UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT

Powering trade

Fine-tuning trade policy for solar and wind energy value chains

UN trade & development | 60 years

Contents

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Key messages

1. **Trade in solar and wind energy technologies is booming, supporting the overall transformation of the electricity sector.** However, the expansion of these technologies has not been fast enough to replace fossil fuel-based energy generation. Moreover, most developing countries are slipping into traditional trade patterns, acting as net exporters of raw materials for solar and wind energy value chains, but net importers of manufactured goods at intermediate and final stages.

2. **Trade costs along solar and wind energy technology value chains remain high.** This has adverse implications in terms of affordability of renewable energy technologies, and of industrialization opportunities. Currently, developing countries' average tariffs on green energy goods range from 2.5% in Asia and Oceania to 7.1% in Africa. Non-tariff border measures add additional costs of 0.4%-0.7%.

3. **Lower tariffs on intermediate goods across the solar and wind energy value chains can facilitate developing countries' entry at the assembly stage**. For example, in Africa, tariffs on intermediate products can reach up to 8.1%, compared to 4.1% in Asia and Oceania.

4. **There is scope for fostering regional integration by tackling both tariffs and non-tariff barriers.** For instance, intra-African tariffs are almost double the level applied within other developing regions. Similarly, in Africa and Latin America and the Caribbean, regional producers can face up to four times higher non-tariff border costs for green energy goods than competitors from outside the region.

5. **Temporary trade defence measures on green energy goods are increasing, especially for Asian traders.** Improving trade remedy mechanisms and using them more effectively to find mutually accepted solutions prior to imposing anti-dumping or countervailing duties could help strengthen their green energy sectors.

6. **Developed countries should reassess their trade, investment and aid policies towards developing countries for green energy goods.** These policies need to be consistent with the global ambition of the energy transition, universal energy access, and sustainable development.

Introduction

In our race against global warming, every fraction of a degree matters.

The urgency of tackling climate change cannot be overstated. Climate change manifests relentlessly and globally – whether through heatwaves, melting glaciers, or hurricanes, its impacts are undeniable and severe.

Renewable energy is key for tackling climate change and energy poverty. It has the power to decouple our prosperity from burning fossil fuels and the CO_2 emissions that accompany it. Moreover, it has the potential to bring power to 685 million people who live without electricity and reduce the poverty that implies.

To reduce our dependency on fossil fuels and to meet the growing global demand for renewable energy, it is essential to significantly expand our capacity to produce renewable energy. Trade plays a key role in facilitating this expansion. Although trade in renewable energy goods has been increasing, even faster than other industrial goods, this growth is still far from enough. Trade policy can help boost it.

This paper examines current tariffs and other trade measures that either support or hinder the global expansion of solar and wind energy technologies. It highlights a persistent historical pattern in supply chains: developing countries remain mostly confined to exporting raw materials for solar and wind energy technologies, while importing manufactured renewable energy goods. These patterns restrict the development prospects of these countries and limit the collective ability of the world to harness the full potential of green energy technologies.

The paper provides insights for trade policy improvements. For instance, lower tariffs on intermediate goods in Africa could foster the emergence or development of local green energy industries. In Latin America and the Caribbean, reducing border costs for intra-regional trade could strengthen regional supply chains for renewable technologies. In Asia and Oceania, where trade defence measures are on the rise, implementing more effective trade remedy mechanisms could reduce recourse to trade defence duties.

Trade policy can be a powerful tool in our quest to reduce global temperatures, even by fractions of a degree.

This work aims to inspire reflection and action
to shift from the trade policy we have to the trade policy we need.

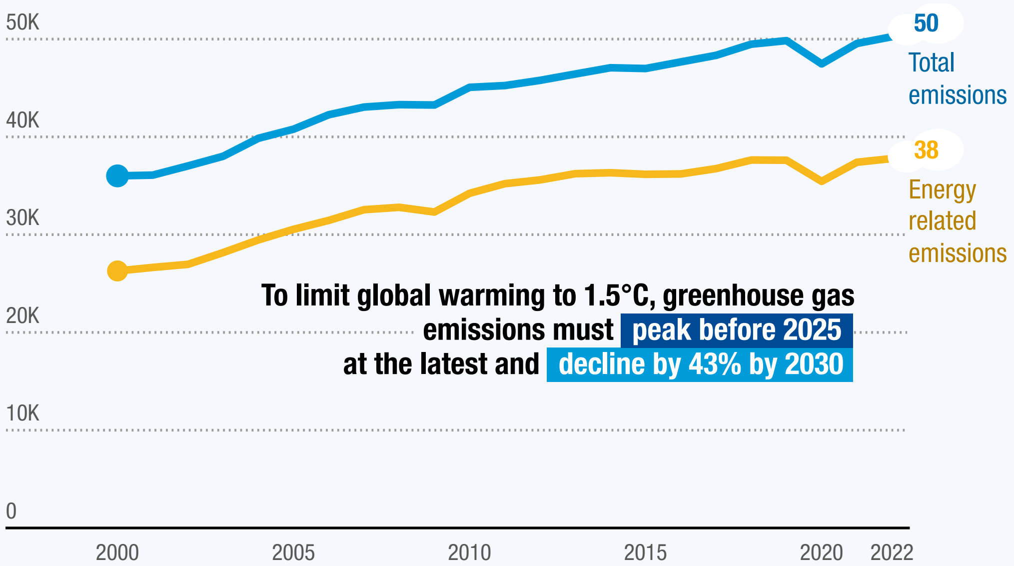
1. Tackling climate change and energy access

