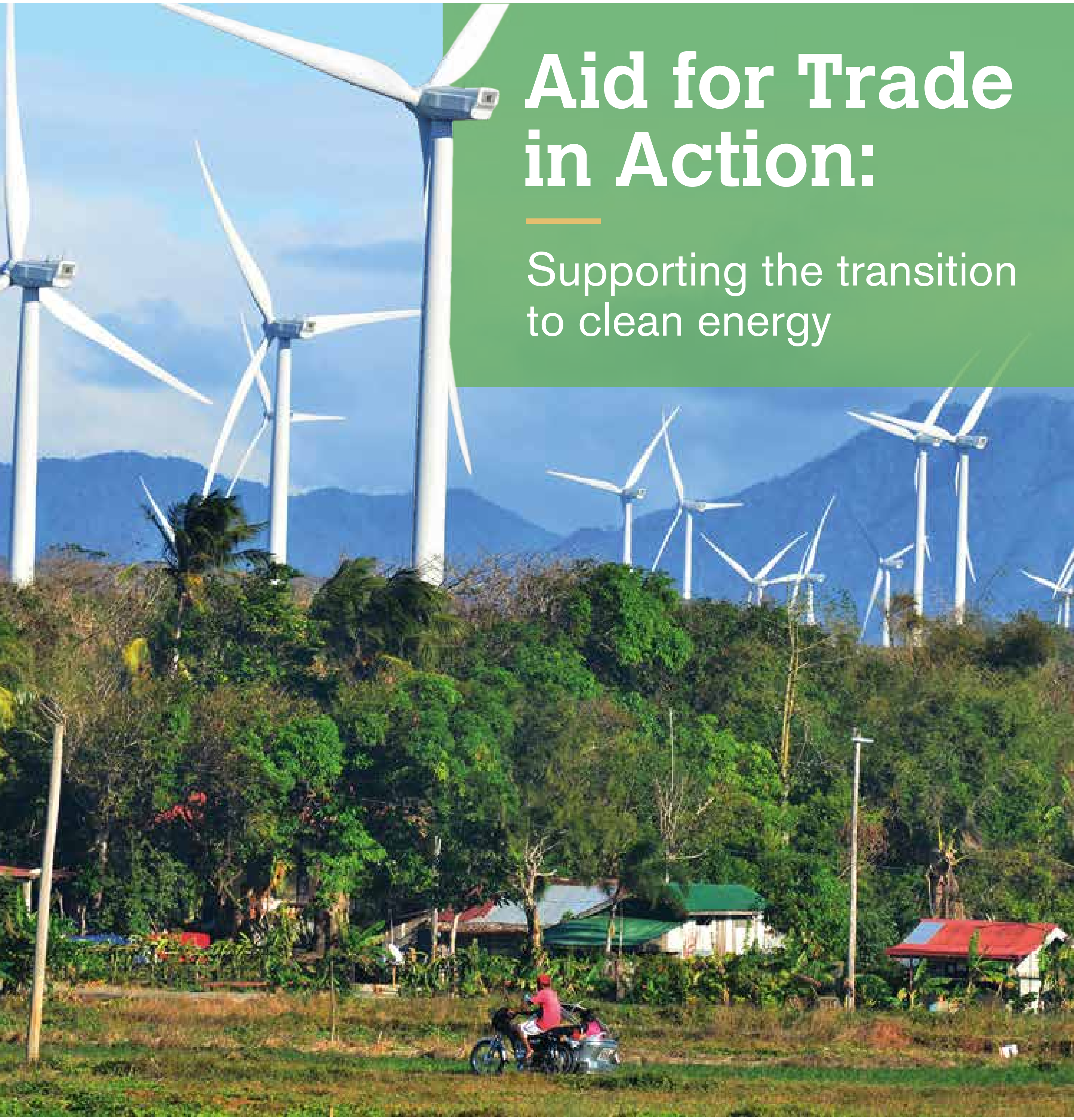
World Trade Organization

Aid for Trade in Action:

Supporting the transition to clean energy



Disclaimer

Photo caption

A 150-megawatt wind farm in Burgos, Philippines.

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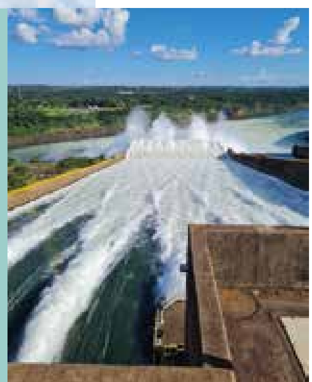

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Acknowledgements

This publication was prepared by Visvanathan Subramaniam (Economic Affairs Officer, WTO) and Michael Roberts (Head of the Aid for Trade Unit of the Development Division, WTO), under the supervision of Deputy Director-General Xiangchen Zhang and Taufiqur Rahman, Director of the Development Division. The publication was edited and reviewed by Anthony Martin and Helen Swain of the Information and External Relations Division.

Valuable comments were also provided by Aik Hoe Lim (Director of the Trade and Environment Division, WTO), Svetlana Chobanova, Rainer Lanz, José-Antonio Monteiro and Ankai Xu (WTO), Olivier Cattaneo, Coralie Martin and Silvia Sorescu (OECD) and Peter Levi (IEA).

Abbreviations

ADB	Asian Development Bank
AfDB	African Development Bank
AIIB	Asian Infrastructure Investment Bank
CCUS	carbon capture, utilization and storage
COP	Conference of the Parties
EBRD	European Bank for Reconstruction and Development
GHG	greenhouse gas
GWh	gigawatt hour
IDB	Inter-American Development Bank
IEA	International Energy Agency
IMF	International Monetary Fund
ISA	International Solar Alliance
IsDB	Islamic Development Bank
JETP	Just Energy Transition Partnership
LDC	least-developed country
M&E	monitoring and evaluation
MDB	multilateral development bank
MSME	micro, small and medium-sized enterprise
MW	megawatt
NDC	nationally determined contribution
ODA	official development assistance
OECD	Organisation for Economic Co-operation and Development
OECD DAC	OECD Development Assistance Committee
PV	photovoltaic
R&D	research and development
SDGs	Sustainable Development Goals
TW	terawatt
TWh	terawatt-hour
UN	United Nations
UNDP	United Nations Development Programme
UNEP	UN Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
USAID	United States Agency for International Development
WEF	World Economic Forum
WMO	World Meteorological Organization
WTO	World Trade Organization

Overview of the Aid for Trade initiative

The Aid for Trade initiative, led by the WTO, grew out of the 2005 WTO Hong Kong Ministerial Conference. Its aim is to help developing economies integrate into world trade by mobilizing additional development support to address supply-side capacity and trade-related infrastructure constraints in these economies. In 2006, the Task Force on Aid for Trade was constituted by the WTO Director-General to report to the General Council with recommendations on how to operationalize Aid for Trade.[1]

Identifying sustainable economic and export diversification opportunities for developing economies and least-developed countries (LDCs) is an area of thematic focus in this work programme. It seeks to build on policy insights emerging from the 2020-2022 Aid for Trade work programme titled "Empowering Connected Sustainable Trade". The 2023-24 Aid for Trade work programme, titled "Partnerships for Food Security, Digital Connectivity and Mainstreaming Trade", was agreed by WTO members on 10 February 2023.

What does the initiative seek to achieve?

The WTO-led Aid for Trade initiative encourages developing-economy governments, donors and South-South partners to take account of the role that trade can play in their national and regional development strategies. The initiative recognizes that many developing economies face barriers that hinder their effective participation in the global trading system and prevent them from unlocking many of the benefits of international trade. In particular, the initiative seeks to mobilize financial resources to address the trade-related constraints identified by developing economies and least-developed countries.

The initiative also seeks to promote policy coherence by examining how trade is integrated into national and regional strategies, with a focus on how it can contribute to critical thematic areas for developing economies.

What is considered Aid for Trade?

The recommendations of the Task Force on Aid for Trade, which was endorsed by WTO members in 2006, identified the following categories of official development assistance (ODA) as defining the scope of Aid for Trade:

Trade policy and regulations: Technical assistance delivered to help economies develop trade strategies, negotiate more effectively and implement multilateral trade outcomes.

Trade development: Assistance for activities such as investment promotion, business support services, e-commerce, trade finance, trade promotion, market analysis and development.

Infrastructure: Financing that aims to develop the transport, energy and communications infrastructure to produce, move and trade goods for import and export activities.

Productive capacity: Assistance delivered to domestic industries and sectors to help economies expand and diversify exports by building on comparative advantages.

Adjustment assistance: Help with the costs associated with tariff reductions, preference erosion or declining terms of trade.

Development assistance directed to energy-related infrastructural activities (such as electrification, power generation and distribution networks) falls under the scope of Aid for Trade under the infrastructure category. Affordable and reliable energy is a fundamental input for creating tradable goods and services. Developing economies and LDCs often require energy investments to improve domestic capacity, which can lead to increased exports. Energy is also a critical input for trade-supportive activities such as storage of goods, transportation, customs procedures and electronic data interchanges. Furthermore, many developing economies may have comparative advantages in the production and trade of renewable energy and associated goods and services.

Trading priorities, flows and impact

The WTO and the Organisation for Economic Co-operation and Development (OECD) monitor Aid for Trade flows as reported by donors reporting to the OECD Development Assistance Committee (DAC). Non-OECD reporters (including South-South partners) also participate in the initiative, and examples of their cooperation activities are included in this report.

Between 2006 and 2021, a total of US$ 631.2 billion was disbursed for financing Aid for Trade programmes and projects, with disbursements to LDCs amounting to US$ 174 billion. Disbursements to LDCs have increased in constant terms, from US$ 5.5 billion in 2006 to US$ 13.5 billion in 2021. This represents a 150 per cent increase over a 15-year period.

The energy sector is one of the largest recipients of Aid for Trade support, accounting for nearly 25 per cent of all disbursements (US$ 116 billion) over the 2010-21 period. In 2021, the sector received nearly US$ 11 billion of Aid for Trade disbursements, only surpassed by disbursements allocated to transport and storage of goods.

Clean energy and energy efficiency have emerged as key Aid for Trade priorities over recent years. More than half (approximately US$ 60 billion) of the Aid for Trade commitments towards energy infrastructure over the period 2011-21 targeted these objectives. Aid for Trade directed to greener energy accounts for 30 per cent of all Aid for Trade allocated to climate-related measures over this same period.

This report contains many examples of Aid for Trade in action i.e., projects, programmes and initiatives that support developing economies' participation in the clean energy transition.

Endnotes

1. According to WTO official document WT/AFT/1 (available from https://docs.wto.org/).

Executive summary

Energy generation infrastructure has long been identified by Aid for Trade stakeholders as requiring additional, predictable and sustainable financing to enable developing economies and LDCs to participate more fully in international trade. The energy sector is one of the largest recipients of Aid for Trade support, accounting for nearly 25 per cent of all disbursements (US$ 116 billion) over the 2010-21 period.

Aid for Trade already supports the clean energy transition. Over the period 2011-21, nearly 30 per cent of all Aid for Trade commitments with climate objectives were related to the energy sector. Aid for Trade helps to provide developing economies and LDCs with the necessary supply-side capacity-building support to adopt clean energy technologies. It is also helping to support policy reforms and facilitating the integration of micro, small and medium-sized enterprises (MSMEs) in developing and LDC economies into international value chains for clean energy technologies.

Furthermore, Aid for Trade stakeholders recognize the importance of aligning Aid for Trade with climate objectives. The 2022 Aid for Trade Monitoring and Evaluation (M&E) exercise revealed that donors and partner economies reference environmental objectives, including those relating to clean energy and electricity, in their national development strategies. There has also been a steady increase in the value and number of projects with climate objectives.

Yet Aid for Trade flows remain small in comparison to what is required to capitalize on the economic development opportunities. More is required to ensure that developing-economy firms benefit from the trade opportunities that will emerge as a result of the clean energy transition. The catalytic role that Aid for Trade can play in mobilizing additional financial resources needs to be further explored to ensure that all avenues for delivering targeted assistance are considered.

The clean energy transition is a trade and sustainable development opportunity.

The clean energy transition is an opportunity for developing economies to benefit more fully from trade and to promote sustainable development. According to the International Energy Agency (2024), clean energy (e.g., wind, solar, hydro, hydrogen and nuclear power) accounts for nearly 40 per cent of global electricity production, and it is predicted that this will expand to between 75 and 80 per cent of production by 2050, as net zero greenhouse gas (GHG) targets gain traction. Nearly 110 economies have already incorporated clean energy growth targets into their nationally determined contributions – the efforts made by each economy to reduce national emissions and adapt to the impacts of climate change under the Paris Agreement.

Accelerating this energy transition could provide an opportunity to advance industrial development in developing economies and least-developed countries (LDCs), and to address long-standing constraints in their energy generation capacity.

The falling costs of clean energy deployment in comparison to GHG-emitting alternatives, such as fossil fuels, should help to improve energy affordability, accessibility, and reliability – vital targets under Goal 7 of the United Nations Sustainable Development Goals (SDGs). Improving affordable access to electricity could help to accelerate economic growth by helping to bridge the digital divide between developed and developing economies and enabling less developed communities to play a greater part in the digital services economy.

Most developing economies and LDCs depend heavily on imported fossil fuels for energy generation, but this dependency can create fiscal imbalances and volatility risks. Transitioning to clean energy practices could help to reduce volatility and promote energy security. A progressive reduction in fossil fuel energy imports could positively affect balance-of-payments outlooks and currency stability, leading to better perspectives for export performance.

At the heart of realizing transition opportunities is investment.

In 2022, over US$ 600 billion was invested in renewable electricity generation, a 70 per cent increase compared to 2017. Solar and wind capacity doubled between 2018 and 2022, with renewable power accounting for 78 per cent of new generation capacity in 2022. Clean energy investment is projected to exceed US$ 1.7 trillion in 2022, and renewable electricity capacity is expected to increase by over 60 per cent between 2020 and 2026.

Yet there is a disparity in clean energy investments between developing and developed economies. Developing economies receive less than one-fifth of global clean energy investments, despite representing two-thirds of the global population. This disparity coincides with a pivotal phase in their socio-economic advancement: driven by growing populations, urbanization and rising living standards, the collective electricity demand of developing economies and LDCs is expected to increase by as much as 300 per cent by 2050. There is significant scope for further growth in clean energy adoption, if the necessary development finance can be mobilized.

International trade can play a critical role in a clean energy transition. As highlighted in this report, developing economies and LDCs could leverage the clean energy transition to achieve trade growth and export diversification objectives. This could be achieved through an increased participation in the value chains associated with clean energy production. Ensuring that economies can use the opportunities generated during this process is critical to enable a just transition.

This report highlights that significantly more can be done to seize trade opportunities arising from participation in clean energy global value chains. Shortfalls in the existing energy infrastructure and a gap in technology capacity also continue to constrain a clean energy transition, as does the deficit in the flow of clean energy-related financing toward developing economies and LDCs. These are areas in which Aid for Trade can play a positive role.

RENEWABLE ELECTRICITY GENERATION

over

US$ 600 billion

was invested

+70% increase on **2017 levels**

in 2022

RENEWABLE ELECTRICITY CAPACITY

expected to increase by over

60%

between 2020 and 2026

ELECTRICITY DEMAND OF DEVELOPING ECONOMIES AND LDCS

expected to increase by as much as

300%

by 2050

The clean energy value chain offers opportunities for trade integration.

This report examines opportunities for developing economies to integrate more fully into global trade in three segments of the value chain – minerals and metals, machinery and equipment manufacturing, and services. It also provides examples of how Aid for Trade is supporting these energy transition opportunities in developing economies and LDCs.

In terms of the expansion of mineral exports, the clean energy transition is driving a significant increase in mineral extraction worldwide. Over 3 billion tons of minerals and metals will be needed to achieve a net zero transition by 2050. Clean energy technologies, such as wind and solar power, require large quantities of minerals which are available in limited quantities in nature. Developing economies and LDCs with favourable mineral endowments are already benefitting from the increased demand stemming from the development of clean energy technologies by attracting investment in mineral extraction, processing and manufacturing capabilities. This, in turn, could create employment opportunities, increase domestic income and foster economic development in these economies.

Developing economies and LDCs can also seize opportunities arising from rising momentum in the manufacture of clean energy technologies. The value of manufacturing clean energy equipment is expected to exceed US$ 1 trillion by 2050. Many developing economies and LDCs could leverage their comparative advantages (such as natural resource endowments), market size and locational advantages to become nodes in manufacturing value chains. This would potentially increase their exports and create positive spillovers in terms of generating employment, income gains and economic growth. As competition to attract clean energy manufacturing is fierce, and the development of industrial policies is on the rise, identifying the appropriate policy mix – both domestic and international – is a significant challenge for these economies.

The development of services sector operations is also essential for a successful clean energy transition. As this report notes, developing economies and LDCs can enhance growth prospects and generate employment by prioritizing value-added services associated with clean energy generation. For instance, by providing adequate workforce training, domestic labour markets can gain sufficient technological expertise to perform renewable energy services such as grid installations, administration and maintenance operations. This would help to enhance the domestic use of clean energy, and strengthen labour competitiveness. Overall, less attention has been devoted to the services segment of the clean energy value chain – even though the barriers to entry may be less onerous for developing economies and LDCs than for other segments of the clean energy value chain.

This report highlights the opportunities in the value chains for five sources of clean energy:

Wind energy, which has witnessed accelerated adoption over recent years, with expansions in both onshore and offshore installations.

Solar photovoltaic (PV), which has also experienced a rapid increase in deployment, with growth driven by falling costs and technological advancements that have improved production efficiency.

Green hydrogen, an energy source increasingly viewed as an effective energy carrier to decarbonize hard-to-abate (i.e., for which the transition to net zero is difficult either in terms of technology or cost) sectors, for which direct electrification is not possible.

Hydropower, which remains a major source of renewable power globally, and one in which developing economies are already significant participants. However, it has come to be perceived as less "reliable" as a result of unpredictable rainfall patterns due to climate change.

Nuclear power, a technology that is expected to grow, mainly in developing economies, but which faces sustainability and cost challenges due to the limited availability of existing technologies.

Each of the clean energy segments indicated above has unique characteristics and advantages, and their deployment within economies varies based on geographical, economic and technological factors. However, challenges such as high adoption costs, limited access to finance and trade barriers continue to hinder widespread adoption.

Moving forward, far greater emphasis must be given to the participation of developing economies and LDCs in clean energy value chains. This is an area on which Aid for Trade has been focused in recent years – and one which requires more concerted action.

The first section of this report examines the support provided by development finance partners to help developing economies access clean energy opportunities through Aid for Trade financing. The second section explores trade and market opportunities for developing economies that could be created by a transition to clean energy. It also explores the possibility of leveraging carbon market opportunities and using carbon capture, utilization and storage (CCUS) technologies to enhance development opportunities. The third section examines some of the challenges faced by developing economies in achieving this change. The fourth and final section takes a deep dive into the trade opportunities associated with major clean energy technologies, and reviews how development finance partners are supporting projects in each of these technology areas.

Each section includes examples of Aid for Trade in action – projects where Aid for Trade financing is supporting the transition to clean energy. The report concludes with the recommendation to further align Aid for Trade with clean energy opportunities.

01

Introduction

1.1 Clean energy adoption is a development opportunity

The energy sector underpins economic activity. Ensuring universal access to clean, affordable and reliable energy is a critical sustainable development goal.

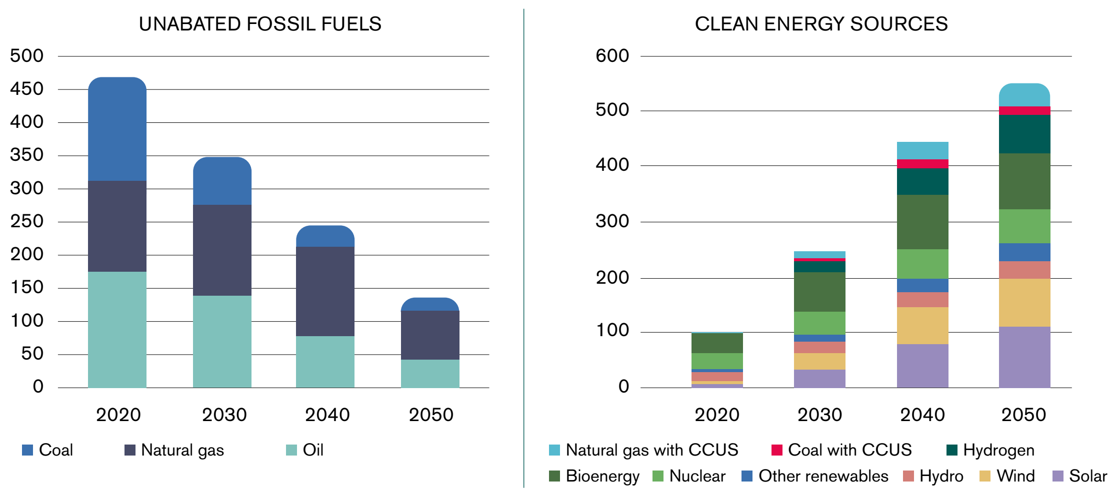
Clean energy accounted for 28 per cent of the 28,334 terawatt-hours (TWh) of electricity produced globally in 2021 (IEA, 2022a). International Energy Agency (IEA) projections indicate that clean energy could account for 90 per cent of total electricity generation by 2050 (IEA, 2023a).[1] Clean energy adoption is driven by net zero greenhouse gas (GHG) emission pledges and increasing rates of household and industrial adoption.

Enabling the clean energy transition is a significant global investment opportunity. In 2022, global investments worth US$ 600 billion were channelled into renewable electricity generation, a 70 per cent increase on 2017 levels. This growth is being driven by expansion of solar and wind generation capacity, which doubled over the five-year period 2018-22 (IEA, 2023h). The IEA also estimates that investments into renewable power generation accounted for 78 per cent of all new energy generation capacity in 2022. Clean hydrogen has emerged as an area of focus over recent years, with investments into electrolysers for power generation increasing sixfold over the 2018-22 period (IEA, 2023a).

This expansion in investment is expected to result in a tangible acceleration in clean energy adoption rates. Renewable electricity adoption is expected to increase by more than 60 per cent between 2020 and 2026 (IEA, 2022e), and expected to generate 80 per cent of the global electricity supply by 2050, if net zero pledges are realized (IEA, 2023e).

Figure 1.1 provides a breakdown of supply estimates per energy source, based on the IEA's "Net Zero Emissions by 2050 Scenario".[2] It indicates that the clean energy mix is made up of diverse energy forms that include both renewable and non-renewable sources (IEA, 2021c). This scenario projects that a gradual decline in unabated fossil fuel use could be complemented by more than proportional growth in clean energy usage.

