef ciency to increase credit returns in consecutive cycles. Financial incentives offered through carbon credits therefore contribute to an overall reduction of GHG emissions by the domestic economy. The World Bank notes that carbon credit markets could help developing economies by reducing the cost of implementing NDCs by as much as US$ 250 billion by 2030. Developing economies such as Chile, Ghana, Jordan and Vanuatu are building end-to-end digital infrastructures to support their participation in international carbon markets (World Bank, 2022a).

In the context of an energy transition, one particular renewable source that can bene t from carbon market integration is bioenergy. Currently accounting for 6 per cent of global energy supply, bioenergy can be either derived through biomass fuels (such as charcoal, wood, industrial residues and agriculture by-products) or biofuels (such as bioethanol, biodiesel and methanol) (IEA, 2023l). Approximately 80 per cent of bioenergy is used for cooking and heating in buildings and industry.

Biomass and biofuels are considered renewable because they can be produced using fast-growing organic matter. However, unlike other forms of renewable energy, they are pollutive and generate negative environmental and health consequences. Traditional forms of biomass carry particular risk, but they remain a primary energy source in many developing economies and LDCs. Nearly 2.4 billion people, mostly in developing regions of sub-Saharan Africa and South Asia, continue to rely on inef cient biomass sources to generate energy for cooking and other household needs (IRENA, 2022b). The combustion of wood fuels for cooking is estimated to generate up to 1 gigaton of carbon dioxide equivalent

A transition to re ned bioenergy sources (such as compressed wood pellets) could help to reduce health and environmental impacts (see Box 3.8 for an example of a project integrating this technique). It could also offer nancial opportunities, as the act of replacing pollutive bioenergy sources with a cleaner alternative with fewer CO_2

FIG RE 3.4 Carbon capture, utilization and storage

2(25) are expected to operate at even lower costs, at a proximately 35 percent of costs estimated in 2014.

T e use of CCUS technologies can be particularly u eful in the context of bioenergy with carbon capture a d storage (BECCS), which involves capturing and s ring CO_2 where biomass is converted into fuels or directly burned to generate energy.[24] BECCS h s been identi ed in consecutive United Nations Clin ate Change (UNFCCC) Assessment Reports as on of the strategies to enable a net zero transition. Acco ing to IRENA estimates, it is the most developed exa ple of carbon removal technology that is currently ava ble (Lyons, Durrant and Kochhar, 2021).

The use of CCUS technologies can also provide an incentive to decarbonize bioenergy production. This can be a particularly effective strategy to curb emissions generated during the use of scaled biomass combustion for industrial processing. In many developing economies and LDCs, agricultural wastes and process residues are used as biomass sources are used to generate such energy. Research by the United Nations Industrial Development Organization (UNIDO) and the Global

How can Aid for Trade help unlock trade opportunities?

Aid for Trade can play a role in accelerating the diffusion of carbon capture technologies by:

Providing nancial and technical support to promote carbon capture technologies. For instance, Aid for Trade can facilitate technology transfer from developed economies to developing nations, helping them access advanced carbon capture solutions.

Enhancing the technical capacity of developing economies and LDCs. This may involve the training of local engineers and technicians in the design, installation and maintenance of CCUS systems.

Endnotes

1. In this context, the term “renewables” refers to electricity generated through solar photovoltaic (PV), wind, hydropower, hydrogen, nuclear and bioenergy sources.
2. See https://www.iadb.org/en/whats-our-impact/RG-T3340.
3. See https://www.worldbank.org/en/news/press-release/2019/05/01/new-world-bank-fund-to-support-climate-smart-mining-for-energy-transition.
4. See https://sps.com.gh/
5. See https://ec.europa.eu/commission/presscorner/detail/en/fs_22_1120.
6. See, for example, the “Declaration on China-Africa Cooperation on Combating Climate Change” issued by the Ministry of Foreign Affairs of People’s Republic of China on 2 December 2021 (https://www.fmprc.gov.cn/eng/wjdt_665385/2649_665393/202112/t20211203_10461772.html).
7. See https://iacepa-katalis.org/about-katalis/.
8. See https://www.dfat.gov.au/sites/default/ les/katalis-fact-sheet.pdf.
9. See at https://prospera.egnyte.com/dl/gIhE6zAMui.
10. See https://un-soff.org.
11. See https://circulareconomy.earth/publications/how-can-we-create-circular-opportunities-for-energy-access
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14. See https://sdg.iisd.org/news/ nancing-facility-to-support-ldcs-and-sids-on-climate-observations/
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17. See https://energytransition.org/2022/06/enhancing-nigerias-clean-cooking-access-to-reduce-greenhouse-emissions/#:~:text=In%20Nigeria%2C%20about%20174%20million,increase%20access%20to%20the%20commodity
18. See https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=ZG.
19. See https://www.gsma.com/mobilefordevelopment/blog/introducing-powerstove-pay-as-you-go-smokeless-biomass-cooking-in-nigeria/.
20. See https://www.afd.fr/en/powerstove-factory-inauguration/abuja-nigeria.
21. See https://unfccc.int/process-and-meetings/the-kyoto-protocol/mechanisms-under-the-kyoto-protocol/the-clean-development-mechanism#:~:text=UNF>>> BDC (4rCtwssi4TTuTt-mec)20%20tCthe-20tDd [(develo20tMent-mec)20.1 (h%22_11

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16. See