Energy faces a double imperative for sustainable development. Achieving global access to affordable, reliable, sustainable, and modern energy is crucial for structural transformation objectives, and ensuring shared prosperity. Simultaneously, energy remains the largest contributor to global greenhouse gas emissions. Decarbonizing the energy sector are key to achieving both the 2030 Agenda for Sustainable Development and the net-zero emissions targets outlined in the Paris Agreement on Climate Change.

Global greenhouse gas emissions must peak now. The United Nations Intergovernmental Panel on Climate Change warns that global warming beyond 1.5°C above pre-industrial levels could unleash severe climate change impacts, including more frequent and severe droughts, heatwaves and flooding. To achieve the 1.5°C target, greenhouse gas emissions must peak before 2025 – next year – and decline 43% by 2030.

However, emissions continue to rise, including those from the energy sector. With the exceptions of 2009 and 2020, following the global financial crisis and the COVID-19 pandemic, total greenhouse gas emissions and those related to the energy sector have continued to increase over the past decades – growing on average at an annual rate of 1.5% and 1.7%, respectively. About 75% of global greenhouse gas emissions are related to energy, with the biggest component being electricity and heat generation.

Figure 1
Greenhouse gas emissions continue to rise, despite energy transition efforts.
Gigatonnes of CO_2 equivalent



Source: UN GCRG – technical team, based on Climate Watch / World Resources Institute (2024), and growth rates for 2022 from International Energy Agency (2023) and European Commission, JRC (2023). UNFCCC on the Paris Agreement.

Simultaneously, progress towards universal energy access and SDG 7 has reversed for the first time in over a decade. In 2022, the number of people without access to electricity increased to 685 million –10 million more than in 2021.