FIGURE 1.1 IEA total energy supply projections to 2050[3]



Source: IEA (2023e).

BOX 1.1 SDG 7 – Access to affordable and clean energy

A clean energy transition is among the objectives set out in the United Nations (UN) Sustainable Development Goals (SDGs). It is framed in SDG 7,[4] which aims to ensure "affordable and clean energy" for all. Five targets have been defined for SDG 7, with each having important linkages to a clean energy transition:

7.1

by 2030

ensure universal access to affordable, reliable and modern **energy services**

7.2

by 2030

increase substantially the share of renewable energy in the global energy mix

7.3

by 2030

double the global rate of **improvement in energy efficiency**

7.3a

by 2030

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

7.3b

by 2030

expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing economies, in particular least-developed economies, small-island developing states and landlocked developing economies, in accordance with their respective programmes of support

Approximately 20 per cent of all Aid for Trade disbursed over the period 2012-20 targeted SDG 7 objectives. This is indicative of a sustained interest in fulfilling SDG 7 goals among Aid for Trade stakeholders. Rising interest in fulfilling clean energy objectives should further increase the prioritization of SDG 7 in Aid for Trade flows over the coming years.

The energy sector accounts for approximately 60 per cent of annual global GHG (IEA, 2021b). Unsurprisingly, it has been the focus of successive United Nations Framework Convention on Climate Change (UNFCCC) Conferences of the Parties (COP) since the Paris Agreement, which was adopted in 2015. Clean energy goals have been prioritized under SDG 7, which provides five targets with important linkages to the clean energy transition (see Box 1.1).

The centrality of clean energy adoption for a net zero transition was recognized during COP28, held in 2023 in Dubai. The COP28 outcome document[5] underlines the importance of "transitioning away from fossil fuels in energy systems in a just, orderly and equitable manner so as to achieve net zero by 2050". Parties recognized the need to triple the rate of adoption of renewable energy and to double energy efficiency by 2030, while building momentum towards a new architecture for climate financing to achieve this goal. Additional references to the importance of a clean energy transition in this decision text can be found in Box 1.2.

Fossil fuels are expected to remain as transitional fuels in the global energy mix with limited contributions in an abated form by means of carbon capture utilization and storage (CCUS) technologies.[6] Such technologies are necessary to achieve net zero objectives, as they capture and subsequently store or utilize CO_2 emitted by fossil fuel combustion.[7] If adoption costs decline, this technology could provide breathing space for LDCs and developing economies reliant on the production and exports of fossil fuels. An appropriate technology transfer and diffusion regime is an important consideration.

Growing populations, rapid urbanization and rising living standards are driving up the demand for electricity. IEA estimates suggest that the growth in the demand for electricity among developing economies, based on the IEA's "Net Zero Emissions by 2050 Scenario", could increase by 50 per cent by 2030, and by 300 per cent by 2050 (IEA, 2021c). Many developing economies are on the cusp of a historically energy-intensive time window as their manufacturing and infrastructure expands. Taken together, these factors could stimulate the demand for energy.

BOX 1.2 Clean energy references in the 2023 COP28 decision text[8]

Article II.A.28 of the 2023 COP28 decision text recognizes the need for deep, rapid and sustained reductions in GHG emissions in line with 1.5°C pathways and calls on parties to contribute to the following global efforts, in a nationally determined manner, taking into account the Paris Agreement and their different national circumstances, pathways and approaches:

a) "Tripling renewable energy capacity globally and doubling the global average annual rate of energy efficiency improvements by 2030;

b) Accelerating efforts towards the phase-down of unabated coal power;

c) Accelerating efforts globally towards net zero emission energy systems, utilizing zero- and low-carbon fuels well before or by around mid-century;

d) Transitioning away from fossil fuels in energy systems, in a just, orderly and equitable manner, accelerating action in this critical decade, so as to achieve net zero by 2050 in keeping with the science;

e) Accelerating zero- and low-emission technologies, including, *inter alia*, renewables, nuclear, abatement and removal technologies such as carbon capture and utilization and storage, particularly in hard-to-abate sectors, and low-carbon hydrogen production;

f) Accelerating and substantially reducing non-carbon-dioxide emissions globally, including in particular methane emissions by 2030;

g) Accelerating the reduction of emissions from road transport on a range of pathways, including through development of infrastructure and rapid deployment of zero- and low-emission vehicles;

h) Phasing out inefficient fossil fuels that do not address energy poverty or just transitions, as soon as possible".

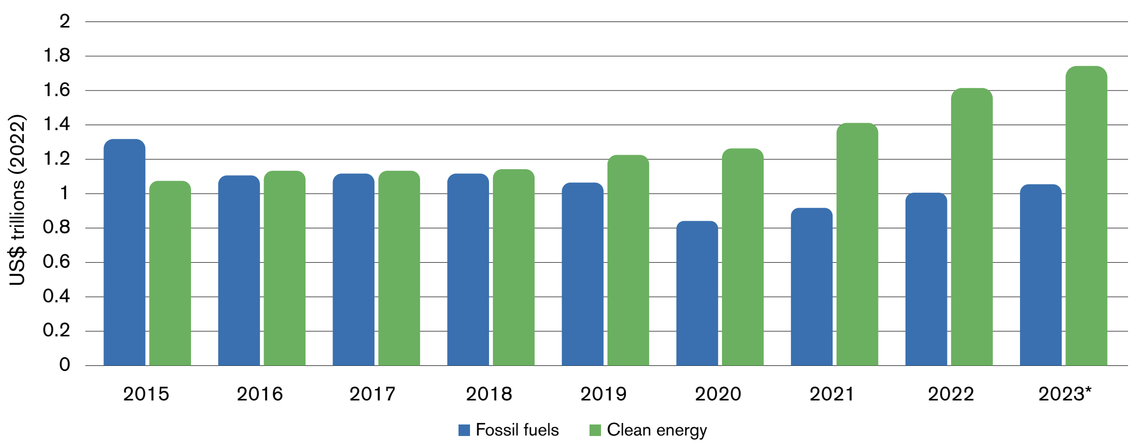
1.2 Clean energy technologies are increasingly cost-competitive

In 2021, the global installation costs of solar photovoltaic (PV) and hydropower were 11 per cent lower than those of the cheapest new fossil-fuel-fired power generation option, while the global installation costs of onshore wind power were 39 per cent lower for the same amount of energy generated (IRENA, 2022a). Renewables and other clean energy sources are positioning themselves as the cheapest sources of electricity generation for greenfield investments, (i.e., when a parent company builds a new venture in another country from the ground up).

The falling costs of clean energy relative to fossil fuels are indicative of an imminent inflection point for the energy transition. This refers to when clean energy adoption reaches a critical mass, so that clean energy deployment is driven by market decisions rather than the regulatory investments of the transition to clean energy. Annual investments into global fossil fuel production have witnessed a gradual decline over the past decade as clean energy, especially renewables, has become more cost-competitive. Figure 1.2, prepared using data compiled by the IEA, illustrates the gradual shift towards clean energy investments. In 2015, each dollar spent on clean energy investment was offset by a US$ 1.2 investment into brown energy (i.e., energy from polluting sources) generation. This trend had reversed by 2022, with each dollar spent on brown investment matched by a US$ 1.6 investment in clean energy capacity. In other words, clean energy investment is outpacing the pace of brown energy investment.

Accelerating investments into clean energy presents an opportunity for developing economies and LDCs, for instance, by helping these economies reduce their reliance on fossil fuel imports. Four out of five people live in economies that import fossil fuels (UN, 2020). Nearly 90 per cent of the energy requirements in the Pacific islands are currently satisfied through oil and coal imports. A clean energy transition – particularly in the context of renewables such as wind and solar energy – could have long-term cost benefits, as the installation

FIGURE 1.2 Investments into clean energy and fossil fuels 2015-23



Source: IEA (2023a).

BOX 1.3 The Fossil Fuel Subsidy Reform Initiative (FFSR)

Forty-eight WTO members are co-sponsoring joint action at the WTO with the aim of achieving effective WTO disciplines on fossil fuel subsidies.

The co-sponsors are of the view that inefficient fossil fuel subsidies encourage wasteful consumption, are disadvantageous to the generation of renewable energy, and depress investment in energy efficiency. They argue that addressing fossil fuel subsidies effectively will deliver trade, economic, social and environmental benefits, as well as releasing government funds to support a green and climate-resilient recovery from the COVID-19 pandemic.

The co-sponsors aim to seek the rationalization and phase-out of inefficient fossil fuel subsidies that encourage wasteful consumption along a clear timeline and plan to bring forward concrete options to advance this issue.

Reducing fossil fuel dependency negates the need for extensive fossil fuel subsidy programmes, leading to budgetary savings. For instance:

- **Fuel price adjustments in Indonesia** led to savings of US$ 15.6 billion in fiscal revenue. This amounted to a nearly 10 per cent gain in government revenue, which was used to finance social welfare programmes and infrastructural upgrades.
- **Fossil fuel subsidy reforms in Egypt** in 2013-16 led to a 30 per cent decline in energy-related expenditure. Much of the savings from this policy were then redirected towards health and education expenditure (Pradiptyo et al., 2016).

of capital equipment is an infrequent expense requiring less recurrent expenditure. In this context, a clean energy transition could help to lessen current account pressures and improve fiscal sustainability by reducing the need for fuel subsidies.

The war in Ukraine has sharpened policy attention to the role of clean energy technologies in addressing energy security issues. Installed clean energy capacity has absorbed some of the shock from the turbulence in fossil fuel energy markets. As reported by the International Renewable Energy Agency (IRENA), renewable capacity added in 2021 helped economies to save US$ 55 billion in 2022 by reducing the need for fossil fuel imports. In Europe between January and May 2022, as a result of solar PV and wind generation, it was possible to forego US$ 50 billion in fossil fuel imports, predominantly gas. IRENA estimates that in the long term, investment in brown energy technology could be four to six times more expensive than any new additions to solar and onshore wind capacity (IRENA, 2022a). These figures highlight a broader issue related to volatility linked to energy imports and the fiscal impact of price variability.

Annual investments into global fossil fuel production have witnessed a gradual decline over the past decade as clean energy, especially renewables, has become more cost-competitive.

1.3 Developing economies and LDCs are key stakeholders in a clean energy transition

Many developing economies and LDCs have a potential “latecomer” energy advantage in the adoption of clean energy infrastructure. For instance, Africa’s grid infrastructure remains insufficient to sustain reliable and affordable power supply. In 2017, the length of transmission lines in the entire continent was 247 km per million people (Lerner et al., 2017). This collective figure was well below that of other developing regions. Extending this infrastructure now offers significant potential to integrate transmission systems that can align with clean energy needs, and that can stimulate backward industrial and services linkages.

Several economies have rapidly expanded their domestic renewable capacity over recent decades. China stands as a prominent example. Over the past 10 years, Chinese renewable energy capacity has increased by around 90 times, and by 2025, China expects its renewable energy generation capacity, driven by wind and solar power output, to account for more than 50 per cent of total generation capacity (Zheng, 2022).

Morocco is an example of an economy with accelerated renewable energy adoption. Renewables contribute to almost 40 per cent of Morocco’s installed energy capacity, and they are targeted to exceed 50 per cent by 2030. Morocco’s Noor Ouarzazate Solar Complex is the largest concentrated solar power plant in the world, spread over 3,000 hectares of desert and with an overall capacity of 580 megawatts (MW) of power. The economy has also developed more than a dozen large-scale windfarms, as well as providing incentives for businesses and residences to invest in their own solar panels to save on energy costs (Papathanasiou, 2022).

Latin America and the Caribbean have made remarkable progress in renewable energy adoption. According to data from the Latin American Energy Organization (Organización Latinoamericana de Energía – OLADE), more than a half (59 per cent) of electricity generation now comes from renewable sources. The ambition is to reach 70 per cent by 2030 (OLADE, 2023).

BOX 1.4 The Noor Ouarzazate Solar Complex Project[9]

The NOOR Ouarzazate Solar Complex Project, with a capacity of approximately 580 MW, represents a pivotal milestone in Morocco’s National Energy Strategy (2010-2030). This initiative is part of the broader NOOR Program and aims to develop integrated solar energy projects with a cumulative capacity of at least 2,000 MW by 2030. The Ouarzazate solar power station (OSPS) stands as the flagship endeavour within Morocco’s new energy strategy, striving to elevate the proportion of renewable energy sources to 52 per cent by 2030.

Supported by international partners, Morocco is progressing toward energy independence and sustainable development, reversing its previous reliance on imported fossil fuels for up to 95 per cent of its electricity. The objectives of constructing the Ouarzazate solar power station include diminishing Morocco’s energy dependence, mitigating the adverse fiscal and trade balance effects of imported fossil fuels, increasing electricity production through harnessing sunlight efficiently, fostering the growth of a national solar energy industry, and reducing long-term GHG emissions.

The project’s beneficiaries encompass Moroccan communities, businesses and various sectors such as industry, transportation and agriculture. These stakeholders stand to gain not only from an improved electricity supply but also from the cleaner and more sustainable nature of power generation. At the local level, the Ouarzazate province, with an estimated population of 583,000 and a poverty rate of around 23 per cent, anticipates socio-economic advantages from the project.

Clean energy deployment over the past decade has also contributed to some reduction in energy poverty.[10] Research by IRENA estimates that the number of connections to renewable grids doubled between 2010 and 2019, and that approximately one-third of this increase involved so-called “Tier 1” entrants, that is, entrants from the lowest level of energy access (IEA et al, 2021). Nearly 105 million people have received energy access through decentralized solar grids in sub-Saharan Africa alone.

Less well-known is that clean energy adoption can generate positive spillovers on digital connectivity, as access to electricity affects the availability, uptake and usage of mobile connectivity (Houngbonon, Le Quentrec and Rubrichi, 2021). This in turn has the potential to boost growth, expand economic opportunities and improve service delivery (Lerner, Fukui and Gallegos, 2017).

The expansion in clean energy investment has also been accompanied by a decline in funding for fossil fuel-based power generation. Since 2014, global investments in oil production have declined steadily, with a drop of 65 per cent in 2020 alone. The drop in funding for fossil fuels has been accompanied by sharp reductions in regulatory permits for new coal-fired power plants, with an 80 per cent reduction in permits compared to five years ago (IEA, 2021e). This is notwithstanding the uptick in fossil fuel energy generation driven by energy security concerns emanating from the war in Ukraine. IEA estimates reveal that for every US$ 1 spent on fossil fuels, US$ 1.7 is now spent on clean energy. In comparison, this ratio was 1:1 in 2017 (Sustainable Energy for All et al., 2023). And this ratio is expected to grow further in favour of clean energy.

Clean energy investment features prominently in the nationally determined contributions (NDCs) of developing economies, including those of LDCs. The NDCs, a key component of the Paris Agreement on climate change, outline economy-level commitments to reducing GHG emissions and adapting to the impacts of climate change.[11]

The UNDP notes than more than 110 economies have included clean energy targets in their NDCs.[12] Many economies have included targets for increasing the use of clean energy sources (such as wind, solar and hydropower) in their NDCs. For example, various economies have set targets for increasing the share of renewable energy in their electricity mix or for increasing the number of electrical vehicles on their roads (IRENA, 2022c). In addition to setting targets for clean energy, many economies have also included policies and measures to promote the deployment of clean energy technologies. Such measures include incentives for renewable energy investments, support for research and development (R&D) of new clean energy technologies, and regulatory reforms to remove barriers to the deployment of clean energy.

NDCs were a key topic of discussion during COP28 in 2023. The COP28 decision text calls upon economies to submit revised NDCs well ahead of COP30 in 2025, and highlights the need for these new NDCs to be more ambitious, to ensure that the goal to limit global warming to 1.5° Celsius is reached by 2050.

The inclusion of strengthened clean energy targets in NDCs will operate as a market signal for more investment inflows into clean energy generation. According to estimates by the IEA, the implementation of current NDCs could drive an additional US$ 13.5 trillion in clean energy investment by 2030 (IEA, 2016). Box 1.5 provides some examples of clean energy commitments found in the NDCs of developing economies and LDCs.

Clean energy expansion was recognized as a development priority by WTO members responding to the monitoring and evaluation (M&E) exercise carried out in 2022 by the WTO and the OECD. Of the developing-economy respondents, 78 per cent highlighted that their national development strategies identified SDG 7 (“Affordable and Clean Energy”) as a key goal. SDG 12 (“Responsible Production and Consumption”) and SDG 13 (“Climate Action”), which bear a collective clean energy emphasis, were also highlighted as priority Aid for Trade needs by members.

According to IEA estimates, almost US$ 4-5 trillion (in real terms) is required as clean energy investment worldwide per annum by 2035. In 2023, total investments disbursed reached US$ 2.8 trillion (IEA, 2023a).

BOX 1.5 Examples of clean energy targets in developing-economy NDCs[13]

BANGLADESH
Increase the share of **renewable energy in power generation** to
10% **by 2021** and to
15% **by 2025**

MEXICO
Achieve a
35%
clean energy share in its electricity generation **by 2024**

BRAZIL
Increase the share of **renewable sources in its energy mix** to
45% **by 2030**

MALAWI
Increase the share of **renewable energy in power generation** to
30% **by 2030**

ETHIOPIA
Achieve
100%
access to electricity from renewable energy sources **by 2025**

RWANDA
Increase the share of **off-grid renewable energy** in its electricity generation mix to
22% **by 2030**

INDIA
Achieve
40%
cumulative **electric power capacity** from **non-fossil-fuel-based energy** resources **by 2030**

SENEGAL
Increase the share of **renewable energies in installed capacity** to
40%
of its electricity mix **by 2030**

KENYA
Achieve
100%
renewable energy in its electricity generation mix **by 2030**

1.4 The clean energy transition is a trade integration opportunity

The demand for products and activities associated with clean energy is picking up pace. OECD research reveals that over the period 2017-19, the trade of critical raw materials used in clean energy products expanded more quickly – at an average growth rate of 38 per cent – than trade in all merchandise products, which had an average growth rate of 31 per cent (Przemyslaw and Legendre, 2023). IEA projections (under the Announced Pledges Scenario) indicates that the global market for manufactured clean energy technologies will be worth around US$ 650 billion a year by 2050, which is triple the value of current market estimates (IEA, 2023b).[14] Clean energy adoption would also boost the need for ancillary services, such as maintenance, operations and management, thus creating additional job and value generation possibilities.

Developing economies and LDCs can leverage the clean energy transition to achieve trade growth and export diversification. Key to meeting this target is integrating into value chains catering to the mineral, manufacturing and service inputs required for clean energy generation. Aid for Trade can play an important role in this process. Subsequent chapters of this report will further explore how Aid for Trade can help in achieving this integration.

Endnotes

1. Projections are based on the IEA's "Net Zero Emissions by 2050 Scenario" (https://www.iea.org/reports/global-energy-and-climate-model/net-zero-emissions-by-2050-scenario-nze). The scenario is designed to show what is needed across the main sectors by various actors for the world to achieve net zero energy-related CO_2 emissions.
2. See https://www.iea.org/reports/global-energy-and-climate-model/net-zero-emissions-by-2050-scenario-nze.
3. Projections are per the IEA's "Net Zero Emissions by 2050 Scenario".
4. See https://www.un.org/sustainabledevelopment/energy/.
5. See https://unfccc.int/sites/default/files/resource/cma2023_L17_adv.pdf.
6. According to the OECD, abatement refers to technology applied, or measures taken, to reduce pollution and/or its impacts on the environment.
7. https://www.iea.org/fuels-and-technologies/carbon-capture-utilisation-and-storage.
8. See https://unfccc.int/sites/default/files/resource/cma2023_L17_adv.pdf
9. See https://www.afdb.org/en/documents/morocco-noor-ouarzazate-solar-complex-project-phase-iii-noor-ouarzazate-iii-power-plant-project-completion-report.
10. The term "energy poverty" is defined by the G20 as occurring "when households or territorial units cannot fulfil all of their domestic energy needs as a result of lack of access to energy services, an inability to afford them, or their poor quality of unreliability in order to, at minimum, safeguard their health and provide for opportunities to enhance their well-being".
11. See https://unfccc.int/process-and-meetings/the-paris-agreement/nationally-determined-contributions-ndcs.
12. See the United Nations Environment Programme (UNEP) NDC Registry at https://unfccc.int/NDCREG.
13. See https://unfccc.int/NDCREG.
14. The Announced Pledges Scenario (APS) projections by the IEA illustrates the extent to which announce ambitions and targets can deliver the emissions reductions needed to achieve net zero emissions by 2050.

A 75-megawatt solar power plant in Lopburi, Thailand.

02

Development financing for a clean energy transition

2.1 Overview

Official development assistance (ODA) accounts for a significant majority of finance utilized by developing economies and LDCs to support climate action: nearly 80 per cent of climate finance flows since 2019 have taken the form of official development financing measures (OECD, 2021a).

In recent years, energy accessibility and the clean energy transition have increasingly become key priorities for ODA donors and South-South partners supporting decarbonization pathways in developing economies and LDCs, with a particular focus on clean energy.

For instance, one commitment made by the OECD Development Assistance Committee (DAC) as part of its new approach to aligning development cooperation with the goals of the Paris Agreement is to harness: “ODA and mobilise other resources to help developing countries access more technical opportunities to enable and accelerate a clean, sustainable and just energy transition on voluntary and mutually-agreed terms”.[1]

Given the scale and urgency of the energy transition challenge, sources of finance will need to be widely mobilized, including funding from public, private, domestic and international financial sources. In this context, ODA is playing a catalytic role in the mobilization of commercial finance, notably towards underserved sectors and regions (OECD, 2022a).

The OECD Development Assistance Committee (DAC) has recognized this potential and has developed a set of principles to support development actors in leveraging commercial capital through development finance (OECD, 2021b). Over recent years, development finance instruments and activities have helped to mobilize private finance towards the US$ 100 billion goal for climate financing that was agreed during the 15th Conference of the Parties (COP15) in 2009.