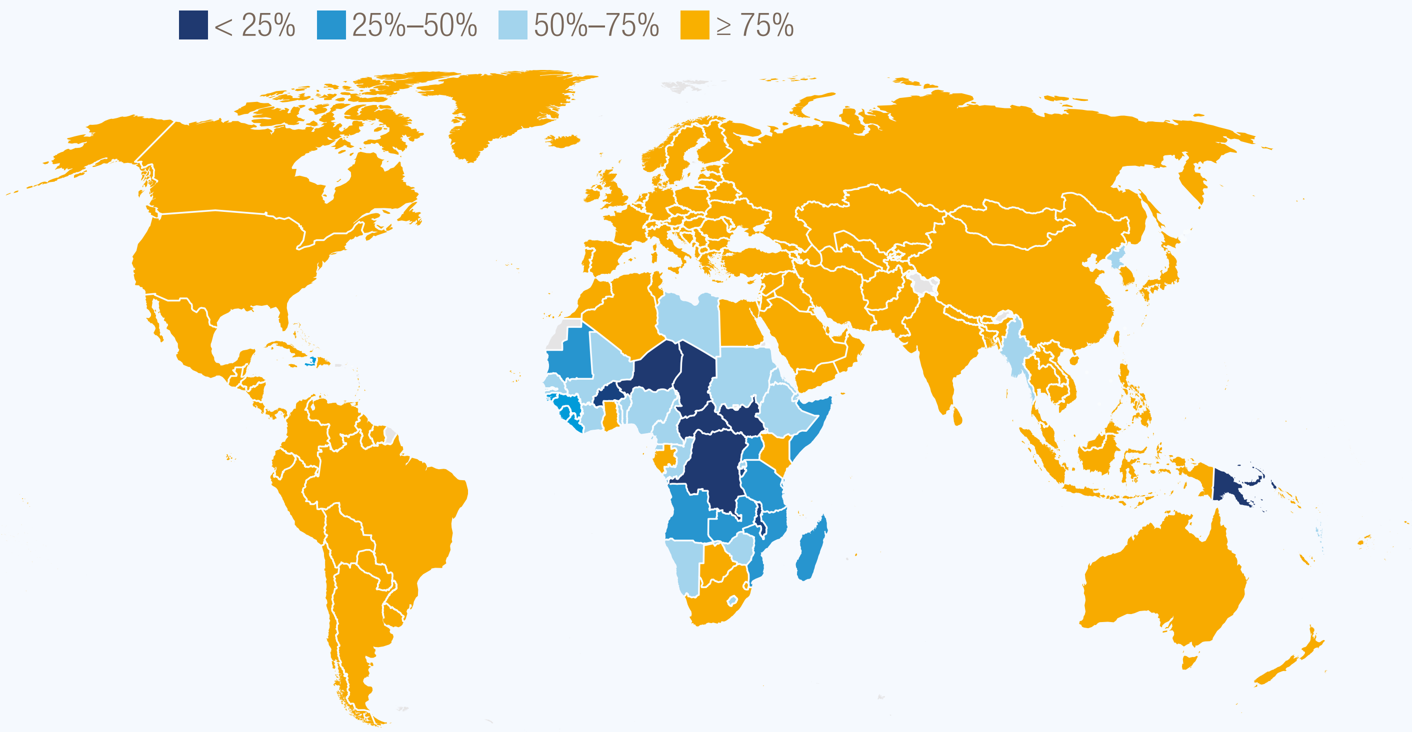
Paradoxically, millions of people lack access to electricity even in regions with abundant renewable energy resources. The vast majority of people lacking access to energy live in Africa, the continent exposed to the highest levels of energy from the sun (solar irradiance)[1] and rich in critical minerals. Asia and Oceania, followed by Latin America and the Caribbean, are developing regions with the greatest potential for harnessing wind as a resource for power generation. Africa also possesses enough onshore wind potential to satisfy the entire continent's electricity needs 250 times over.

Policies favourably targeting renewable energy seem promising to fulfil the double imperative of the energy sector: expanding access while reducing emissions. Solar energy, particularly through mini–grids, has emerged as the most cost-effective solution for bringing electricity to remote locations where grid extension would be unaffordable. By 2030, solar mini-grids could provide electricity to about half a billion people in unpowered or underserved communities at the lowest cost.[2]

1 For further details see, Global Solar Atlas. https://globalsolaratlas.info/support/getting-started

2 Furthermore, energy yield studies on African wind projects suggest that wind farms produce peak power during evenings and mornings due to thermal drivers near coastal sites, coinciding with peak demand of residential areas and complementing solar.

Figure 2
In many countries, access to electricity remains limited amidst high renewable energy potential.
Share of population with access to electricity in 2022 (%)



Source: UN GCRG – technical team, based on World Bank (2023), The Energy Progress Report.

2.
Solar and wind driving the energy transition

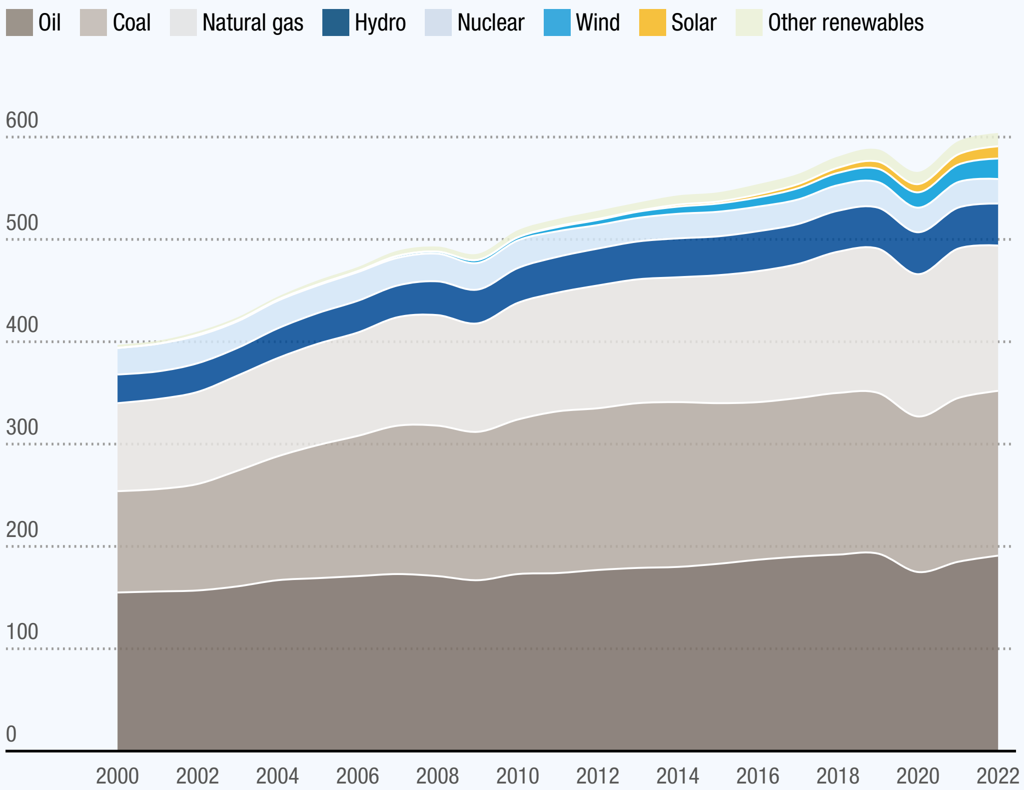
Despite the rapid growth of renewables, the world remains heavily reliant on fossil fuels. Fossil fuels accounted for 82% of global energy consumption in 2022. Although renewable energy is on the rise, reducing dependence on fossil fuels presents an ongoing challenge, particularly in harder-to-abate sectors such as transport and residential heating.