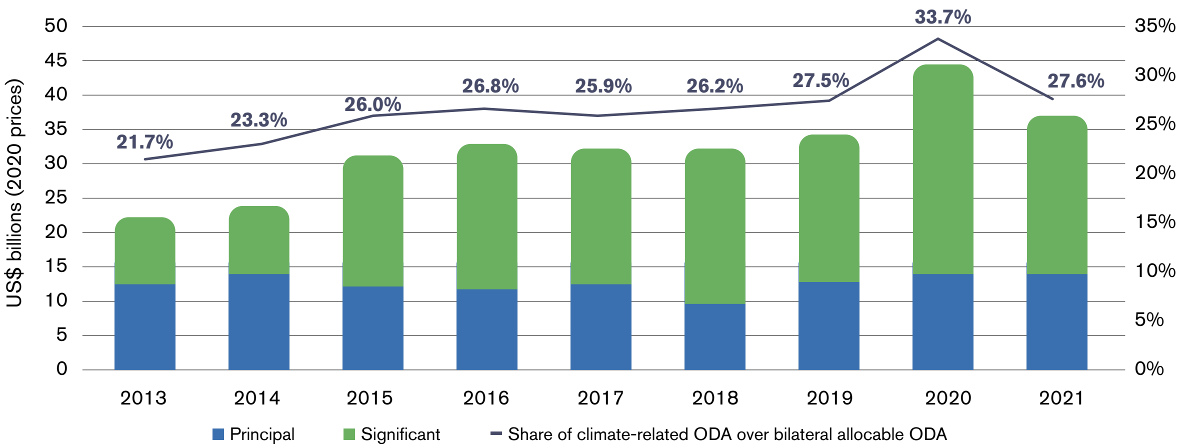
An aspect which has not until now been given significant attention in ODA, however, is how to help developing economies and LDCs realize the trade opportunities that could arise from the transition to clean energy, including:

- Mobilizing finance for green supply-side infrastructure;
- Supporting policy and regulatory reforms that promote renewable energy investment and trade;
- Supporting the private sector to take advantage of opportunities in the low-carbon economy;
- Assisting developing economies in participating in international renewable energy markets.

2.2 Snapshot of climate-related development finance flows

Since 2010, approximately US$ 387 billion of bilateral ODA has been allocated to projects with climate-related objectives, showing that these objectives have been increasingly prioritized in recent years. Financing commitments to climate-related objectives increased from US$ 22 billion in 2013 to US$ 38 billion in 2021. The value of commitments in 2021 accounted for nearly 28 per cent of available bilateral ODA commitments for that year (OECD, 2023a). Approximately US$ 14 billion (36 per cent) and US$ 24 billion (64 per cent) of ODA for 2021 pursued “principal” and “significant” climate objectives respectively.[2,3] Meanwhile, 25 per cent of commitments to Africa pursued climate objectives. Yearly allocations of ODA for climate-related commitments are represented in Figure 2.1.

FIGURE 2.1 Trends in climate-related overseas development assistance (2010-21)



Source: OECD (2023a).

The OECD classifies the climate impact of bilateral development finance using the "Rio Markers", which are based on the objectives agreed during the United Nations Conference on Environment and Development (also known as the "Earth Summit") of 1992. Projects are classified as serving "climate mitigation" objectives if they contribute to the stabilization of GHG concentrations in the atmosphere. The transformation of energy systems plays a critical role in climate mitigation, as energy is a key contributor to GHG emissions.

In 2021 US$ 13.5 billion

of bilateral ODA commitments were used to address

CLIMATE MITIGATION OBJECTIVES

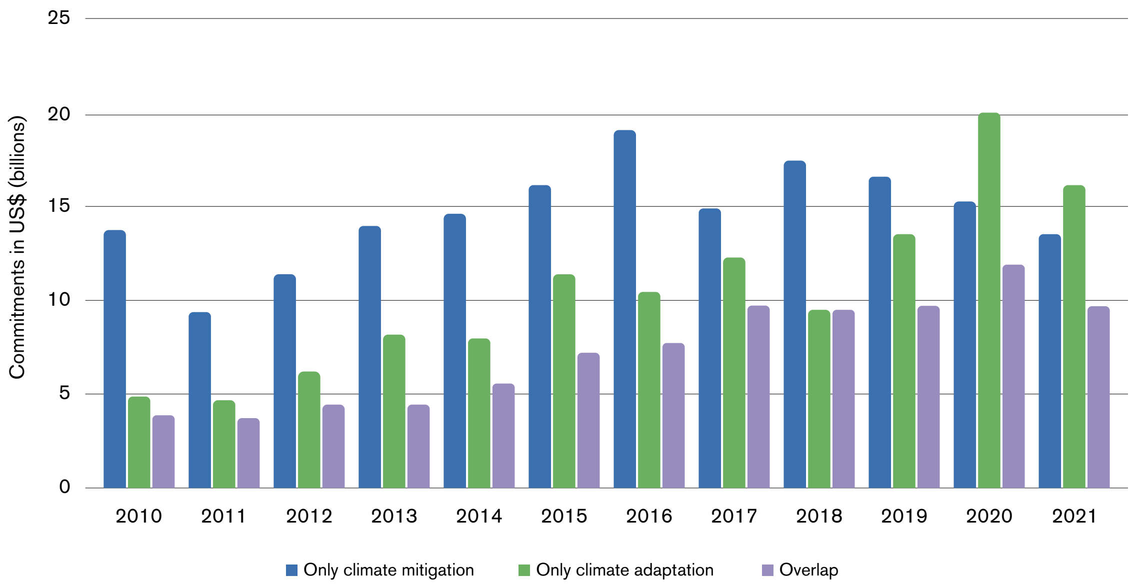
This accounted for

35% of the total pool of bilateral commitments with climate-related objectives.

Similarly, projects are tagged as serving "climate adaptation" objectives if they seek to reduce the vulnerability of human or natural systems to the impacts of climate change. Energy plays a key role in this context as well, since reliable, affordable and sustainable modern energy services are essential to strengthen capacity to adapt to climate change impacts. This includes enabling emergency services during disasters, providing temperature control services during heatwaves or intensely cold periods, and providing cold storage facilities to promote food security (IRENA, 2021a).

In 2021, US$ 13.5 billion of bilateral ODA commitments were used to address climate mitigation objectives. This accounted for 35 per cent of the total pool of bilateral commitments with climate-related objectives. In the same year, US$ 16.5 billion (42 per cent) of bilateral ODA explicitly targeted climate adaptation objectives, while approximately US$ 9.5 billion (22 per cent) of ODA addressed both mitigation and adaptation objectives. The flows of ODA commitments by climate objective are illustrated in Figure 2.2.

FIGURE 2.2 Bilateral ODA commitments by climate objective



Source: OECD DAC Climate-related Development Finance Statistics.[4]

Examining annual bilateral ODA statistics indicates that there is increased alignment with climate adaptation objectives. Figure 2.2 illustrates trends in bilateral ODA commitments for each objective over the period 2013-21 and indicates that since 2020, more projects have targeted adaptation goals than mitigation goals.

The growing prioritization of climate objectives by the reporters to the OECD DAC is expected gradually to accelerate ODA spending on energy-related activities. This would address the demands of developing economies for the most sustainable possible support for their development priorities. Such alignment is visible in the "OECD DAC Declaration on a new approach to align development co-operation with the goals of the Paris Agreement on Climate Change".[5] Under this declaration, DAC members committed to "support partner countries' own just transitions to sustainable pathways and to achieve global net zero emissions; and to increase their ability to adapt to the adverse impacts of climate change and improve resilience".

Reliable, affordable and sustainable modern energy services are essential to strengthen capacity to adapt to climate change impacts.

The importance of improving access to clean energy to facilitate a transition to net zero emissions has also been recognized by many multilateral development banks (MDBs). The commitments these MDBs have made can be seen in Box 2.1.

BOX 2.1 Commitments by multilateral development banks to climate transition and clean energy financing

Multilateral development banks (MDBs) are big players in the Aid for Trade initiative. Together, they account for 39 per cent of total aid for trade flows in 2021. They are also important players in a climate transition. This box provides examples of MDB strategies outlining clean energy priorities may be summarized as follows:

World Bank Group: The World Bank Group weighs in as one of the largest multilateral financiers of clean energy projects. It aims to advance the climate transition aspects of its Green, Resilient, and Inclusive Development (GRID) approach by means of the Climate Change Action Plan 2021–2025. As per the Plan, the World Bank Group is continuing to invest in renewable energy generation, integration and enabling infrastructure (World Bank Group 2021). This support also covers on-grid, off-grid and distributed renewables. During COP28, the World Bank Group declared its intention to increase its climate commitment, setting a goal of 45 per cent of its annual financing to be directed towards projects related to climate in the upcoming fiscal year. This represents an increase of approximately US$ 9 billion per year compared to its previous target of 35 per cent.

Asian Development Bank (ADB): Operational Priority C ("Tackling Climate Change, Building Climate and Disaster Resilience, and Enhancing Environmental Sustainability") of the ADB's "Strategy 2030" document[6] highlights steps to mitigate climate change and accelerate the deployment of climate-neutral technology. In addition, the ADB's "Energy Policy", introduced in 2021, seeks to "support universal access to reliable and affordable energy services while promoting the low-carbon transition in the region". At COP28, the ADB presented a climate change action plan, allocating US$ 100 billion from its own resources and collaborating with both the public and private sectors to enhance its climate impact.[7]

Asian Infrastructure Investment Bank (AIIB): As part of its commitment to align its operations with the goals of the Paris Agreement, the AIIB will look to allocate 50 per cent of total approved funds towards climate financing by 2025. The AIIB's 2022 Energy Sector Strategy Update, will look to ensure "that clean energy services are affordable, of adequate capacity and good quality, available when needed, reliable, convenient, and safe".[8] Starting on 1 July 2023, the AIIB has been investing exclusively in transactions that adhere to the Paris Agreement on climate change, and during COP28, the AIIB presented tangible initiatives in alignment with their Climate Action Plan (CAP) unveiled at AIIB's Annual Meeting in Sharm El-Sheikh.

African Development Bank (AfDB): During COP26, the African Development Bank launched a "Framework for Climate Change and Green Growth" to address climate change and promote green growth on the continent. A shift away from coal is one of the key pillars of this framework. At COP28, the initial call for climate adaptation proposals under the Climate Action Window (CAW) has been initiated. Approximately $258 million is designated for this call, intended to be distributed in the form of grants.

European Bank for Reconstruction and Development (EBRD): According to its Green Economy Transition policy framework, the EBRD aims to achieve a green financing share of more than 50 per cent of its annual investments by 2025. Under this plan, energy efficiency and renewable energy installed capacity are highlighted as key performance indicators for future projects. In December 2023, the Energy Sector Strategy (2024-28) was approved, prioritizing the acceleration of decarbonization through increased deployment of renewable energy, improvements to grids, advocacy for zero-carbon fuels and the gradual phasing out of unmitigated fossil fuels. The EBRD estimates an annual investment of US$ 180 billion, with the power sector requiring US$ 130 billion, for its regions until 2030.

BOX 2.1 Commitments by multilateral development banks to climate transition and clean energy financing (continued)

Inter-American Development Bank (IDB): As per its Vision 2025 strategy, the IDB will aim to allocate US$ 24 billion for climate and green finance projects, as well as working to build green and resilient infrastructural systems. The IDB Group aims to triple both direct and mobilized climate financing for Latin America and the Caribbean to reach US$ 150 billion in the next ten years. This initiative is set to receive backing from members, including the expected recapitalization of its private-sector branch, IDB Invest.

Islamic Development Bank (IsDB): Reaching a climate finance target of 35 per cent by 2025 forms a key goal of the IsDB's Climate Change Action Plan 2020-25. The Plan also projects to increase efforts by the IsDB to help members undergo an economic transition by ramping up economy-level investment, particularly in the context of finance and policy support for projects into renewable energy. In 2023, the IsDB published the Just Transition Conceptual Framework & Action Plan 2023-25, and announced a commitment of over US$ 1 billion in climate finance at COP28.

At COP28, MDBs issued a joint statement that delineates precise and urgent actions aimed at bolstering financial support, enhancing the evaluation of climate outcomes, reinforcing collaboration at the national level, and augmenting co-financing and private sector participation in the global effort to tackle climate change.[9]

Development financing for a clean energy transition can also be expected to gain further momentum given the importance attached to this topic in in major intergovernmental forums. For instance, the Leaders' Declaration arising from the 2023 G20 summit recognizes that developing economies need to be supported in their energy transitions and that G20 leaders will "work towards facilitating access to low-cost financing for developing countries, for existing as well as new and emerging clean and sustainable energy technologies and for supporting the energy transitions".[10]

Financing for a clean energy transition was also a topic of discussion at COP28. The COP28 decision text recognizes that "about USD 4.3 trillion per year needs to be invested in clean energy up until 2030, increasing thereafter to USD 5 trillion per year up until 2050, to be able to reach net zero emissions by 2050".

One example of efforts to harness development financing for clean energy systems is the Just Energy Transition Partnerships (JETPs). JETPs are collaborative initiatives aimed at facilitating a fair and equitable transition to clean energy, particularly in economies heavily dependent on fossil fuels. JETPs bring together governments, businesses, civil society organizations and the private sector to work towards inclusive clean energy transition. The first JETP emerged from COP26, when France, Germany, the United Kingdom and European Union committed to allocate US$ 8.5 billion to South Africa to help reduce fossil fuel dependency (Kramer, 2022). Since then, three additional JETPs have been established, to allocate US$ 20 billion to Indonesia, US$ 15.5 billion to Viet Nam and US$ 2.7 billion to Senegal. Additional information on the JETP with Senegal is provided in Box 2.2.

BOX 2.2 Just Energy Transition Partnerships

Created during COP 26 in Glasgow, Just Energy Transition Partnerships (JETPs) look to simultaneously address climate change and socio-economic impacts that may occur during a climate transition. JETPs emphasize the importance of social inclusion, job creation and community empowerment, with a focus on vulnerable and marginalized groups. By engaging diverse stakeholders, these partnerships seek to develop strategies and policies that balance environmental sustainability with social equity.

In June 2023, a JETP agreement was signed by Senegal and backed by the European Union, France, Germany and Japan as key development partners. This is the first JETP agreement that focuses on the energy transition of an LDC. Approximately EUR 2.5 billion worth of funding (mostly in the form of concessional financing) will be provided over a period of three to five years to support this partnership (European Commission, 2023). The aim of this JETP is to help accelerate Senegal's renewable energy deployment with a view to fulfilling Senegal's goal of increasing its share of renewable energies to 40 per cent of the energy mix by 2030.

As part of the JETP agreement, Senegal will also draft a new investment plan that identifies the investment requirement and the opportunities available domestically during a just energy transition (Sarr et al. 2023). This investment plan is due to be finalized in 2024.

In addition, Senegal will release a revised nationally determined contribution by COP30, which will reflect the enhanced climate ambition of this new energy strategy.

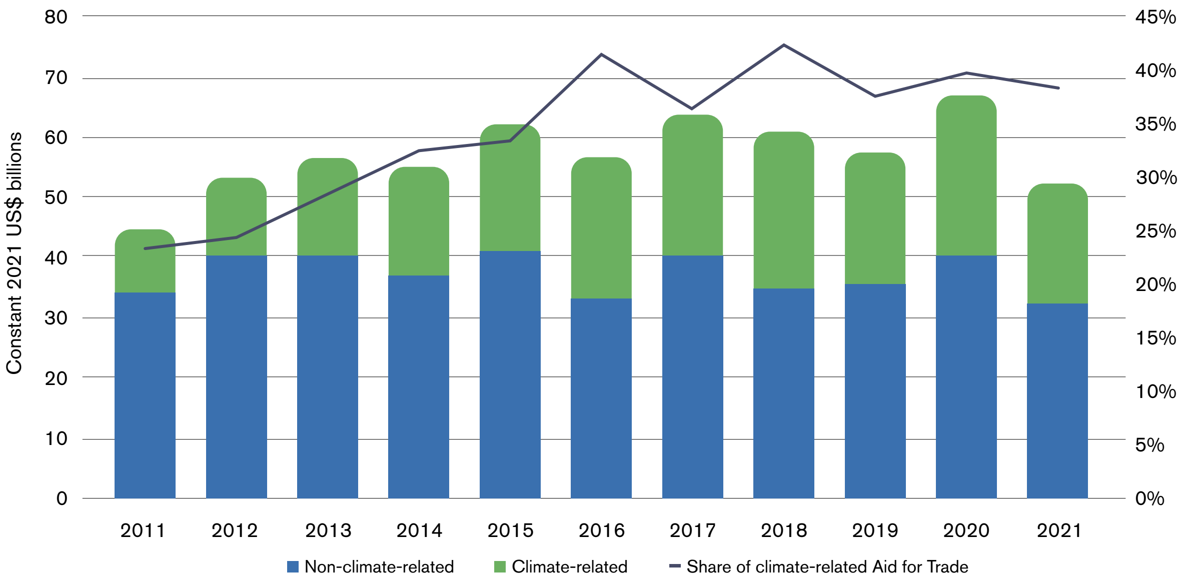
2.3 Aid for Trade, climate finance and the energy transition

Aid for Trade stakeholders have recognized the importance of aligning Aid for Trade to support environmental and climate objectives. This is reflected in responses to the 2022 M&E exercise: 80 per cent of the Aid for Trade strategies, policies or plans of participating donors included environmental objectives, and for 88 per cent of partner economies that participated in the survey, access to finance was the main obstacle in their transition toward sustainable development (OECD and WTO, 2022).

An examination of available data reveals that trends in Aid for Trade flows have generally reflected these points. Over the period 2011 to 2021, approximately US$ 221 billion worth of Aid for Trade was committed to projects with a principal or significant climate objective. This accounted for 35 per cent of aggregate commitments during the 11-year window.

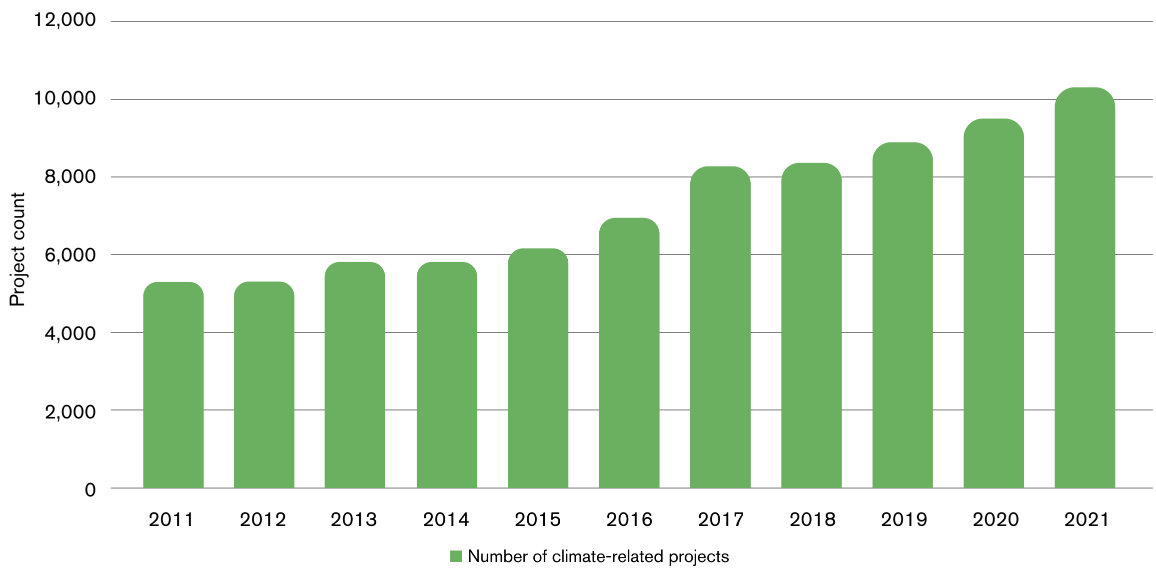
Climate-related commitments have in fact experienced gradual year-on-year gains, increasing from 23 per cent to 38 per cent of annual flows over the period 2015 to 2021. This growth in climate-related flows is reflected in Figure 2.3. As indicated in Section 2.1, the slight decline in Aid for Trade commitments between 2020 to 2021 can be attributed to a redistribution of ODA, away from trade and climate concerns, to tackle emerging crises during the period (notably the COVID-19 pandemic) (OECD, 2022b).

FIGURE 2.3 Evolution of Aid for Trade commitments, 2011-21



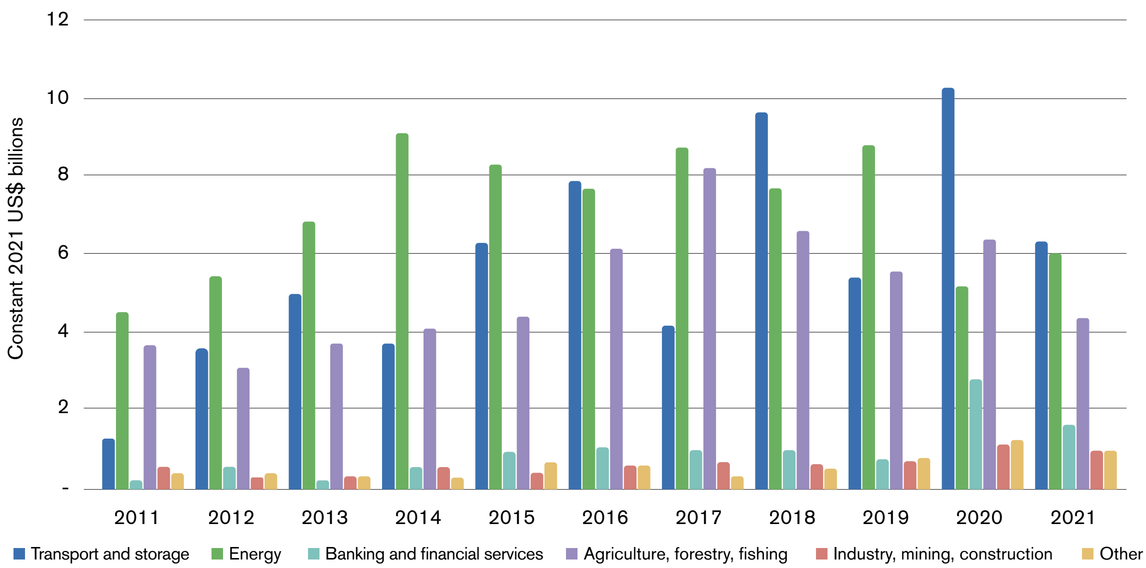
Source: OECD.Stat, Creditor Reporting System.[11]

FIGURE 2.4 Number of climate-tagged Aid for Trade projects (2011-21)



Source: OECD.Stat, Creditor Reporting System.

FIGURE 2.5 Sectoral climate-related Aid for Trade commitments (2011-21)



Source: OECD.Stat, Creditor Reporting System.

The rise in value of climate-related Aid for Trade over the past decade has been complemented by a steady increase in the number of projects with a climate objective. From 2011 to 2021, the number of such projects doubled, from 5,009 in 2011 to 10,343 in 2021. Figure 2.4 serves to illustrate this gradual increase. Steady and simultaneous gains in the number and value of climate-focused aid is indicative of a progressive transformation in Aid for Trade to address climate concerns.

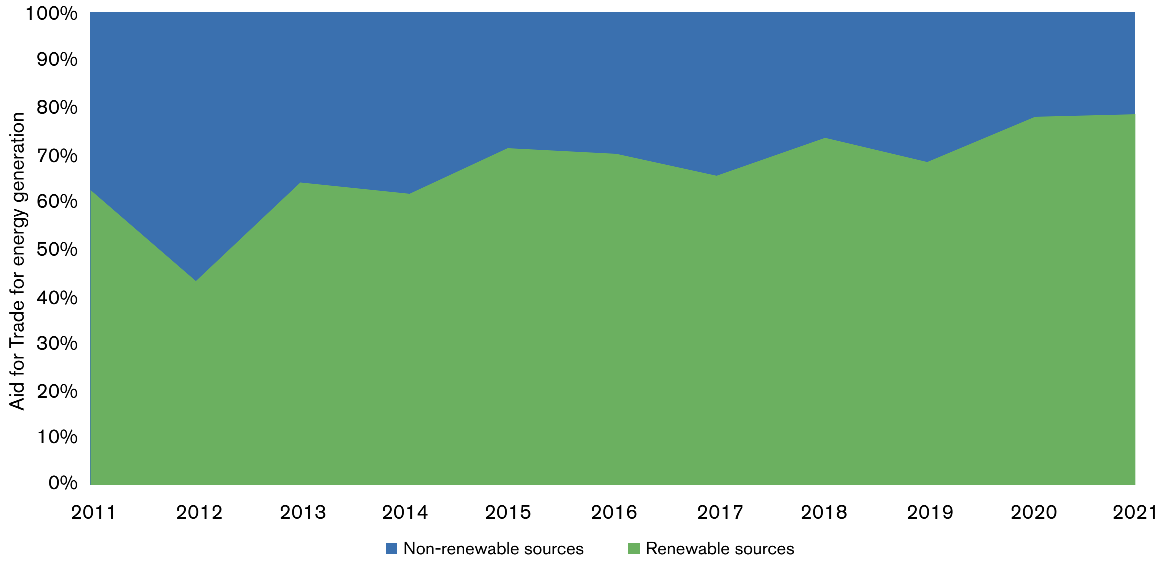
Aid for Trade continues to support the energy transition of developing economies and LDCs, and the energy sector is one of the largest recipients of Aid for Trade, accounting for nearly 25 per cent of all disbursements (US$ 116 billion) over the period 2010-21. In 2021, the sector received nearly US$ 11 billion of Aid for Trade disbursements, only surpassed by disbursements allocated to transport and storage.

Aid for Trade towards the energy sector has increasingly prioritized climate objectives. Nearly US$ 60 billion worth of commitments to this sector over the period 2011-21 were marked as principally or significantly targeting climate objectives. This accounts for 30 per cent of total Aid for Trade marked for climate-related measures. As illustrated in Figure 2.5, nearly US$ 6 billion of climate-related Aid for Trade commitments was disbursed to the energy sector in 2021.

Commitments to the energy sector primarily target climate mitigation goals: 89 per cent of climate-marked commitments for the energy sector over 2011-21, amounting to approximately US$ 53 billion, principally served a climate mitigation objective. This means that climate mitigation is explicitly stated as fundamental in the design of or the motivation for the development project.

A growing prioritization of clean energy is also visible when analysing trends in the composition of Aid for Trade flows (OECD and WTO, 2022). In 2011, approximately 40 per cent of all disbursements for the purpose of building energy generation capacity were channelled into non-renewable operations. By 2021, this proportion had halved to around 20 per cent. Figure 2.6 illustrates the gradual shift over the past decade. Moving forward, donor and partner commitments are

FIGURE 2.6 Share of Aid for Trade for renewable and non-renewable power generation



Source: OECD.Stat, Creditor Reporting System.

expected to further reduce Aid for Trade funding for brown (non-renewable) energy generation.

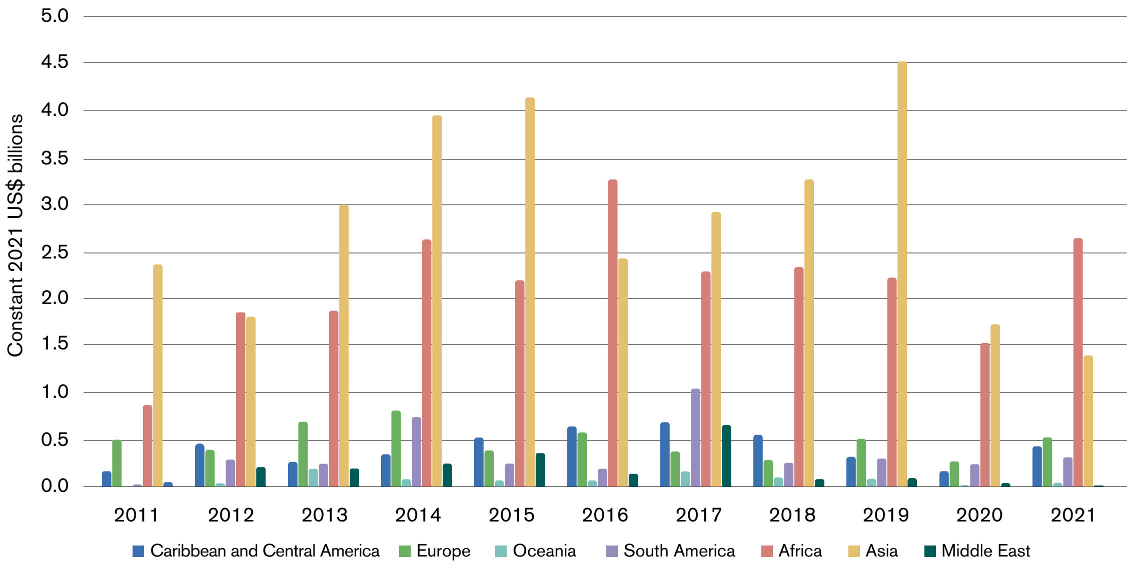
The inclusion of a climate lens on energy-related Aid for Trade fulfils a key concern highlighted by Aid for Trade stakeholders during the 2022 M&E exercise. More than 60 per cent of the donors and partners who responded to the questionnaire indicated that existing energy and power generation infrastructures were an impediment to a sustainable development transition. In addition, more than 75 per cent of respondents to the questionnaire observed that SDG 7 ("Affordable and Clean Energy") was referenced in their domestic policy frameworks.

Climate-tagged Aid for Trade commitments for energy sectors span income and regional classifications of developing economies. In terms of income classifications, lower middle-income economies were the main beneficiaries in 2011-21, receiving 41 per cent of all sectoral commitments over the period. LDCs received 22 per cent of energy-related Aid for Trade during the same period. On a regional level, economies in South and Central Asia were the largest recipients of climate-related disbursements, followed by Africa (split sub-regionally as North and South of the Sahara) and East Asia. A yearly breakdown of regional disbursements can be seen in Figure 2.7.

Germany emerged as the top donor of climate-related energy projects over the period 2011-21, with commitments of US$ 25 billion. Japan was also a top energy donor, with sectoral commitments worth US$ 17 billion over the same period (see Figure 2.8).

South-South cooperation has evolved into an important source of development financing over recent years. Trends in this form of aid for trade financing are difficult to discern, as South-South donors do not report commitments and disbursements to the OECD Creditor Reporting System (CRS). The importance of South-South financing is nevertheless recognized by the Aid for Trade initiative, and South-South partners are a key target group of the OECD-WTO Aid for Trade M&E process. Examples of South-South financing included in

FIGURE 2.7 Regional disbursements of climate-related energy projects (2011-21)



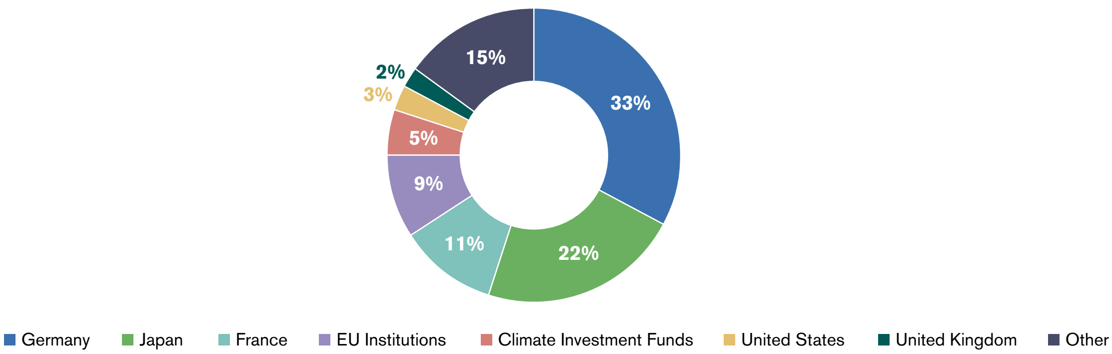
Source: OECD.Stat, Creditor Reporting System.

this text include support provided by India (through the ISA) and China (Asian Development Bank to Bhutan).

Various donor (OECD-DAC members and South-South partners) commitments to expand the provision of climate finance and Aid for Trade were also reflected in the 2022 M&E exercise. Commitments made by donors fall into the following categories:

- Commitments to offer preferential loan conditions for renewable energy projects and schemes in response to climate change.
- Commitments to include environment, climate and energy objectives in future trade agreements.
- Commitments to mobilize public and private investments to focus on private sector engagement.

FIGURE 2.8 Top donors of climate-related Aid for Trade commitments for energy (2011-21)



Source: OECD.Stat, Creditor Reporting System.

Given the scale of the financing needs and urgency to act, Aid for Trade can help to address productive capacity in the energy sector of developing economies and LDCs, and to support their integration into clean energy trade markets.

2.4 Blended finance to drive clean energy deployment and trade

Investment in clean energy is on an upward trend, but there is a significant gap between investment levels in developing and developed economies. International Energy Agency (IEA) estimates reveal that clean energy investments in developing economies and LDCs account for just one-fifth of global investment flows, although these economies account for two-thirds of the global population. Annual clean energy investments in these economies currently average US$ 150 billion (IEA, 2021a). In 2015, renewable energy investments *per capita* in Europe and North America (excluding Mexico) were almost 23 times higher than that in sub-Saharan Africa, while in 2021, renewable energy investments *per capita* in Europe were 41 times those in sub-Saharan Africa, and in North America they were 57 times higher (IRENA and CPI, 2023).

According to UN estimates, the compound annual growth rate of renewable energy in developing economies was 9.5 per cent over the period 2015-20. This rate is considerably lower for LDCs (5.5 per cent) and landlocked economies (3.8 per cent). At current average annual growth rates, it would take these economies almost 40 years to reach the same level of clean energy installation that developing economies achieved in 2020 (UN, 2023).

High upfront costs incurred when establishing clean energy infrastructure are one possible reason for this investment gap. The high cost of capital in developing economies (especially economies in debt distress) constitutes a significant disincentive for domestic investment into the energy transition (UNCTAD, 2023b). Another probable cause for this disparity is a perception that investments in developing economies and LDCs are classified as higher risk. In many of these economies, this perception is exacerbated by the absence of an adequate system to deliver market-relevant information for risk assessments (UNEP, 2016). As a result, international investors view market volatility as being too high, too dynamic and too variable. This dampens confidence and stems investment flows.

Targeted action is needed for the deployment of clean energy investments in developing economies and LDCs. As highlighted by the United Nations Conference on Trade and Development (UNCTAD), official development assistance (ODA) can be leveraged in the form of public-private partnerships, blended financing, investment guarantees, and other de-risking mechanisms to help bridge the investment gap. Aid for Trade, which forms nearly 25 per cent of ODA funding as of 2021, can play a catalytic role in this context.

One form of support receiving attention is "blended financing", which is defined by the Organisation for Economic Co-operation and Development (OECD) as "the strategic use of development finance for the mobilisation of additional finance towards sustainable development in developing countries" (OECD, 2018). Blended financing is already supporting an energy transition. OECD estimates reveal that over the period 2018-20, ODA was used to mobilize private finance worth US$ 6.8 billion for renewable energy projects. An additional US$ 700 million of leveraged private investments was allocated to the transmission and distribution infrastructure of developing economies (OECD, 2023b). Box 2.3 provides an example of such an initiative.

The Aid for Trade initiative can be instrumental in attracting greater private sector financing for clean energy investments, but can play a more catalytic role by:

BOX 2.3 Mobilizing institutional capital through listed product structures

MOBILIST (i.e., "Mobilising Institutional Capital Through Listed Product Structures") is a flagship programme funded by the United Kingdom's Foreign, Commonwealth and Development Office (FCDO). MOBILIST supports investment solutions that help to fund sustainable development and climate transition in developing economies.

The programme supports private funds that aim to list products or projects from developing economies in major stock exchanges. This helps to address market failures, as listing provides publicly available pricing and risk information on developing economy renewable assets (OECD 2022a).

In 2021, MOBILIST helped to establish the ThomasLloyd Energy Impact Trust (TLEI), with an initial investment of GBP 25 million (ThomasLlloyd Group 2021). TLEI operates as an investment trust vehicle and is focused on investing in sustainable energy infrastructure projects, including renewable energy power generation, transmission infrastructure, energy storage and sustainable fuel production in developing Asia.

TLEI will look to leverage the expertise provided by the ThomasLloyd Group, which has successfully deployed over US$ 1 billion across 16 projects in renewable energy power generation, transmission and sustainable fuel production across high-growth and emerging markets in Asia.

BOX 2.4 The Seed Capital Assistance Facility (SCAF)

The Seed Capital Assistance Facility (SCAF)[12] is a public sector donor-funded facility managed by the UN Environment Programme (UNEP). It is designed to support private sector stakeholders interested in clean energy deployment in developing Southeast Asia and sub-Saharan Africa. The Development Assistance Committee (DAC) list of ODA recipients is the foundation for SCAF eligibility. Projects are currently underway in Burkina Faso, Mali, the Philippines, Viet Nam and Zimbabwe.

SCAF uses a combination of grants and concessionary loans to address the investment barrier. Private sector stakeholders are provided with financial and technical support to create strong project pipelines, and with bankable investment opportunities that attract additional financing.

SCAF's investment outreach has strong trade linkages, and it helps to improve energy stability and trade-related infrastructural capacity. For instance, the Dam Nai plant in Viet Nam,[13] which operates with the help of SCAF support, contains 15 turbines that supply approximately 100 gigawatt hours (GWh) of power per year to a region that otherwise lacks energy access.

Phase I of SCAF was funded by the Global Environment Facility (GEF), the UN Foundation, the UN Environment Fund, the ADB and the AfDB.

- Helping to mobilize additional sources of finance for green supply-side infrastructure and MSME support to take advantage of opportunities in the low-carbon economy (WTO, 2022a);
- Harnessing capacity in developing economies and LDCs to adopt energy policies and laws that encourage investment in renewable energy sources; and
- Leveraging different forms of financing, including public-private partnerships, to funnel capital and expertise to support the development of renewable energy projects.

Green investment growth may be held back by a lack of clarity on what an investment promotion strategy entails in the context of the climate transition. This can make it difficult for governments to develop commercially viable green projects that can support develop and aid in the transition to a low-carbon economy (ASEAN Catalytic Green Finance Facility et al., 2020). Therefore, Aid for Trade can also be used to show stakeholders the benefits and means to attract private financing to achieve domestic clean energy goals. Box 2.4 highlights the Seed Capital Assistance Facility (SCAF) as an example of a UN-led investment promotion initiative.

Multilateral and regional research and support can help to address these gaps in understanding. For instance, the *Green Infrastructure Investment Opportunities* reports,[14] published by the Climate Bonds Initiative in partnership with the Asian Development Bank, help economies to showcase domestically available, financially attractive investments. Reports are currently available for Australia and New Zealand, Brazil, Indonesia, the Philippines, Viet Nam and Malaysia. Such projects can help investors discover viable alternatives to non-green assets and could stimulate the creation of a larger pool of green investments.

Endnotes

1. See the “OECD DAC Declaration on a new approach to align development co-operation with the goals of the Paris Agreement on Climate Change” of 27 October 2021 at https://web-archive.oecd.org/2021-10-29/614436-dac-declaration-climate-change-cop26.pdf.
2. OECD-DAC reporting classifies projects as serving a “principal” climate objective when a climate priority is explicitly stated as fundamental in the design of or the motivation for the activity. Projects are classified as serving a “significant” climate objective when climate priorities are explicitly stated but are not the fundamental driver or motivation.
3. Climate-tagged ODA for 2021 was lower than the historic peak reached in 2020. This may be indicative of a redistribution of aid to tackle emerging crises during the period 2020-21. Preliminary OECD reporting indicates that DAC donors spent US$ 18.7 billion in 2021 on COVID-19-related activities, representing 10.5 per cent of their combined net ODA.
4. See https://oecd.org/dac/financing-sustainable-development/development-finance-topics/climate-change.htm.
5. See https://web-archive.oecd.org/2021-10-29/614436-dac-declaration-climate-change-cop26.pdf.
6. See https://www.adb.org/sites/default/files/institutional-document/435391/strategy-2030-main-document.pdf.
7. See https://www.adb.org/what-we-do/energy-policy.
8. See https://www.aiib.org/en/policies-strategies/strategies/sustainable-energy-asia/.content/index/_download/AIIB-Energy-Sector-Strategy-Update_Final_Nov-2022.pdf.
9. See https://www.ifc.org/en/statements/2023/cop28-mdb-joint-statement
10. See https://www.consilium.europa.eu/media/66739/g20-new-delhi-leaders-declaration.pdf.
11. See https://stats.oecd.org/Index.aspx?DataSetCode=crs1.
12. See https://wedocs.unep.org/bitstream/handle/20.500.11822/31625/SEEDC.pdf?sequence=1&isAllowed=y.
13. See also https://www.unep.org/news-and-stories/story/how-wind-power-transforming-communities-viet-nam.
14. See https://www.climatebonds.net/green-infrastructure-investment-opportunities-giio-programme.

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).

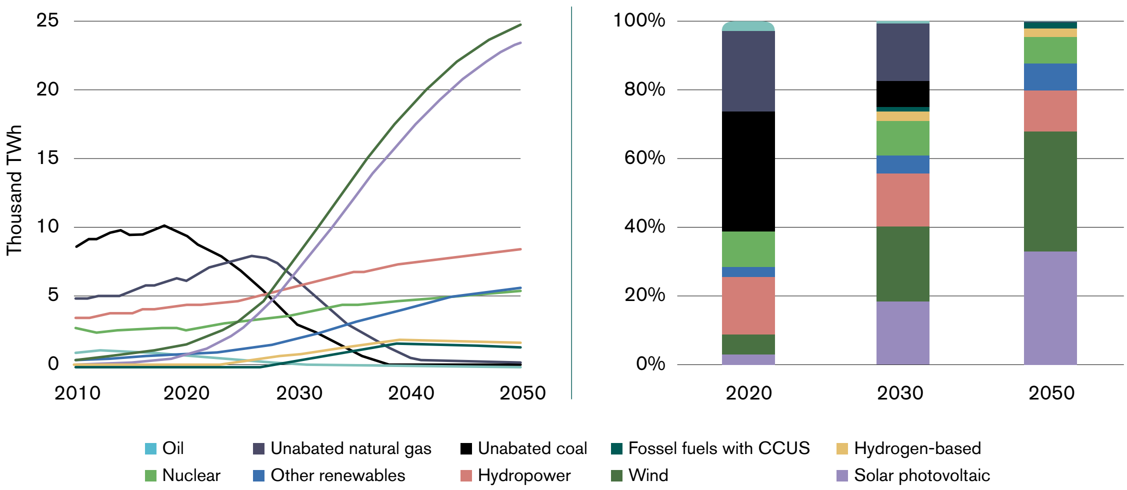
Accelerating the rate of renewable energy diffusion promises economic benefits. One study projects that a 1 per cent increase in renewable energy consumption is expected to generate 0.07 per cent, in the short run, and 1.9 per cent, in the long run, of African economic growth (Qudrat-Ullah and Nevo, 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.

FIGURE 3.1 Global electricity generation by source (2010-50)



Source: IEA (2021).

Note: "Unabated natural gas/coal" refers to the production and use of these fossil fuels without interventions that substantially reduce the amount of greenhouse gases emitted throughout the life cycle (IPCC 2023).

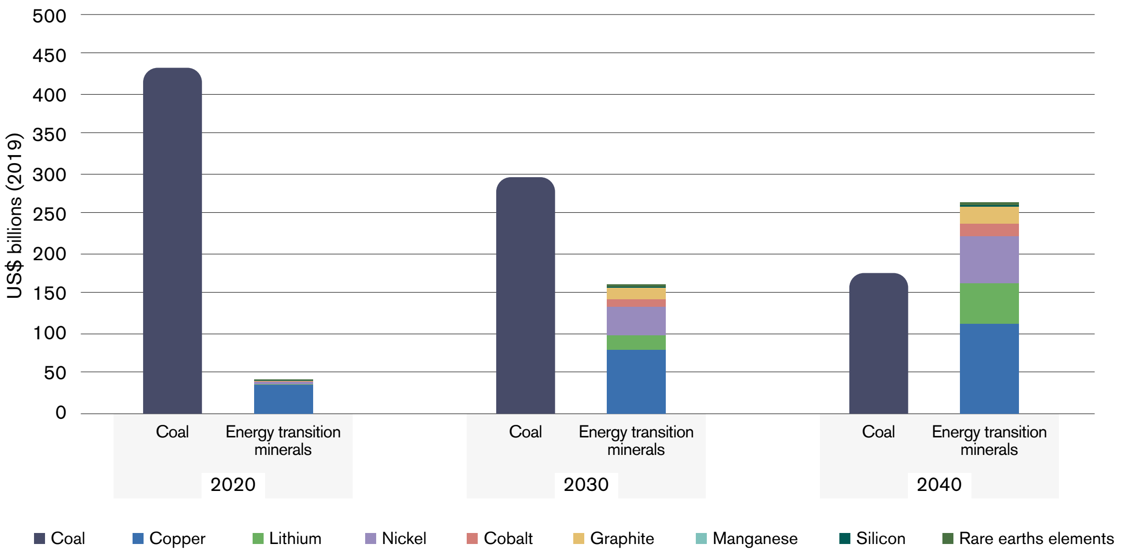
3.1 Supply of critical minerals and metals

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 specific example, an onshore wind plant requires nine times more mineral resources than a gas-fired power plant (IEA, 2022h).

Given their critical role in the clean energy deployment, the demand for minerals and metals is expected to expand over coming decades. For example, the World Bank estimates that over 3 billion tons of minerals and metals will be needed to deploy clean energy for a net zero transition by 2050 (Hund et al., 2020). It is estimated that the aggregate demand for critical materials for solar PV alone could expand as much as 400 per cent by 2030 (IEA, 2022f). This translates to increased revenue potential from sustainable mineral extraction. As indicated in Figure 3.2, revenues from coal production were approximately 10 times larger than those from producing minerals in clean energy technologies.

> Given their critical role in the clean energy deployment, the demand for minerals and metals is expected to expand over coming decades.

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



Source: IEA (2022h).

However, by 2040, the combined revenue from the mining of minerals required for the energy transition is expected to exceed that of coal.

The manufacture of clean energy equipment already accounts for a substantial proportion of global metal demand. Solar PV production accounted for 10 per cent of the global demand for silver and approximately 40 per cent of global tellurium use in 2021. Aluminium, a key metal in the solar PV manufacturing process, is also witnessing a considerable spike in demand; solar panel production will account for more than 40 per cent of the world's aluminium production by 2040 (Lennon et al., 2022). Essential minerals to produce clean energy, such as graphite, cobalt and nickel are also expected to witness accelerated demand gains. The IEA estimates that the demand for these three minerals could increase by up to 25 times within the next 20 years.

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.

The demand for copper, an essential metal input in wind turbine production and for electrification, is also expected to increase as the scale of grid connectivity and wind energy deployment expands. Currently, onshore wind farms are estimated to use approximately 4 tons of copper per MW, while offshore installations utilize 10.5 tonnes of copper per MW (Copper Development Association Inc., 2022). The accelerated deployment of clean energy is expected to double the demand for copper by 2035, compared to 2021 estimates (see Box 3.1).

BOX 3.1 Copper and a clean energy transition

Copper is often termed the "metal of electrification". This is due to its extremely high electrical conductivity potential, which allows for an efficient 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 five 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 figure 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 first production, more than 12 years to complete exploration and feasibility studies, and four to five 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 swelled over recent decades. In a report on lithium mining, McKinsey observed that 30 per cent of the demand for lithium in 2015 was for batteries. The bulk of demand in that year was split between ceramics and glasses (35 per cent) and greases, polymers and other industrial uses (over 35 per cent) (Azevedo et al., 2022). By 2030, however, batteries are expected to account for 95 per cent of lithium demand.

Many developing economies and LDCs are favourably endowed with mineral and metal resources needed to produce clean energy (e.g., for battery, solar PV, wind turbine and hydrogen production), which offers them opportunities to expand their export potential by catering to the expanding demand for these resources.

For instance, the Democratic Republic of the Congo (DRC) accounts for 74 per cent of global cobalt production; Chile and Peru collectively account for more than 40 per cent of all copper exports; Guinea accounts for approximately 55 per cent of all currently traded aluminium; South Africa produces and exports approximately 70 per cent of all platinum; and nickel and laterite deposits are mainly found in Indonesia, the

BOX 3.2 Minerals in battery production

Minerals are not just vital to produce clean energy. They are essential inputs for the manufacture of energy storage technology as well. International Monetary Fund (IMF) estimates indicate that a typical electric vehicle battery pack requires around 8 kilogrammes of lithium, 35 kilogrammes of nickel, 20 kilogrammes of manganese and 14 kilogrammes of cobalt (Boer, Pescatori and Stuermer 2021). IEA research also indicates that a battery-powered electric vehicle contains five times more copper (60-83kg) than a car fitted with an internal combustion engine.

Mineral requirements for battery production are expanding exponentially as demand for electric vehicles grows. The IEA (2023l) expects electric vehicle sales to increase from 30 million in 2022 to 250 million by 2030 under the Announced Pledges Scenario (APS). This can be expected to significantly increase the demand for minerals such as lithium, cobalt and nickel, which are already consumed heavily in the process. In 2022, approximately 60 per cent of lithium, 30 per cent of cobalt and 10 per cent of nickel demand was used for electric vehicle battery production (IEA, 2023m).

Increased material and production requirements for electric vehicle batteries could expand the trade potential of developing economies. Research by the Peterson Institute for International Economics notes that Argentina, Bolivia and Chile collectively hold nearly two-thirds of known lithium reserves (Leruth, Mazarei and Renneboog 2022). Increased demand for nickel will benefit economies such as Indonesia and the Philippines, which hold considerable reserves of this resource.

One example of an Aid for Trade initiative is a regional project developed by the Inter-American Development Bank for Argentina, Chile, Bolivia and Peru.[2] The project, initiated in 2019 and closed in 2021, seeks to construct a common development agenda for the lithium industry. This will help to help expand extraction in a coordinated and sustainable manner as to support export development opportunities.

Philippines and the Pacific 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 socio-economic benefits of extraction activities are maximized and well-distributed. For instance, assuring labour safety during extraction activity is a key consideration (see Box 3.3).

Developing economies can also generate benefits by integrating into value chains focused on mineral recycling, given that the demand for primary minerals is likely to be complemented by a strong secondary market for recycled raw materials. Secondary markets are already well established for certain minerals and metals. For example, in 2018, nearly 8.7 million tonnes of copper were recycled from scrap materials, and one-third of nickel supply was sourced from recycled materials (Copper Alliance, 2022).

Many developing economies and LDCs are favourably endowed with mineral and metal resources needed to produce clean energy.

BOX 3.3 Aid for Trade in action: the World Bank's Climate-Smart Mining Facility

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 benefit 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 deployed over a five-year timeframe. The Facility is assisting developing economics build robust policy, regulatory and legal frameworks that promote climate-smart mining and create an enabling environment for private capital.

Projects may include:

- **Supporting the integration of renewable energy into mining operations,** given that the mining sector accounts for up to **11%** **of global energy use**
- **Supporting the use of geological data** for a better understanding of strategic mineral endowments;
- Preventing deforestation and **supporting sustainable land-use practices;** and
- **Supporting circular economy approaches** to recycle minerals in a sustainable manner.

Currently, up to 70 per cent of aluminium is recycled, with rates as high as 90 per cent in some economies. Production of aluminium from recycled sources delivers a positive environmental impact, as the associated carbon footprint is approximately 5-10 per cent that of primary production (Hund et al, 2020). According to IEA estimates, by 2040 recycled copper, lithium, nickel and cobalt may account for 10 per cent of the global supply of each of these minerals (IEA, 2022h).

Economies also can add value by leveraging circular economy practices that extend mineral and metal life beyond the decommissioning stage. Operations such as material sorting and recycling can create additional employment and offer opportunities to penetrate international secondary markets for scrap resources. A WEF (2021) study also shows that the high-quality repurposing of lithium-ion batteries can help to create livelihoods and upskilling opportunities for the populations of many low-income economies (see also Box 3.2).

How can Aid for Trade help unlock trade opportunities?

Aid for Trade can help developing economies and LDCs integrate into mineral value chains in several ways.

Aid for Trade can be disbursed with a view to enhancing the sectoral infrastructure of economies, to ensure that they have adequate capacity to partake in safe and sustainable extraction methods. The World Bank's Climate-Smart Mining Facility (see Box 3.3) is an example of this.

Aid for Trade can help trade facilitation and improve the socio-economic footprint of mineral extraction by advancing supply-chain transparency and traceability protocols.

Aid for Trade can be used to address technological and regulatory barriers that prevent efficient mineral recycling methods.

Aid for Trade can be used to deliver targeted investment promotion that helps incentivize private sector activity.

3.2 Machinery and equipment manufacturing

Value chains for solar panels, wind turbines and other clean energy equipment continue to evolve and expand to match growing demand. As a result, market opportunities are expected to increase rapidly over the coming decades. By 2050, the value of manufacturing operations for these products is expected to exceed US$ 1 trillion (IEA, 2021f). This is comparable to the current size of the international oil market.

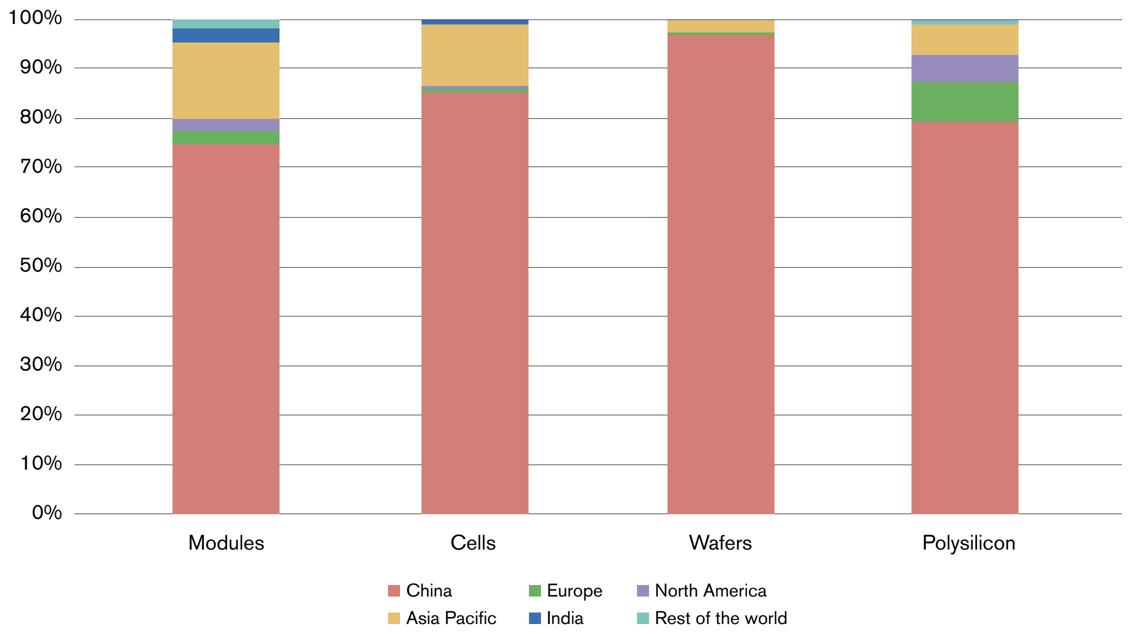
Expanding clean energy markets presents trade opportunities for developing economies and LDCs. Many possess competitive advantages that favour their participation in manufacturing value chains, such as raw materials (e.g., metals and minerals, as detailed in Section. 3.1) and large domestic market and/or locational advantages that could position them as vital sustainable energy value chain nodes. By embedding into these value chains, these economies could expand their export potential, increase employment prospects, enhance foreign direct investment flows, and accelerate the diffusion of technology necessary for efficient local clean energy adoption.

As is clear from Figure 3.3, China has emerged as the key manufacturing hub for clean energy technologies. Some other developing economies have experienced a degree of success in integrating into these value chains. For instance, Malaysia and Viet Nam have positioned themselves as important nodes in the solar PV value chain, and since 2017, components such as solar wafers, cells and chips account for around 10 per cent and 5 per cent respectively of their trade surpluses (IEA, 2022g). India, Thailand, Mexico and Philippines have also carved out niche spaces for themselves in solar and wind turbine manufacturing.

African economies also have the potential to participate in the manufacturing value chains for renewable energy technologies. Examples of firms actively involved in domestic and regional value chains already exist. For instance, Solar Power Solutions (SPS) is a Ghanaian firm that manufactures, supplies and installs off-grid and grid systems, photovoltaic systems and PV streetlights.[4] Established at a cost of US$ 50 million in 2016, the firm has the capacity to produce 30 MW of solar modules a year with plans to expand production in the future.

Expanding clean energy markets presents trade opportunities for developing economies and LDCs; many possess competitive advantages that favour their participation in manufacturing value chains.

FIGURE 3.3 Solar PV manufacturing capacity by economy and region, 2021



Source: IEA (2022e)

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 private sector investment to support the deployment of clean energy technologies is a priority of this initiative.

The "China-Africa Cooperation on Climate Change" seeks to enhance South-South cooperation to facilitate the delivery of climate technologies and services in Africa.[6] And the Africa Renewable Energy Manufacturing Initiative (AREMI), launched in 2023, aims to drive investment and mobilize action to scale up renewable energy manufacturing capacity. A significant action priority of the initiative is to partner with government officials to create a facilitatory policy environment for clean energy investment. The initiative will also seek to improve supply-side capacity by training engineers and technicians to support manufacturing operations.

BOX 3.4 Renewable energy manufacturing in Africa

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 identified 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 specific 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.

NAMIBIA

Namibia offers strong projected demand for renewable energy by 2030. It also possesses high-quality infrastructure and mineral resources, and it has prioritized the development of clean energy, particular hydrogen, for export markets.

SOUTH AFRICA

South Africa's projected solar energy demand is expected to increase exponentially over the next few years. Its strong manufacturing base, coupled with an enabling policy space, means that a domestic industry could be established to cater to this spike in domestic consumption.

Ways in which Aid for Trade can help developing economies and LDCs to integrate into manufacturing value chains include:

- Financing the development of infrastructure projects critical for clean energy technology manufacturing to improve trade competitiveness. Activities include establishing renewable energy generation facilities, scaling domestic grid infrastructure and modernizing transportation networks (e.g., port and roadway infrastructure).
- Connecting developing-economy and LDC manufacturers with potential buyers, distributors, and partners in other economies. Aid for Trade can also be leveraged to help firms establish and implement operations that comply with international standards, making it easier to trade these products globally.
- Helping regulators streamline trade procedures to minimize trade-related costs. Aid for Trade can also be used to encourage regional cooperation and integration between neighbouring economies. This allows economies to pool resources and build a stronger collective presence in the global clean energy technology market.
- Providing financial assistance in the form of grants, loans, or guarantees to attract private sector investment to clean energy technology manufacturing.

BOX 3.5 Grid scale battery production in Indonesia

IA-CEPA ECP Katalis (Katalis)[7] is a five-year (2020-25) development programme backed by Australia that looks to unlock the economic potential arising from the partnership established under the Indonesia-Australia Comprehensive Economic Partnership Agreement Economic Cooperation Program (IA-CEPA ECP).[8]

Katalis seeks to maximize the benefits from the bilateral partnership in three ways:

- improve bilateral market access,
- increase bilateral trade and investment, and
- help achieve inclusive economic growth in Indonesia.

Katalis was flagged as a flagship Aid for Trade partnership by Australia in its response to the 2022 Aid for Trade M&E exercise.

One strategy employed by Katalis to achieve these objectives is to leverage breakthrough investment from advanced manufacturing firms based in Australia into Indonesia. As part of this strategy, Katalis is funding a market entry study[9] to identify the next steps to establish manufacturing plants for grid-scale long-duration batteries in Indonesia by 2026. The demand for such batteries is expected to grow in the medium to long term, as economies increasingly look for ways to store surplus energy created through clean energy sources.

The establishment of such a battery plant offers trade and economic benefits for Indonesia. It would help to supply local needs and to scale up domestic manufacturing capacity, as well as providing trickle-down benefits to local MSMEs, who now have an opportunity to integrate into the services or manufacturing battery value chain as product and service providers. The plant would also help expand export potential, as Indonesia could develop into a source for battery production for regional neighbours in Southeast Asia.

3.3 Services value chains

Services activities play a vital role in every stage of the clean energy generation cycle. They are essential from the planning of clean energy production sites down to the eventual decommissioning of capital equipment. LDCs and developing economies could enhance growth prospects and generate additional employment by prioritizing value-added services as they build domestic clean energy capacity.

The importance of services operations in clean energy deployment has been recognized in several studies. For instance, an IRENA study on wind energy reveals that nearly 75 per cent of the labour involved in deploying a 50 MW wind farm was comprised of services sector activities, such as grid installation, operation and maintenance (IRENA, 2017a). Another study, focused on solar PV plants, indicated that nearly 56 per cent of labour was involved in services such as operations and maintenance (IRENA, 2017b).

Estimates by IRENA and the AfDB (IRENA and AfDB, 2022) project that the energy transition has the 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 identified 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**: Includes service activities such as site surveying, drafting technical and financial feasibility reports, engineering design and project development.
- **Manufacturing services**: Involves services such as the cutting, welding, washing, bending, melting and joining of clean energy equipment.
- **Transport**: Delivering supplies and/or finished equipment by truck, plane, train or boat.
- **Installation and grid connection**: Encompasses site preparation activities involving staff operating loaders, cranes, trucks and excavators.
- **Operation and maintenance**: Activities that take place during the entire expected lifetime of clean energy equipment. Key activities in this phase focus on preventive and corrective maintenance.
- **Decommissioning**: Involves products dismantling and activities involved in clearing sites.

Operation and maintenance services, in particular, are essential roles in the life cycle of clean energy plants. These include activities such as ensuring smooth turbine or solar PV operations, handling equipment failure and coordinating with utility services to ensure streamlined energy transmission to the national grid.

Efficient clean energy production also requires inputs from external service operators providing essential support for daily operations. Box 3.6 focuses on the World Meteorological Organization's Systematic Observations Financing Facility (SOFF),[10] which provides institutional support to LDCs and small-island developing states to develop advanced weather forecasting systems. This is an important activity, given that only 10 per cent of required basic weather and climate forecasting systems are available in this economy group (WMO, 2022).

> Services activities are essential from the planning of clean energy production sites down to the eventual decommissioning of capital equipment.

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 efficiency 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 defined under WISE (Bouchene et al., 2021).

BOX 3.6 The Systematic Observations Financing Facility (SOFF)

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 influenced by fluctuations 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 sufficient 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 significant 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 significant export earner for many LDCs.

Launched in 2021, the Systematic Observations Financing Facility (SOFF) is a financing mechanism that aims to address this measurement deficit.[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 financing 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 financial support has been provided by donors, including Austria, Denmark, the Nordic Development Fund, Norway and Portugal.

How can Aid for Trade help unlock trade opportunities?

Aid for Trade can support developing economies and LDCs to capture market share in the services value chains for clean energy by:

- Channelling capacity-building and training programmes for local service providers in 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.

BOX 3.7 Aid for Trade in Action: USAID capacity-building assistance in Guajira, Colombia

In recent years, Colombia has enacted a series of regulatory initiatives to promote domestic wind energy potential. These commitments are centred around the Guajira region, located in Colombia's north-eastern peninsula. Over the next three years, 16 wind park projects, representing around 70 per cent of the newly installed capacity in Colombia, will be situated in the region.

Although it is rich in wind energy resources, Guajira is one of the most impoverished parts of Colombia. Approximately 20 per cent of its urban residents lack electricity services, and this number rises to 60 per cent in the region's rural areas. Ensuring that the local community benefits from electricity access and the economic opportunities arising from clean energy investments have emerged as key policy priorities.

With support from USAID, Colombia has created a sustainable local workforce training programme for Guajira[15] that will meet the needs of both the indigenous communities and the renewable energy companies situated working in the province. The project will be spearheaded by SENA ("Servicio Nacional de Aprendizaje"), a government initiative that develops vocational training programmes to increase employment and strengthen Colombian competitiveness. Assistance from USAID will be delivered under its flagship "Scaling Up Renewable Energy" (SURE) initiative.[16]

Upon completion of the training, participants are certified as competent in the knowledge and skills necessary to work in areas related to renewable energy. Through this initiative, Colombia is helping to build regional capacity with a view to enabling the younger generation to service and manage a future fleet of renewable energy projects on a national and regional scale.

- Leveraging finance to expand aggregate investments in renewable energy services. Aid for Trade can be used to catalyse financial 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-tariff barriers.

- Assisting MSMEs in developing economies and LDCs in their efforts to comply with international standards and quality requirements for renewable energy services. Providing firms with the support to understand and comply with quality assurance frameworks, certifications and conformity assessment measures can enhance the credibility and marketability of services. This allows for better access to global markets.

- Facilitating technology transfer and innovation partnerships to promote the adoption of advanced technologies in renewable energy services.

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 verified 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 significant 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 benefit from a potential income-generating mechanism.

For developing economies, carbon credits can be an important source of revenue and can help finance 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 efficiency 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 benefit 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 inefficient 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 (Clean Cooking Alliance, 2020). This equates to about 2 per cent of global CO_2 emissions.

BOX 3.8 Powerstove – digitalized clean cooking solutions for development

Nearly 70 per cent of all Nigerian households continue to use solid biomass, such as firewood and charcoal, for cooking. In their raw forms, these energy sources are highly pollutive and burning them can cause respiratory problems.[17] Increasing access to alterative and cleaner energy sources for cooking has proven difficult due to limited grid accessibility: the World Bank estimates that nearly 50 per cent of Nigerian households lack access to electricity access.[18]

Founded in 2018, Powerstove is a Nigerian company that manufactures cookstoves using wood bio-pellets to produce reliable energy. Cookstoves produced by Powerstove are smokeless and burn 70 per cent less biomass than traditionally used cooking solutions. This represents a significant, locally created step toward improving access to clean cooking in Nigeria.[19]

Powerstove is in the process of incorporating innovative technology that improves the efficiency and revenue-generating capacity of manufactured cookstoves. For instance, cookstoves will be integrated with self-powered devices that help to monitor user behaviour and generate carbon credits in a transparent and traceable channel. Each device will be geo-tagged to help pay a share of the carbon credits through digital identities. These gains are delivered directly to households through registered mobile money accounts.

Powerstove products are exported across the continent. It is an example of a developing-economy MSME that has used digitalization to gain from a trade opportunity during a clean energy transition.

This new digitalization initiative is being conducted in coordination with the Agence Française de Développement (AFD).[20] With AFD assistance, the project will include the development of the Powerstove Academy, a training platform for the company's employees in Nigeria, Kenya and Zimbabwe. Funds provided by AFD will also be used to help Powerstove acquire mobile kiosks to sell its products in new areas of Nigeria.

A transition to refined 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 financial opportunities, as the act of replacing pollutive bioenergy sources with a cleaner alternative with fewer CO_2 emissions can generate carbon credits. The financial benefits gained through leveraging carbon credits in recognized markets can offer an additional incentive to participate in a transition. This is an opportunity that has been increasingly exploited over recent years. Revenue from carbon credits rose to more than US$ 11 million in 2020, a 22-fold increase over the US$ 500,000 tracked in 2017 (Galt et al., 2023).

How can Aid for Trade help unlock trade opportunities?

Aid for Trade can help developing economies and LDCs benefit from the opportunities presented by carbon markets by:

Helping MSMEs in developing economies navigate the complex requirements to enter international carbon markets. Activities with which firms may face difficulties in complying include project registration and the valuation of credits gained through renewable energy initiatives and energy efficiency programmes.

These are important steps to enter recognized carbon markets such as the Clean Development Mechanism (CDM).[21]

Assisting economies in developing legal and regulatory frameworks to participate in carbon markets, including establishing transparent reporting mechanisms, standards for carbon accounting and rules for the verification of emissions reductions.

Supporting the development of market intelligence and information-sharing portals to share carbon market opportunities with stakeholders in developing economies. This information can help businesses and governments make informed decisions about participating in carbon markets.

Mobilizing development and climate finance sources to support businesses interested in investing in clean energy and emissions reduction projects. The case study in Box 3.8 is one example of such a partnership in action.

Recent development in the carbon, capture, use and storage (CCUS) sphere may also help developing economies and LDCs in the clean energy transition. CCUS refers to a range of technologies and equipment that can help to capture and store or utilize CO_2 emitted by fossil fuel combustion,[22] with a view to permanently removing carbon emissions from the atmosphere.

By implementing CCUS technologies, companies can offset additional carbon, thus creating an additional revenue generating mechanism by earning carbon credits. Carbon credits can also help boost firm-level clean energy deployment by offering firms an added monetary incentive to reduce their carbon footprint. The various means to achieve CCUS are represented in Figure 3.4.

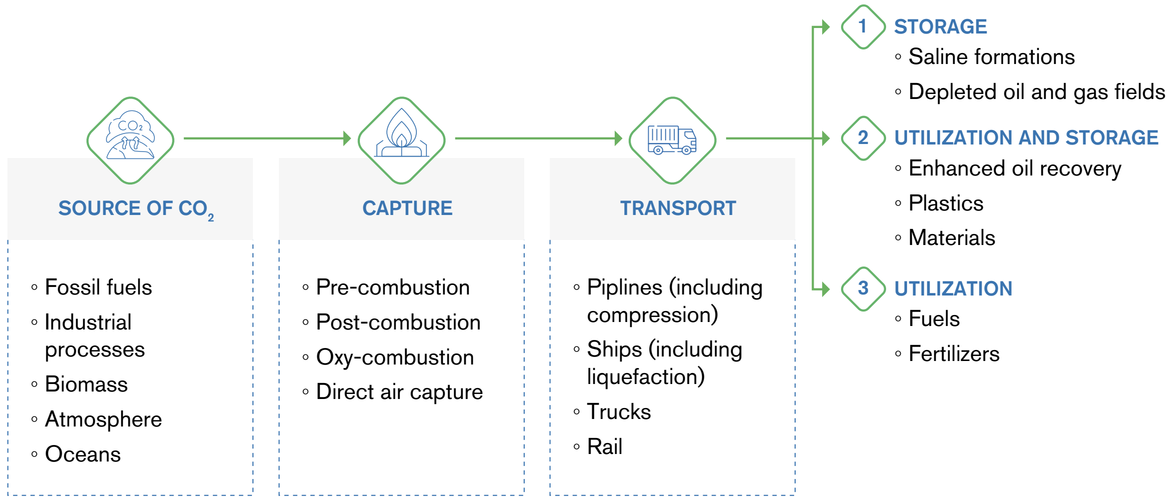
CCUS technologies can also be used to cater to market opportunities by serving the demand for goods with embedded carbon. Examples of activities that benefit from CCUS expansion include the production of fertilizers, industrial chemicals, building materials, food and beverages. Reframing CCUS technologies as investments that complement the returns from carbon markets may help to increase adoption rates, as they serve as a strong monetary incentive to reduce energy emissions. Box 3.9 offers an example of this strategy in action.

CCUS technologies can also play a crucial role in smoothing the energy transition challenge for many economies. The IEA forecasts that fossil fuels will continue to play a role in the global economy, and estimates that approximately 10 per cent of global electricity in 2050 will be generated from fossil fuels using existing coal, oil or natural gas plants (IEA, 2021c). Several developing economies and LDCs will remain particularly sensitive to trends in this industry. Fuels currently account for approximately 25 per cent of total LDC exports and dominate the export baskets of several economies – for example, fuels accounted for 92 per cent, 77 per cent and 88 per cent of all merchandize exports for Angola, Chad and South Sudan, respectively, in 2020.[23]

Retrofitting fossil fuel plants with CCUS technologies contributes to achieving net zero goals by reducing the emission intensity of fossil-fuel based power systems, as reducing and then removing carbon emissions in this manner could help to bridge the emissions gap until innovative technologies are commercialized. As a result, hard-to-abate sectors can continue their operations with reduced or no GHG emissions.

Currently, the high capital costs for CCUS integration act as an impediment for its adoption in developing economies. However, CCUS technologies may become cheaper through technology spillovers and economies of scale. The costs of large-scale CCUS projects have already shown declines; IEA (2021g) research notes that the cost of CCUS capture from large-scale coal power plants has come down by 35 per cent over the period 2014 to 2020. Planned coal plants with carbon capture (commissioned from

FIGURE 3.4 Carbon capture, utilization and storage



Source: IRENA (2021c).

2025) are expected to operate at even lower costs, at approximately 35 percent of costs estimated in 2014.

The use of CCUS technologies can be particularly useful in the context of bioenergy with carbon capture and storage (BECCS), which involves capturing and storing CO_2 where biomass is converted into fuels or directly burned to generate energy.[24] BECCS has been identified in consecutive United Nations Climate Change (UNFCCC) Assessment Reports as one of the strategies to enable a net zero transition. According to IRENA estimates, it is the most developed example of carbon removal technology that is currently available (Lyons, Durrant and Kochhar, 2021).

BOX 3.9 Retrofitting thermal infrastructure with CCUS

Founded in 2009 and headquartered in London, Carbon Clean[25] delivers cost-effective CCUS solutions to industrial carbon emitters. This includes firms involved in activities such as cement, steel and energy production and waste processing. Its rapid expansion has enabled Carbon Clean to open offices in India, Spain and the United States, as well as 44 facilities across the globe. As of June 2022, Carbon Clean had removed over 1.5 million metric tonnes of carbon by means of these facilities.

In 2022, Carbon Clean partnered with India's largest power station, Vindhyachal Super Thermal Power Station,[26] to explore the possibility of capturing CO_2 from plant flue gas to produce 10 tonnes per day of methanol for commercial trade.[27] Methanol is used as a starting substrate for the synthesis of various other chemical compounds required for the production of adhesives, foams and paints.

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 Environment Facility (GEF) has shown that this has proved to be a viable strategy for economies with a large agricultural production base (UNIDO and GEF, 2021).

Examples provided in this research include:

- Waste from avocado cultivation to generate biogas to cover manufacturing electricity needs in Kenya.
- Substrate wastes from food processing units (e.g., potato scraps, dairy sludge) to generate electricity in Brazil.
- Agricultural residues, such as rice husks, rice straw, cotton seeds and maize cobs, to produce charcoal briquettes in Uganda.

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 financial 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/files/katalis-fact-sheet.pdf.
9. See at https://prospera.egnyte.com/dl/glhE6zAMui.
10. See https://un-soff.org.
11. See https://circulareconomy.earth/publications/how-can-we-create-circular-opportunities-for-energy-access.
12. See https://cordis.europa.eu/project/id/776680.
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15. See https://www.usaid.gov/energy/colombia-clean-energy-future/inclusive-transition/community-buy-in.
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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/.
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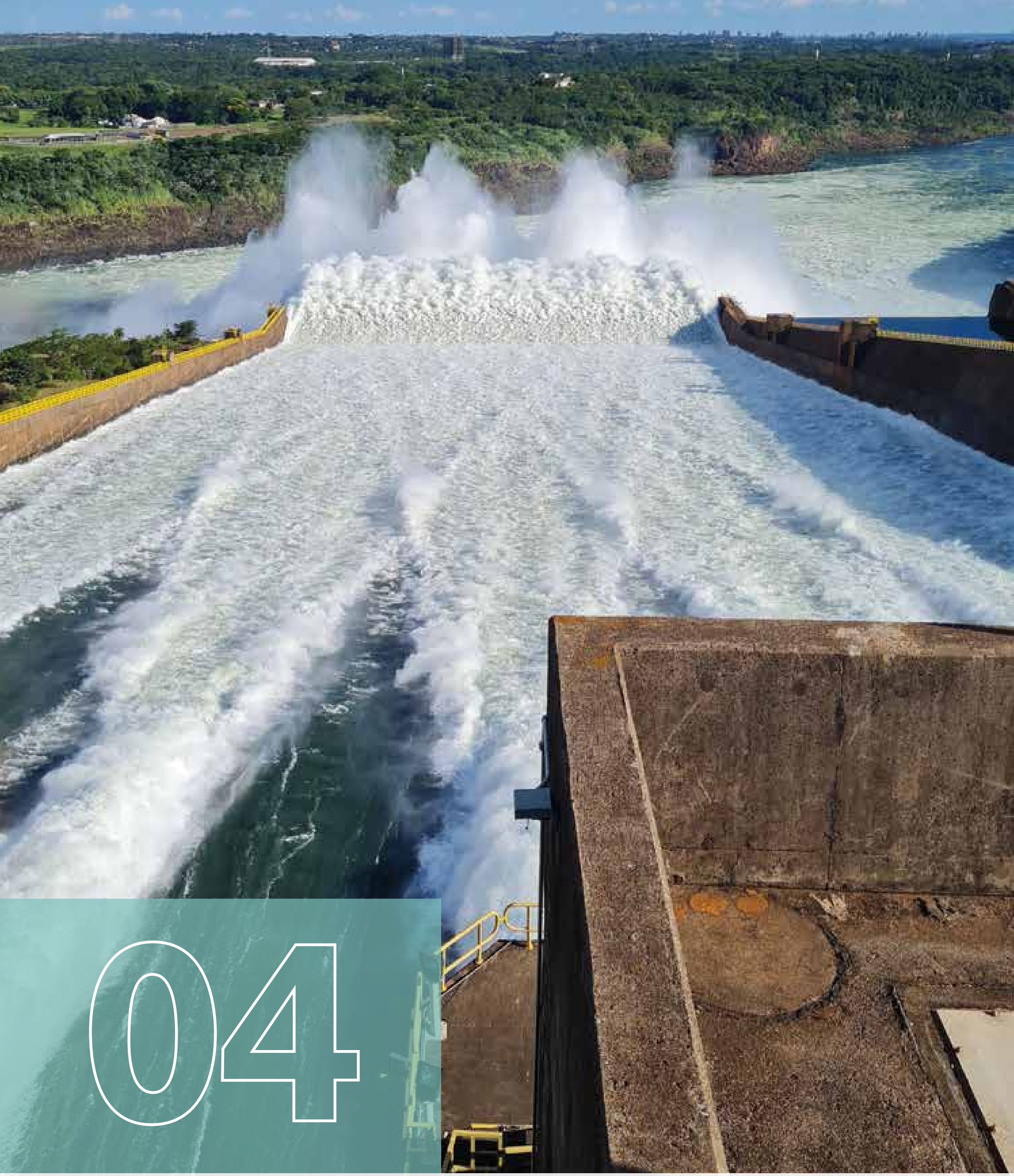
21. See https://unfccc.int/process-and-meetings/the-kyoto-protocol/mechanisms-under-the-kyoto-protocol/the-clean-development-mechanism#:~:text=UNFCCC%20Nav&text=The%20Clean%20Development%20Mechanism%20(CDM,reduction%20project%20in%20developing%20countries.
22. See https://www.iea.org/fuels-and-technologies/carbon-capture-utilisation-and-storage.
23. See WTO official document number WT/COMTD/LDC/W/71 (available via https://docs.wto.org/).
24. See https://www.iea.org/energy-system/carbon-capture-utilisation-and-storage/bioenergy-with-carbon-capture-and-storage.
25. See https://www.carbonclean.com/about-us.
26. See https://www.world-energy.org/article/26923.html.
27. See https://www.carbonclean.com/news/ntpc-power-plant-india.



04

Opportunities for trade integration in specific clean energy technology value chains

4.1 Enabling clean energy access through electrification

A just clean energy transition is underpinned by universal electricity access. This is because electricity facilitates the use of renewables to cater to energy demand needs. For instance, in energy-deprived communities, ensuring electricity access can lead to a shift away from traditional and polluting energy sources like kerosene lamps and diesel generators.

Accelerating the process of electrification can also unlock a green transition in other sectors. Electrification, for instance, enables the deployment of electric vehicles as a substitute for internal combustion engine vehicles and allows for the adoption of electric heating systems in buildings.

Electricity access remains a pressing issue in many developing economies and LDCs. Nearly 760 million people worldwide were without electricity access in 2022. Some 608 million, or approximately 80 per cent of those without electricity access that year, were in sub-Saharan Africa (IEA, 2023j); and only 48 per cent of the population in sub-Saharan Africa has access to electricity.[1] The region uses the same amount of electricity as Spain despite having a population 18 times greater. An energy deficit on this scale impacts the possibilities for economic growth, trade integration and sustainable development.

Directly integrating communities without access to renewable electricity grids has been shown to be an effective strategy to promote energy access. According to IEA et al. (2021), the number of connections to renewable grids doubled between 2010 and 2019, with approximately one-third of this increase involving so-called "Tier 1" entrants, i.e., those from the lowest level of energy access. Nearly 105 million people have received energy access through decentralized solar grids in sub-Saharan Africa alone.

Clean energy is necessary both for climate transition and to solve a key trade-related infrastructure bottleneck faced by developing economies. Power generation is a key constraint for productive capacity, which inhibits trade and export potential.

An often-neglected question is how the development of renewable energy technologies can open opportunities for industrial development and value chain integration. Fulfilling such opportunities depends on a complex combination of factors, including competitive advantages, natural resource endowment, domestic supply-side capacity and the facilitatory trade and clean energy policies of developing economies seeking to enter specific clean energy value chains.

Another example of an initiative that can help generate spill over effects is the One Sun One World One Grid initiative (see Box 4.1). The initiative was established during the 26th session of the Conference of the Parties (COP26) in 2021 and is operated in partnership with the International Solar Alliance (Box 4.6) and the World Bank.

The subsequent sections will provide a deep dive into five renewable energy value chains that could be used to improve clean energy access through electrification and to improve development outcomes. Each section also discusses how Aid for Trade can help to seize opportunities in each technology.

Directly integrating communities without access to renewable electricity grids has been shown to be an effective strategy to promote energy access.

BOX 4.1 One Sun One World One Grid and the Green Grids Initiative

The Global Green Grids Initiative (GGI) was announced at the United Nations Climate Change Conference COP26 held in Glasgow in 2021.[2] Supported by Australia, France, India, the United Kingdom and the United States, the initiative seeks to create a more inter-connected global electricity grid to promote trade in energy from sun, wind and water across borders. This requires new transmission lines that cross borders and connect different time zones, forming a global ecosystem of interconnected renewable energy, combined with expanded and modernized national and regional grids.

To help realize this vision, an action agenda for global cooperation was developed through working groups of interested governments, regulators, financiers, institutions, companies, legislators and researchers.

The "One Sun One World One Grid" (OSOWOG)[3] initiative was launched by India and the United Kingdom during the same COP summit.[4] The aim of the "One Sun One World One Grid" initiative is to enable power access to nearly 140 economies through a common, cross-border grid that will help transfer clean and efficient solar power.

As per the OSOWOG Declaration,[5] the aims are to provide a common global framework for:

- "Investing in solar, wind, storage and other renewable energy generation in locations endowed with renewable resources for supporting a global grid."
- "Building long-distance cross-border transmission lines to connect renewable energy generators and demand centres across continents, underpinned by effective and mutually beneficial cross-border power trading arrangements."
- "Developing and deploying cutting edge techniques and technologies to modernise power systems and support green grids which can integrate billions of rooftop solar panels, wind turbines and storage systems."
- "Supporting the global transition to zero emission vehicles through incorporating the role of electric vehicles to help improve grid flexibility."
- "Attracting investment into solar mini-grids and off-grid systems to help vulnerable communities gain access to clean, affordable, and reliable energy without grid-access in their own areas, enhancing socio-economic development and a resilient power supply for all."
- "Developing innovative financial instruments, market structures, and facilitate financial and technical assistance to attract low-cost capital, including climate finance, for global solar grid infrastructure."

4.2 Wind energy value chains

Wind can be used to generate electricity through the conversion of kinetic energy produced by rotating turbine blades. It is one the fastest-growing renewable clean energy sources, with capacity expanding threefold over the past decade alone.

In 2022, wind accounted for 2100 terawatt-hours (TWh) of electricity generation, or nearly 25 per cent of all renewable production (IEA, 2023k). It is the second most adopted renewable technology after hydropower.

Wind is harnessed using turbines in either onshore or offshore locations. Onshore infrastructure is predominant, accounting for 93 per cent of all wind energy produced in 2021.

The scale of onshore adoption, coupled with major technological advancements, has led to steep cost declines. In fact, the weighted average levelized cost of electricity fell 68 per cent between 2010 and 2021 (IRENA, 2022a). This has made onshore wind generation competitive with electricity generated from fossil fuel sources. Following two consecutive years of decline, new global onshore wind installations are expected to recover significantly and reach almost 107 GW in 2023.

Offshore wind infrastructure is less diffused in comparison, generating approximately 7 per cent of all wind-based electricity in 2021 (IEA, 2022k). Rapid technological process has propelled deployment rates over recent years. Offshore capacity grew by 30 per cent year on year between 2010 and 2020. This momentum is set to continue, with estimates projecting that offshore wind may become the fastest growing clean energy source over the next four years, expanding by 240 per cent in capacity by 2026 (IEA, 2022e).

Offshore wind promises substantial electricity generation potential for coastal economies with optimal wind speeds of above 7 m/s. For instance, a study conducted by the World Bank of eight developing economies suggests that offshore wind turbines could produce 3.1 TW – a value that outstrips current electricity supply for these economies.[6] The study considers offshore areas within 200 kilometres of the coastline, with a fixed capacity of 1,016 GW and a floating capacity of 2,066 GW.

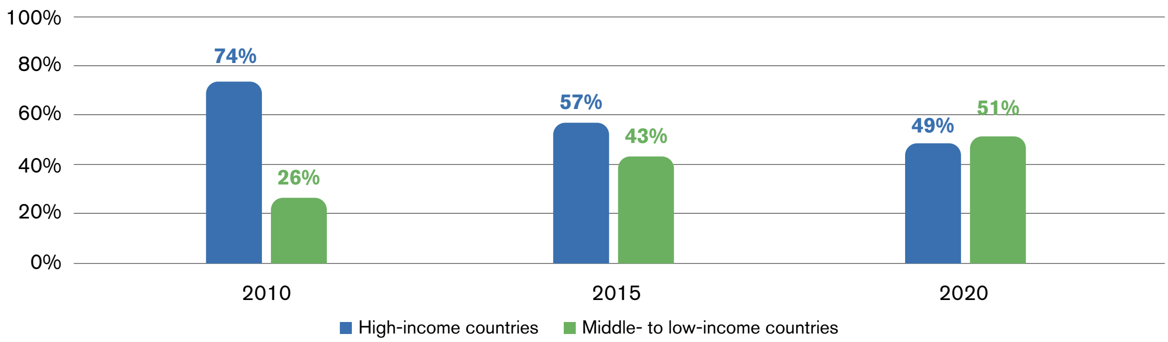
Falling costs and rapidly improving efficiency make wind a viable clean energy source for many developing economies and LDCs. Wind permits a larger scale of electricity generation, at a higher capacity factor, than any other clean energy source.

It is an ideal energy source for urban centres situated near optimal wind generation sites, which is the case for several African cities. A study by the International Finance Commission reveals that as much as 180,000 TWh of wind potential could be harnessed close to major African cities – enough to satisfy the continent's current energy demands 250 times over (Munyengeterwa and Whittaker, 2021).

High initial costs, limited local technical and knowledge capacity may initially hold back offshore turbines development. Experience with solar PV technology suggests, however, that costs could fall quickly once scale is achieved and supportive policy frameworks are crafted (GWEC and IRENA, 2013). In this context, adoption rates for both technologies have been growing over recent years.

Wind is one the fastest-growing renewable clean energy sources, with capacity expanding threefold over the past decade alone - it is the second most adopted renewable technology after hydropower.

FIGURE 4.1 Wind technology deployment across income groups



Source: UNCTAD (2023a).

Figure 4.1 illustrates this trend, concluding that disparities in wind energy deployment between income groups have tilted over recent years due to a faster rate of adoption in developing economies. The scale and magnitude of wind energy adoption is expected to grow further in coming years, with IEA forecasts estimating a tripling of generation capacity by 2030 and an eleven-fold increase by 2050 (IEA, 2021d).

The deployment of wind power is an important step toward ensuring electricity accessibility for developing economies and LDCs. Wind power is a scalable energy source that can expand rapidly, helping to extend electricity access to remote areas and provide continuous power supply to all communities. This could have a positive impact on economic activity, digital inclusion and thus trade potential.

How can Aid for Trade help to realize opportunities in the wind value chain?

Currently, Aid for Trade support is focused on the deployment of clean energy technology through the creation of wind farms. Significant scope exists to help expand developing-economy and LDC participation in all segments of this value chain. Aid for Trade can help developing economies and LDCs to participate in wind value chains in the following nodes of the value chain:

Minerals and metals: Critical minerals and metals necessary for wind power deployment include copper, nickel, zinc, aluminium and rare earth minerals such as neodymium and praseodymium (IEA, 2022h). These minerals are available in substantial quantities in developing economies and LDCs. The expected surge in the demand for these minerals and metals (in line with increased wind energy option) can be leveraged to enhance export potential. In this context, Aid for Trade can help economies to integrate into these supply chains by helping to harness investments into extraction sites, and the training of local stakeholders in safe and sustainable extraction methods. Box 4.4 provides an example of collaboration between Zambia and the UK to expand sustainable copper mining in order to improve export potential.

Goods: The deployment of wind energy will require the manufacturing and assembling of equipment such as towers, blades, bearings, generators and pumps (Energy Alternatives India, 2010). Ample opportunities for value chain integration exist for developing economies and LDCs. Aid for Trade can facilitate this process by providing support for research and development initiatives and capacity-building to help developing economies establish domestic manufacturing capabilities.

Services: The installation and operation of wind turbines is underpinned by a series of service activities. Wind farm developers provide essential value to the industry by planning, design and developing the structure of wind projects. Geotechnical experts ensure the suitability of projects by conducting feasibility studies on proposed wind farm sites. Transportation also plays a critical role, as wind power often involves technical and very specific modes of delivery. A technical paper presented by the delegation of the United Kingdom to the WTO also underlines the importance of ancillary services such as legal, financial, consultant and R&D inputs to the production of wind energy.[7] Aid for Trade can be leveraged to train a skilled workforce in system design, installation, maintenance and ancillary support to expand wind capacity. An example of such an initiative in Colombia is presented in Box 3.7.

Aid for Trade is already leveraging support for a number of infrastructural projects that improve electricity access – see Boxes 4.2, 4.3 and 4.4.

BOX 4.2 Supporting sustainable copper extraction in Zambia

Copper is utilized in the windings of electric generators in wind turbines and in the powerlines that connect the turbines to grids. The three-fold increase in wind generation capacity by 2030 therefore has the potential to rapidly increase the demand for this critical metal.

In 2021, Zambia was the seventh largest copper exporter in the world, catering to approximately 3.5 per cent of the world's copper demand. Copper forms a critical component of Zambia's export basket. In 2021, Zambia's earnings from the sale of copper were valued at US$ 7.7 billion, or 75 per cent of its annual export value. The importance of consolidating the benefits of copper mining to improve domestic economy fortunes has been underlined in Zambia's "National Trade Policy", "Industrial Policy", "National Export Strategy" and the "8th National Development Plan", documents referenced by Zambia in its response to the 2022 Aid for Trade M&E questionnaire.

The development of Zambia's copper industry is a key priority in the "Green Growth Compact" agreement signed between the United Kingdom and Zambia in 2021.[8] The bilateral compact identifies targets for delivering US$ 3 billion of aid and investments for renewable energy, urban planning and trade connectivity. Through the Compact, the United Kingdom and Zambia look to double bilateral trade volumes and strengthen coordination between UK and Zambian business communities.

As part of the Compact, the two economies will also sign a Memorandum of Understanding on critical minerals, laying the foundation for further UK support for the responsible mining of copper and other metals essential to the global clean energy transition. The United Kingdom will also look to leverage public and private investment worth US$ 210 million in Zambia's Mimbula Copper Mine. This investment will help to expand production, boost exports and growth potential for the Zambian economy.[9]

BOX 4.3 Lake Turkana Wind Power Project (LTWP)

Kenya is a global leader in renewable energy and is on track to transition fully to clean energy by 2030. Renewable energy currently accounts for 73 per cent of Kenya's installed power generation capacity, while 90 per cent of electricity in use is from green sources, among them geothermal, wind, solar and hydro-electric installations.

A flagship project for the Kenyan government is the Lake Turkana Wind Power project, which hosts Africa's largest wind power farm. The project is Kenya's largest single public-private sector investment and is financed by the Government of Kenya, together with an international consortium of lenders, including the African Development Bank, the Danish Investment Fund for Developing Countries, the Finnish Fund for Industrial Cooperation, and Norfund Investments.

The project comprises 365 wind turbines, each with a capacity of 850 kW, a high-voltage substation that is connected to the Kenyan national grid through a 428 km-long transmission line, and the construction of more than 200 km of road to transport equipment to the remote site. The wind farm provides reliable, low-cost energy to Kenya's national grid (about 17 per cent of the economy's installed capacity). Beneficiaries of the generated electricity includes rural and urban communities. The LTWP also serves energy to industrial parks around Kenya, which includes firms oriented toward the export market.

BOX 4.4 Aid for Trade in action: Taiba N'Diaye Windfarm

Spanning an area of approximately 20 square kilometres, the Taiba N'Diaye Windfarm is located about 70 kilometres northeast of the Senegalese capital, Dakar, near the village of Taiba N'Diaye. It is the first wind project in Senegal and the largest wind project in West Africa in terms of installed capacity. The project was initiated as part of Senegal's energy diversification plan, aiming to increase the proportion of renewables in the domestic energy mix and bolster energy security.

The Taiba N'Diaye Windfarm was highlighted by Senegal in the 2022 Aid for Trade M&E exercise as a development project in line with Senegal's aim to become a regional spearhead for clean energy adoption. The windfarm forms a key component of the "Plan Sénégal Emergent" development plan. The windfarm consists of turbines equipped with large rotor blades to catch the strong coastal winds that sweep across the region. It boasts an impressive total capacity of around 150 to 200 MW and contributes significantly to Senegal's power generation capacity. The windfarm is expected to contribute to expand Senegal's total energy capacity by 15 per cent and providing power for over 2 million people.

Energy generation through this windfarm provides several trade benefits. First, it provides a reliable energy source for industries and businesses which require a continuous power supply for production. Second, it aligns domestic production with international sustainability and environmental standards, making Senegalese products and services more attractive to environmentally conscious international markets. Increased export competitiveness could lead to improved trade opportunities and access to international markets for Senegalese goods and services.

The enhancement of regional infrastructure to support the windfarm is also expected to wield diffused trade benefits. Senegal is the third-largest mango exporter in West Africa, and the region surrounding the windfarm is home to some of the largest mango producers. According to USAID (one of the stakeholders in the project), the feeder roads built for the windfarm have optimized farmers' access to regional mango groves, leading to reduced crop losses, increased area incomes and expanded export opportunity.[10]

4.3 Solar photovoltaic value chains

Solar PV technologies use solar panels to convert sunlight into electricity. In 2022, solar PV produced 1300 TWh of electricity, accounting for approximately 4.5 per cent of global electricity generation and 13 per cent of renewable electricity generation respectively (IEA, 2023k). Rising adoption rates and declining costs will place solar PV as the main electricity energy source by 2050.

Adoption rates have accelerated over recent years, with global installed capacity rising 16-fold over the past decade alone. Rapid solar PV deployment in developing economies played a key role in this context (see Figure 4.2). The share of developing economies and LDCs in solar capacity expanded considerably between 2010 and 2020, growing from 4 per cent in 2010 to 52 per cent in 2020.

These expansions are being driven by increased solar adoption rates in China, which has emerged as the global leader in solar installation capacity. In 2022, China accounted for almost half of all new renewable power capacity worldwide (IEA, 2023g). In recent years, China has been joined by economies such as Brazil, India, Thailand and Viet Nam, which are also accelerating the expansion of their solar PV capacity (UNCTAD, 2023a).

Many other developing economies and LDCs could also derive substantial benefits from their own solar PV deployment due to geographical advantages in terms of sunlight. In some locations, year-round sunshine, intense sunlight and limited cloud cover allows installed panels give significant electricity generation potential. World Bank estimates reveal that economies in the Middle East, North Africa, sub-Saharan Africa and the Pacific islands belt possess some of the best climactic conditions to derive maximal solar PV efficiency (ESMAP, 2020).

Adoption gains are being driven by steep falls in the levelized cost of energy for solar PV. Technological advancements, coupled with the growing scale of production, have driven installation costs down from US$ 1.9 per watt in 2010 to approximately US$ 0.2 per watt in 2020.

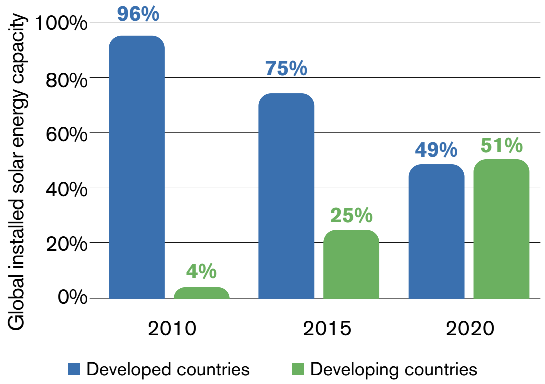
As a result, solar PV has gone from being more than twice as costly as the most expensive fossil fuel option to becoming cost-competitive with the cheapest fossil fuel sources available (IRENA, 2021b). The rapid declines in the cost of solar PV and the associated rise in solar PV trade can be seen in Figure 4.3.

The diffusion of solar PV for energy generation has been recognized as an important step to ensure electricity accessibility for developing economies and LDCs. As highlighted in Section 4.1, nearly 105 million people have received energy access through decentralized solar grids in sub-Saharan Africa alone.

Solar PV is an easily installable energy source that that can help to extend electricity access to remote areas and ensure continuous power supply. This could have a positive impact on economic activity, digital inclusion and, therefore, trade potential. Box 4.5 provides an example of how electricity access can improve economic potential, through the provision of solar mills in Vanuatu.

Deploying solar PV farms may also open new opportunities for electricity exports. In 2019, Morocco switched from being a net importer of electricity (with net imports of 3,374 GWh) to a net exporter, with net exports of 928 GWh. Morocco now ranks fourth globally in electricity generation from thermal solar technologies. Its electricity system is interconnected with Algeria and Spain, making Morocco the only North African economy with a power cable linking it to the European grid (GIZ, IRENA and BMZ, 2020). An investment consortium is currently examining the possibility of connecting Morocco and the United Kingdom through undersea power cables (Reuters, 2023).

FIGURE 4.2 Installed solar PV capacity, split by development category



Source: UNCTAD (2023a).

SOLAR PV INSTALLATION COSTS

in 2010

US$1.9 per watt

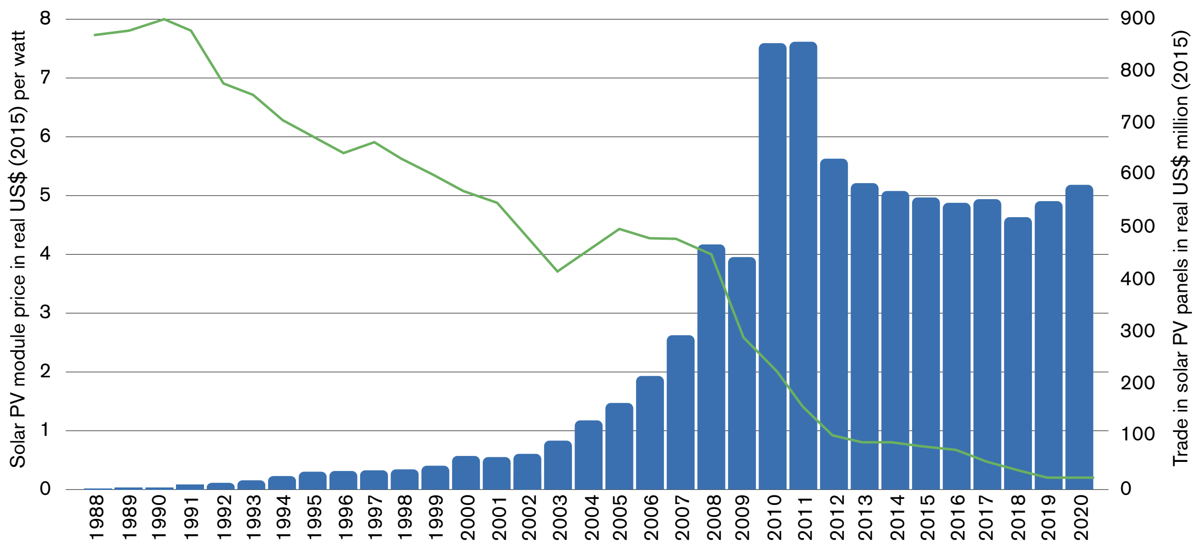
in 2020

US$0.2 per watt

due to technological advancements and the growing scale of production.

The rate of solar PV deployment is expected to increase globally over coming years. IEA research indicates that solar PV is forecast to account for 60 per cent of the increase in global renewable capacity in 2022. More than US$ 1 billion per day of investments is expected to be funnelled into solar investments in 2023, increasing solar investments to more than oil investments for the first time in history (IEA, 2023a). This would provide opportunities for developing economies and LDCs to integrate into value chains.

FIGURE 4.3 Price and trade in solar PV panels



Source: WTO (2022b).

BOX 4.5 Aid for Trade in action: solar mills in Vanuatu

Imported refined petroleum accounts for 72 per cent of Vanuatu's total energy supply. This dependency has a disproportionate economic impact on Vanuatu, as the archipelago's geographical remoteness and dispersed population contributes to marginally higher fuel import costs. As a result, many households rely on an expensive and often unreliable electricity supply to support basic household needs.

Intermittent electricity access has hampered effective capital proliferation in the agricultural sector, which is the primary export earner. It has meant that farmers must often employ manual processes for gathering agricultural produce.

To address this infrastructural constraint, the Australian Government partnered with "Village Infrastructure Angels Australia" to provide solar energy solutions to 3,000 households in Vanuatu.[11] Australian assistance has also helped supply solar agricultural mills to 30 of the economy's 60 inhabited islands This project was reported in the 2022 Aid for Trade M&E questionnaire.

The deployment of solar solutions has been shown to have led to several benefits. It has helped to reduce reliance on fossil fuels and boosted rural incomes. Furthermore, the use of solar power has helped citizens diversify their production base, with more spending time on activities such as basket weaving. It has also helped to improve added value, with many farmers making new products such as vacuum-packed cassava flour and coconut oil, which have a higher profit margin compared to raw crops in export markets.

In addition, more reliable electricity provides better lighting for children to study by at night and will help communities build educational capacity in the long run.

BOX 4.6 International Solar Alliance (ISA) and One Sun One World One Grid

The International Solar Alliance (ISA)[12] was conceived by India and France to mobilize efforts against climate change. It was launched in Paris, in 2015 on the margins of COP21. As of 2022, 101 economies are signatories to the ISA Framework Agreement.

The objective of the ISA is to develop and deploy cost-effective solar solutions to help member economies develop low-carbon growth trajectories. The alliance is guided by its "Towards 1,000" strategy, which aims to mobilise US$ 1 trillion of investment in solar energy solutions by 2030, while delivering energy access to 1,000 million people using clean energy solutions, resulting in the installation of 1,000 GW of solar energy capacity.

The ISA places particular focus on delivering assistance to LDCs and small-island developing states. To this end, the ISA focuses on four priority areas to maximize solar deployment: analytics and advocacy; capacity building; programmatic support; and readiness and enabling activities.

ISA partners include development finance institutions and public- and private-sector organizations.

BOX 4.7 Supporting artisanal bauxite mining in Guinea-Bissau

In the 2022 Aid for Trade M&E exercise, Guinea-Bissau highlighted the "Terra-Ranka" development strategy[13] as an example of a national plan that outlined export objectives. In this strategy, the mining sector was underlined as one of the four sectors with substantial export potential. The strategy looked to promote small-scale mining, particularly in the context of phosphates and bauxites.

Bauxite has substantial clean energy value, as it is a sedimentary rock used to extract aluminium. The demand for this metal is expected to double between 2020 and 2040. Bauxite is especially required in the processing of solar PV frames, and the World Bank estimates that by 2050, around 87 per cent of all aluminium requirements for energy technologies will be for solar PV manufacturing (Hund et al., 2020).

According to AfDB estimates, Guinea-Bissau holds around 160 million metric tonnes of bauxite deposits. These deposits are part of the Fouta Djallon-Mandingo bauxite province, which makes up almost half of the world's total bauxite resources. Establishing a framework that promotes sustainable extraction could therefore help to expand export potential rapidly.

The Terra-Ranka development strategy is working towards this objective by introducing reforms that promote investments and the upskilling of workers to help expand production. To this end, Guinea-Bissau has received assistance from the AfDB through a transition support facility catering to artisanal and small mining.

Through this project, the AfDB intends to support the Terra-Ranka strategy by formalizing artisanal and small-scale mining stakeholders to create jobs and improve the socio-economy, improving the capacity of regulatory institutions to enforce mining laws and regulations, and facilitating project coordination and management.[14]

The AfDB expects this project to have a positive impact on the livelihoods of more than 10,000 people directly involved in the artisanal and small-scale mining subsector. The project will also lead directly to training for more than 500 mining regulatory officials to diffuse best mining and investment practices. Overall, this is expected to trigger export avenues, wealth creation opportunities and decent employment.

How can Aid for Trade help unlock opportunities in the solar value chain?

Aid for Trade can be leveraged to support solar development in various ways. Currently, as is the case for wind energy, Aid for Trade financing has been generally focused on the deployment of the clean energy technology. Possibilities for developing economies and LDCs participation in solar PV include:

Minerals and metals: Copper, aluminium and silver are some examples of metals and minerals essential to the manufacturing of solar PV equipment (IEA, 2022h). The surge in their demand (in line with the expected increase in solar PV adoption rates) can be used as an opportunity to enhance the export potential of developing economies and LDCs endowed with these resources. Aid for Trade can help capture this opportunity by harnessing capital (in the form of concessional and/or blended financing) to support sustainable extraction for exports. Aid for Trade can also be used to improve supply-side capacity to ensure that the economy can leverage resources productively to maximize welfare benefits. Box 4.7 provides an example of such Aid for Trade collaboration in Guinea-Bissau.

Goods: A few examples of components required to assemble solar PV include semiconductors, integrated circuits, wafers, cells electric generators, transformers, transistors and static converters. Production also requires supplementary products, such as concrete, plastic, polymers and corrugated board (WTO and IRENA, 2021). As highlighted in Section 3, a few economies, most notably China, have positioned themselves as important nodes in the solar PV value chain. For instance, components such as solar wafers, cells and account for around 10 per cent and 5 per cent respectively of Malaysia and Viet Nam's trade surpluses. Aid for Trade can facilitate this process by supporting research and capacity building initiatives that help spotlight the manufacturing opportunities in developing economies and LDCs. The research conducted by Sustainable Energy for All (see Box 3.4) is an example of such an activity.

Services: The operation of centralized or decentralized grids is underpinned by a series of services activities that have been highlighted in Section 3.3. Aid for Trade can be leveraged to train a skilled workforce in system design, installation, maintenance and ancillary support to expand solar PV capacity. Aid for Trade can also be used to promote circular economy mechanisms, and can enhance the value of end-of-life service sector operations (see Box 4.8).

BOX 4.8 Solibrium: a solar service provider

Solibrium[15] is a social enterprise based in Western Kenya that provides off-grid electricity solutions to households and business, through a programme with pay-as-you-go service options.

Customers are provided with 24-hour electricity access by means of solar kits integrated to software systems that can track generation capacity and customer needs. Solibrium works not only as a distributor of solar home systems, but offers a holistic and complete sales, distribution and repair ecosystem to rural solar users.

Solibrium is also in the process of introducing an economically viable business model for the recycling of solar kit components. The project, titled "Resource Efficiency and Waste Management for Off-grid Solar products", is being implemented in partnership with the Swiss Agency for Development and Cooperation (SDC).

As a next step, Solibrium intends to develop a solar waste tracking tool to identify types, quantities and locations of products to guide future waste management planning. Through this initiative, Solibrium aims to become a regional leader in the recycling and refurbishing of solar kits to extend product lifespan.

4.4 Hydropower value chains

Hydropower, which involves the production of kinetic energy through the movement of flowing water, is an established source of renewable power worldwide. In 2021, global hydropower capacity was estimated at around 4,300 TWh, accounting for nearly 45 per cent of total annual renewable electricity capacity (IEA, 2023c). Globally, nearly 800 million people rely on hydropower as a cost-effective and dependable source of electricity (IEA, 2023d).

Hydropower can be generated through various means. For instance, run-of-the-river systems harness the natural water flow of rivers to generate electricity. Impoundment systems (for instance by using dams) store and release water for power. Pumped storage involves storing of water that is transported uphill and released in cycles for power generation. Recent innovations have also unlocked the capacity to produce scalable electricity from marine water bodies, by tapping into the power generated through tidal and wave patterns (IRENA, 2023b).

Hydropower has significant potential for further development given that it is already very present in the energy mix of developing economies. IEA research indicates that hydropower supplies more than 50 per cent of total electricity generation in 28 developing economies (IEA, 2023d). Furthermore, 85 per cent of new hydropower plants constructed over the past 15 years are in developing markets. Large hydropower projects also contribute to agricultural development in these economies, by providing the water management infrastructure necessary to secure and expand crop cultivation.

Hydropower investments are prominent in the renewable energy investments being made by China in the context of the Belt and Road Initiative (BRI). An example is the Cambodia Upper Tatay Hydropower Station, bolstered

BOX 4.9 ADB assistance to expand Bhutan's hydropower export capacity

Hydropower generation plays a crucial role in Bhutan's economy. The activity accounts for approximately 25 per cent of annual GDP and contributes to approximately 63 per cent percent of Bhutan's total exports. However, the full potential of hydropower for Bhutan's development remains untapped. According to the Asian Development Bank (ADB), Bhutan is currently only generating about 9-10 per cent of its 26,760 MW hydropower generation capacity.

Since 2008, the ADB and the Government of Bhutan have been collaborating in two "Green Development Projects" to fulfil this potential. These projects aim to enhance Bhutan's clean energy export capacity, while supporting social services and electricity access for the poor.

Under the first Green Development Project,[16] which was in operation from 2008 to 2014, the ADB helped Bhutan deploy the Dagachhu hydropower plant. This plant helped to export power from Bhutan to India through the existing grid[17] and provided electricity access to 8,767 households.

The Second Green Power Development project commenced in 2014.[18] The project outputs include operation of the 118 MW run-of-the-river Nikachhu hydropower plant and its associated transmission lines. This second phase will generate 903,490 MWh annually, on average, and a large share of the power generated is expected to be exported outside Bhutan. The work on this phase is expected to be completed by December 2023.

by Chinese investment, aimed at expanding Cambodia's reliable source of clean energy.[19]

Aid for Trade could play a key role in supporting the deployment of effective hydropower capacity across developing economies. For instance, Aid for Trade can be harnessed for large-scale infrastructural projects that provide direct trade benefits. Box 4.9 provides an example of such a scenario in Bhutan.

How can Aid for Trade help to unlock opportunities in the hydropower value chain?

Aid for Trade can help to leverage possible value chain integration opportunities for developing economies and LDCs. These for instance include:

Minerals and metals: Minerals required for the primary installation and deployment of hydropower include copper (for electrical wiring and conductors in generators), aluminium (for transmission lines) and rare earth minerals such as neodymium and dysprosium (for power generation). As discussed in Section 3.1, many developing economies and LDCs have well-established domestic sectors that can serve the mineral demands of a potential hydropower expansion (see, for example, Box 4.4 on copper extraction in Zambia).

Goods: The deployment of hydropower requires a wide array of equipment and components that could potentially be manufactured in developing economies and LDCs. For instance, in the context of large-scale impoundment systems, the required goods include hydroelectric turbines, electric generators, transformers and hydraulic gates and values.

Services: Institutions can help to transfer knowledge and expertise to support the development and maintenance of domestic manufacturing capabilities in the hydropower sector.

4.5 Hydrogen value chains

Recent technological advances have generated considerable interest in the use of hydrogen as a direct clean energy source for activities such as iron, steel and chemical production, where decarbonizing through electrification is not possible or uneconomic (Nault, 2022).

The association of hydrogen with scalable clean energy generation is a relatively new phenomenon. Until recently, hydrogen was an input in the production process of steel, ammonia, methanol and petroleum products. In the petroleum sector, hydrogen is an essential element in hydrocracking – a process to separate petroleum products in refineries (EIA, 2013). For this purpose, hydrogen was generated using natural gas or other fossil fuels in a highly emission-intensive production. Annual CO_2 emissions through traditional hydrogen production were estimated at 1,100-1,300 Mt in 2022, roughly equivalent in size to Japan's annual CO_2 emissions (IEA, 2022d).[20]

The cleanest hydrogen, in terms of associated GHG emissions, "green hydrogen", can be produced through the process of electrolysis, whereby water is split into its component molecules, including hydrogen, using an electrolyser driven by clean, renewable electricity. The next cleanest alternative is the production of "blue hydrogen", that is, the production of hydrogen using fossil fuels or natural gas (through non-electrolysis reforming methods) but with carbon capture, utilization and storage (CCUS) technologies used to capture and store the CO_2 produced.

BOX 4.10 Colombia's hydrogen road map

Colombia has pledged to reduce GHG emissions by 51 per cent by 2030, compared to 2010 levels. In pursuit of this plan, it has initiated several policy steps to support a clean energy transition. The "Hydrogen Road Map" is an example of such efforts. The Road Map was highlighted by Colombia in its response to the 2022 Aid for Trade M&E exercise.

The aim of the Hydrogen Road Map is to increase volumes of hydrogen production and to help capture export opportunities through trade with regional economies. It was prepared in conjunction with the Inter-American Development Bank and the United Kingdom.

The Hydrogen Road Map projects that Colombia has the capacity to produce between 3.2 and 5.8 Mt of green hydrogen by 2050 if available renewable energy potential is sufficiently captured. This leaves substantial room for export potential, as the domestic demand for hydrogen in Colombia is expected to reach between 1.6 and 1.8 Mt by 2050. Three major export economies or regions have been identified in this regard. The Road Map notes that Asia, particularly Japan, could be a major destination market for exports. The European Union and the United States have also been identified as possible high-value destinations in the near future.

The Hydrogen Road Map also identifies the regulatory changes needed to promote and deploy hydrogen-based technology. It would require the production of blue hydrogen during the initial phase of technology deployment to ensure a gradual transition away from the economy's mining and gas sectors, as a means to minimize social effects. The switch to green hydrogen could occur within 15 to 20 years, when electrolyser technology becomes adequately competitive to substitute production.

In cooperation with national educational institutions, Colombia will also look to develop a hydrogen technology and knowledge transfer plan with universities and companies. Financing programmes for technical and vocational training will also be institutionalized to ensure that the domestic service economy is adequately prepared to cater to the hydrogen economy (Energy Transitions Commission, 2021).

The rapid deployment of green hydrogen is currently hindered by its higher cost of production when compared to production alternatives. The World Bank estimates that it costs approximately US$ 4-5 to produce a kilogramme of hydrogen as of 2023 (IEA, 2023i). This is around two to three times higher than the cost of producing hydrogen using fossil fuels. As a result, less than 1 Mt of cleaner hydrogen was produced in 2021, or roughly 1 per cent of annual hydrogen output (IEA, 2022c). Green hydrogen production is negligible at present, with cleaner hydrogen mostly derived from plants using fossil fuels with CCUS technologies.

> The expansion of clean hydrogen could give substantial impetus to the net zero transition.

Green hydrogen is expected to play a greater role in coming years, as production costs are projected to become cheaper than alternates. This is due to learning effects that enhance technology performance and production processes, as well as economies of scale (Gielen, Lawal and Rocha, 2023). The IEA estimates that by 2030, the production of cleaner hydrogen (both

BOX 4.11 Green hydrogen production in Namibia

Namibia is emerging as a player in the hydrogen market, with ambitions of becoming the leading exporter of green hydrogen in Africa.[21] During COP27, Namibia's Green Hydrogen Council launched a strategy to help steer the domestic economy towards hydrogen goals. However, the Council noted that, although Namibia has favourable renewable energy conditions, it lacks the adequate supply-side infrastructure and sectoral capacity to maximize trading potential.

To this end, a joint communique of intent was signed between Namibia and the German Government in 2022 to promote cooperation in the hydrogen sector and assist in infrastructure development.[22] A key objective of this partnership is to promote Namibia's potential to produce green hydrogen for domestic use as well as for export to Germany and other markets. Strategies to serve this objective include:

- Development of a "National Green Hydrogen Strategy" in Namibia.
- Establishment of strategic pilot plants to assess scalability.
- Allocation of 200 scholarships for Namibians to help domestic technical capacity.
- Formulation of market access partnerships to improve trade facilitation.
- Fund the establishment of a "Green Hydrogen Institute" in Namibia.

In August 2022, the Namibian government began construction of a hydrogen demonstration lab in the Erongo Region. The hub is expected to be in operation by 2024 and will initially produce green hydrogen for local energy use in trucks, locomotives and port equipment. The hub will also include a training and education centre to provide local Namibians with necessary knowledge and skills.

"green" and "blue") could reach 16-24 Mt per year, from a base of 1 Mt per year in 2021 (IEA, 2023i).

The expansion of clean hydrogen could give substantial impetus to the net zero transition. This is because it can function as an effective substitute for liquid petroleum, which is currently used as the predominant energy source for power generation, industrial processing and transport. The IEA estimates that growing demand for clean hydrogen could help reduce CO_2 emissions by 60 Gt in 2050. This is equivalent to approximately 6 per cent of the greenhouse gas emissions reductions required per the Paris Agreement over the period 2021-2050 (IEA, 2022d).

Cross-border trade of hydrogen is often perceived as a risky venture due to the element's highly combustible nature. Improvements in the capacity to safely handle and store hydrogen promise to greatly improve hydrogen portability over longer distances. Better storage methods also allow for green hydrogen to be stored for longer periods of time. The ability to trade hydrogen through alternative carriers such as ammonia

BOX 4.12 Australia and India set up a Green Hydrogen Task Force

India is emerging as a key player in the electrolyser manufacturing space. In January 2023, India approved the "National Green Hydrogen Mission",[23] with a target to achieve green hydrogen production of 5 metric tonnes per annum by 2030. The objective is the creation of export opportunities in the green hydrogen value chain, particularly through the development of indigenous manufacturing capacity.

Australia has also been prioritizing the development of electrolyser capacity. Through the "Hydrogen Headstart" initiative[24] implemented in 2023, Australia has allocated US$ 2 billion to provide revenue support for investment in renewable hydrogen production.

In March 2023, Australia and India agreed to set up a "Green Hydrogen Task Force" to develop green hydrogen resources jointly. The agreement notes that the initial focus area of the task force would be to expand the production of equipment such as electrolysers and fuel cells. Strategies to achieve this objective include:

- Identifying strengths and gaps in industry and resource endowments and skills in each economy.
- Examining specific opportunities on how enabling infrastructure, standards and regulations can be deployed to maximize hydrogen opportunities.
- Researching areas or projects that may benefit from private sector investments.

could also help improve tradability. Research notes that in addition to its role as a fertilizer, ammonia (produced using clean hydrogen) can be used as an effective fuel for stationary power and as a transport fuel, particularly in the maritime industry (IRENA and AEA, 2022).

In this context, green hydrogen produced in regions with abundant solar and wind capacity could be transported elsewhere, paving the way for a clean global hydrogen energy trade. The trade would be based on exports between regions possessing abundant low-cost renewable clean energy production to those with limited production options (IEA, 2021f).

Demand for green hydrogen is expected to increase significantly in the next 30 years as the transition towards a net zero economy advances. The Energy Transitions Commission (ETC)[25] estimates that 500 to 800 Mt/year of hydrogen (in any form) – a four to six-fold increase from current demand levels – will be needed in 2050 (Energy Transitions Commission, 2021). Sectors with high potential in the long term include steel production, shipping, aviation and the power sector. In other sectors, such as domestic heating, high temperature heat applications, plastics manufacturing and heavy-duty transport, hydrogen is seen as a possible alternative to direct electrification or other decarbonization options. Potential short-term but transitional uses of hydrogen to reduce emissions include the co-firing of ammonia or hydrogen in conventional power plants or blending with natural gas.

Developing economies and LDCs are already looking at expanding their production of clean hydrogen production. Economies as diverse as Brazil, China, Colombia, Costa Rica, India, Indonesia, Malaysia, Namibia, Nepal, Morocco, South Africa and Thailand have all made commitments towards domestic hydrogen capacity development.

Developing the hydrogen sector could help to usher in a domestic clean energy transition by providing cleaner alternatives to sectors which are dependent on non-electric sources of power. Hydrogen can also be used as a storage infrastructure for energy produced through renewables. It could also help to improve export diversification potential, as hydrogen created through domestically available renewable sources could be traded as a commodity.

How can Aid for Trade help unlock opportunities in the hydrogen value chain?

Collaboration between Aid for Trade stakeholders to build hydrogen capacity is already evident on a global scale – see, for instance, Box 4.10 on Colombia's "Hydrogen Road Map" and Box 4.11 on collaboration between Germany and Namibia to build domestic hydrogen supply-side capacity.

Possibilities for using Aid for Trade to help developing economies and LDCs participate in hydrogen GVC include:

Minerals and metals: The manufacture of electrolysers for green hydrogen production requires minerals and metals such as nickel, platinum, aluminium, graphite and iridium. Aid for Trade can be directed towards expanding supply-side capacity to enhance sustainable export potential. Aid for Trade can also be used to help establish policies that foster sustainable extraction and assist local stakeholders in implementing safe and environmentally responsible production methods.

Goods: Aid for Trade can help to facilitate technology transfer partnerships that help to expand domestic manufacturing capacity in developing economies. Aid can also be leveraged to help enhance market access and create adequate regulatory conditions for a cross-border hydrogen trade. The establishment of the India-Australia Green Hydrogen Task Force is an example of such a partnership that helps build manufacturing (electrolyser) capacity (see Box 4.12).

Services: Aid for Trade can help to implement training for workforces in system design, installation and maintenance of equipment such as electrolysers and supporting the growth of local service providers.

4.6 Nuclear power value chains

The use of nuclear power continues to grow, albeit more slowly than other clean energy sources. Nuclear energy provides 10 per cent of the electricity produced worldwide and more than 25 per cent of global clean electricity. Nuclear power capacity is expected to double from 413 GW in early 2022 to 812 GW in 2050 (IEA, 2023f). According to the IEA, growth in nuclear power is expected to accelerate in the coming years, reflecting strengthened policy support in leading markets and brighter prospects for small modular reactors. Developing economies are expected to account for more than 90 per cent of global growth, with China set to become the leading nuclear power producer by 2030.

The importance of nuclear power for a clean energy transition was recognized at COP28. The COP28 outcome document included nuclear power among the key clean energy solutions (see Box 1.2).

In addition, more than 20 economies from four continents launched the "Declaration to Triple Nuclear Energy" at COP28. This declaration calls for economies to work together to advance a goal of tripling nuclear energy capacity globally by 2050, and invites shareholders of international financial institutions to encourage the inclusion of nuclear energy in energy lending policies.[26] The declaration, and the references to nuclear power in the outcome document, are indicative of rising interest in establishing nuclear energy as a clean alternative to fossil fuel production. New breakthroughs in the production of energy through nuclear fusion may also help to deliver a newer and more source of clean energy in the long run (CNN, 2023).

In 2020, the number of International Atomic Energy Agency (IAEA) member states operating nuclear power plants increased to 32, after Belarus and the United Arab Emirates connected reactors to the national grid. Of these operating economies, 19 have projects in place to expand their nuclear power capacity. Around 30 newcomer economies are embarking on, or considering, nuclear power.

Some developing economies have considerably advanced in the construction of their first nuclear power plants (IAEA, 2021a). For instance, Bangladesh has made substantial progress in creating infrastructure for nuclear generation capacity. Two reactors, built with assistance from the Russian Federation are expected to become operational by 2024 to provide 9 per cent of Bangladesh's electricity supply (Fisher, 2021).

Several African economies, including Ghana, Kenya, Namibia, Nigeria, South Africa, Sudan, Tanzania, Uganda and Zambia, have in recent years expressed significant interest in developing new nuclear plants (Nordhaus and Lloyd, 2022). Box 4.13 provides a brief overview of emerging nuclear power projects in the African continent developed through cooperation with Russia.

Nuclear capacity can complement the domestic energy mix, ensuring that the gaps created due to the intermitted nature of renewable energy do not cause disruptions to the grid supply of electricity. Furthermore, nuclear power projects can stimulate economic activity and employment across many sectors, including construction, manufacturing, services and agriculture.

Small nuclear reactors are an area of innovation that can help diffuse nuclear technology in developing economies. They are essentially advanced reactors that produce electricity of up to 300 MW per module (IAEA, 2021b). Given the smaller reactor sizes and simplified design, these facilities could be easier to finance, construct and operate. Small nuclear reactors are nearing commercial deployment in several economies in Europe, the Middle East, Africa and Southeast Asia. Investment in small nuclear reactors and other advanced reactors is being encouraged through public-private partnerships.

International trade can play a crucial role in the diffusion of nuclear technology. As of 2022, trade in nuclear reactors, nuclear fuel, machinery and apparatus amounted to US$ 2.8 billion. Trade can facilitate the cross-border flow of nuclear equipment such as reactors, rods fuel cycle facilities and casks between economies. Additionally, trade can also play a role in the diffusion of services and technology required to develop domestic nuclear capabilities.

From a trade policy perspective, the diffusion of nuclear technology Is highly regulated due to the dual use potential of such technology and national security concerns.

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BOX 4.13 Developing nuclear power generation in Africa with Russian assistance

Russia and Egypt are cooperating on a nuclear plant, to be constructed in partnership with Russia's State Nuclear Energy Corporation (Rosatom) and Egypt, in the Egyptian coastal town of El Dabaa.[27] The site for the plant has been approved by the International Atomic Energy Agency (IAEA) and is set to house four nuclear reactors capable of producing nearly 5 GW of energy. The first unit is expected to begin commercial operations in 2026 while the remaining three reactors are scheduled for commissioning by 2029.

Russia, through Rosatom, is also involved in the development of nuclear potential in Uganda. Endowed with a domestic supply of uranium, Uganda is currently in engagement with International Atomic Energy Agency (IAEA) to commence nuclear power generation capacity by 2032.[28] Russia plans to help Uganda with development of nuclear infrastructure and production and application of radioisotopes for industrial use.

Russia is also assisting Morocco in its efforts to established nuclear generation capacity by 2030. Morocco is endowed with substantial phosphate and uranium reserves which are vital raw materials required for power generation through nuclear technologies. As per a nuclear cooperation agreement signed in 2022, Russia will assist Morocco in the creation and improvement of nuclear energy infrastructure, the design and construction of nuclear reactors, as well as water desalination plants and elementary particle accelerators.

Russia has also signed exploratory agreements with Tanzania, Rwanda and Zimbabwe.

Other African states interested in developing nuclear capacity include Ghana, Nigeria, Sudan, Rwanda and Zambia.

BOX 4.14 Developing a low-enriched uranium fuel bank in Kazakhstan

Kazakhstan is the world's largest producer of uranium. Production of uranium accounts for 43 per cent of global production and 22 per cent of the cross-border trade in uranium.[29]

In 2015, Kazakhstan approved an agreement with the International Atomic Energy Agency (IAEA) to establish a low-enriched uranium (LEU) fuel bank at the Ulba Metallurgical Plant in Oskimen, Northeastern Kazakhstan.[30] The idea behind the fuel bank is that any IAEA member can request access to this supply as a last resort. This provides IAEA members with a safety net for energy production from nuclear sources, ensuring that electricity access is not disrupted due to the inaccessibility of an essential raw material.

This LEU bank was developed using a US$ 150 million fund with contributions from IAEA members, including the United States (US$ 49 million), the European Union (US$ 24.4 million), the State of Kuwait (US $10 million), the United Arab Emirates (US$ 10 million) and Norway (US $5 million).

The LEU bank has been operational since October 2019 and operates under the responsibility of the authorities for safety, security and safeguards in Kazakhstan. Thanks to this venture, Kazakhstan has been able to expand its export potential, as uranium supplies held by the LEU bank are purchased domestically.[31]

How can Aid for Trade help unlock opportunities in the nuclear value chain?

Possibilities to use Aid for Trade to help developing economies and LDCs participation participate in nuclear global value chains include:

Minerals and metals: Copper, nickel and chromium are examples of minerals and metals that are required for the deployment of nuclear infrastructure (IEA, 2022h). Energy generation also requires a continuous supply of uranium, a mineral that is extracted in many developing economies and LDCs. As the demand for uranium rises with increased nuclear use, it provides developing economies and LDCs with export opportunities. An example of international cooperation to develop uranium infrastructure in Kazakhstan is provided in Box 4.14.

Goods: Examples of equipment used in nuclear power plants include control rods, moderators, coolants, steam generators and pressurisers.[32] Aid for Trade can help with value chain integration by facilitating technology transfers and by providing financial support to help economies establish these manufacturing capacities.

Services: The deployment of nuclear energy generation requires a workforce that has the capacity to handle specialized tasks requiring substantial skill and expertise. Undertaking a nuclear power programme therefore represents a long-term investment in human capital.[33] According to the World Nuclear Association (WNA),[34] nuclear power plants can operate for over 60 years, creating well-paid jobs for people from a range of fields and educational backgrounds. Investments can also create a spillover effect that benefits other sectors. Leveraging Aid for Trade to develop skills and expertise in nuclear technology can thus create positive feedback loops that benefit trade potential in other sectors.

Endnotes

1. See https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=ZG.
2. See https://ukcop26.org/one-sun-declaration-green-grids-initiative-one-sun-one-world-one-grid/.
3. See https://www.investindia.gov.in/team-india-blogs/green-grids-initiative-one-sun-one-world-one-grid.
4. See https://isolaralliance.org/work/osowog/.
5. See https://ukcop26.org/one-sun-declaration-green-grids-initiative-one-sun-one-world-one-grid/.
6. Dutton et al. (2019). The eight economies examined were Brazil, India, Morocco, the Philippines, South Africa, Sri Lanka, Turkey and Viet Nam.
7. See “Communication from the United Kingdom”, official document number INF/TE/SSD/W/26, available at https://docs.wto.org/.
8. See https://www.gov.uk/government/news/green-growth-compact-agreement-between-the-uk-and-zambia.
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18. See https://www.adb.org/projects/44444-012/main.
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20. See also https://globalcarbonatlas.org.
21. See https://gh2namibia.com/.
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27. See https://www.nsenergybusiness.com/projects/el-dabaa-nuclear-power-project/.
28. See https://www.iaea.org/newscenter/news/iaea-delivers-report-on-nuclear-power-infrastructure-development-to-uganda.
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30. See https://www.iaea.org/sites/default/files/the-iaea-leu-bank.pdf.
31. See https://www.oecd-nea.org/upload/docs/application/pdf/2022-08/7547_maximising_uranium_minings_social_and_economic_benefits.pdf.
32. See https://world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-power-reactors/nuclear-power-reactors.aspx.
33. See https://world-nuclear.org/information-library/energy-and-the-environment/nuclear-energy-and-sustainable-development.aspx.
34. See https://world-nuclear.org/.

A farm worker cleans the solar panels of a solar water pump in Jagadhri, India.

05

Conclusion

The clean energy transition is critical to achieve net zero goals and is a key element of most economies' nationally determined contributions under the Paris Agreement, to keep global warming under a 1.5° Celsius threshold. The clean energy transition also has trade integration potential, as it helps to advance industrial development and addresses capacity constraints in energy generation capacity.

A key message of this report is that developing economies can benefit from the trade integration opportunities that arise during a global transition towards clean energy. The report examines opportunities available in various segments of the clean energy value chain, and explores ways in which Aid for Trade can support economies in exploiting these opportunities.

More than 60 per cent of donors and partners who responded to the 2022 Aid for Trade Monitoring and Evaluation questionnaire indicated that existing energy and power generation infrastructures proved an impediment to a sustainable development transition. Estimates by the Organisation for Economic Co-operation and Development (OECD) reveal that US$ 60 billion worth of funds that were committed towards the energy sector over the period 2011-21 were marked as serving climate objectives. This accounts for 30 per cent of all climate-related Aid for Trade measures during this period.

However, more can and needs to be done to help developing economies and LDCs to capture the trade dividends from a clean energy transition. This report notes that Aid for Trade can support developing economies and LDCs in integrating into emerging international value chains for minerals, manufacturing and services. It highlights the opportunities for value chain integration in five value chains: those for wind, solar photovoltaic, hydropower, hydrogen and nuclear energy. Using various case studies and samples, the report highlights ways in which Aid for Trade can help developing economies and LDCs facilitate productive value chain participation in these value chains.

Moving forward, Aid for Trade can be used to enhance the supply-side infrastructure of economies to reduce trade costs and improve competitiveness. Aid for Trade can also be leveraged to reduce technological barriers and support research and development initiatives. This can be combined with investments into human capital to ensure that the domestic labour force has adequate skills and experience to maximize productivity and export competitiveness. The skills are often transferable, meaning they can create positive feedback loops that benefit trade potential in other sectors.

Aid for Trade can also be used to help MSMEs in developing economies and LDCs build productive capacity. This is a necessary step to ensure value chain participation. For instance, the report observes that MSMEs can be provided with adequate assistance to comply with quality assurance frameworks, certifications, and conformity assessment measures that improve market access. The report also highlights the potential use of Aid for Trade to explore the use of carbon capture, utilization and storage technologies in developing economies and LDCs. Such technologies can help to insulate domestic economies from substantial adjustment shocks as they make the transition from producing and using carbon-emitting energy to cleaner energy.

At the heart of realizing the opportunities from a clean energy transition is investment. Aid for Trade is playing a useful role in this regard. Moving forward, Aid for Trade flows can further mobilize blended financing to support the deployment of clean energy activities. Well-coordinated technical assistance programmes, coupled with facilitatory trade and investment policy frameworks can help to encourage investments in clean energy technologies. Aid for Trade can also be used to leverage different forms of financing to support the development of infrastructures that help to accelerate value chain integration in developing economies and LDCs.

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World Trade Organization
154, rue de Lausanne
CH-1211 Geneva 2
Switzerland
Tel: +41 (0)22 739 51 11
www.wto.org

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Report designed by Formato Verde.
Printed by the World Trade Organization.

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Print ISBN 978-92-870-3894-4
Web ISBN 978-92-870-7630-4
Published by the World Trade Organization.

Aid for Trade in Action: Supporting the transition to clean energy

The transition to clean energy offers opportunities for developing economies and least-developed countries (LDCs) to exploit the export potential of this transition and to accelerate their growth prospects.

The WTO-led Aid for Trade initiative provides significant support to these economies to help them develop their energy sectors and transition to clean energy. However, sustained support is required to ensure that firms benefit from the trade opportunities that will emerge as a result of the clean energy transition.

This report highlights the role that Aid for Trade can play in mobilizing financial resources to deliver targeted assistance and to help developing economies unlock export opportunities created by clean energy. It also underlines the role of development partners in helping firms integrate into clean energy value chains by investing in the production of clean energy technologies, such as green hydrogen and solar power.

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