Energy consumption from renewable sources is growing fast, with solar leading the way. Since 2010, wind energy consumption has increased 6-fold, while solar energy consumption has grown 37-fold, albeit from a much lower base. However, combined, they accounted for only 5% of global energy consumption in 2022.

Figure 3

Fossil fuels still account for 80% of the energy mix.

Primary energy consumption in exajoules



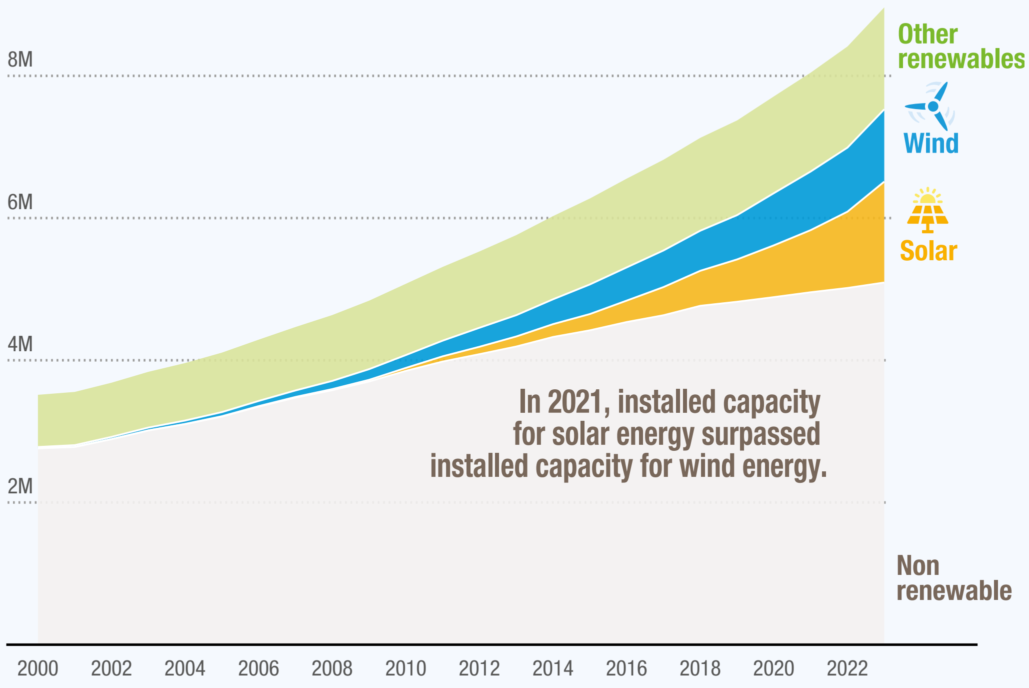
Source: UN GCRG – technical team calculations, based on the Energy Institute (2023). Statistical Review of World Energy.

Note: Hydropower is shown as a separate category as it is not unanimously recognised as green energy. Other renewables include geothermal, biomass, and other renewable sources not included elsewhere.

Solar and wind energy are at the forefront of transforming the electricity sector. Renewable power capacity represented 21% of the total in 2000, reached 30% in 2015, and stood at 43% in 2023. This accelerating growth has been largely driven by the expansion of solar and wind energy, which accounted for less than 1% of installed capacity two decades ago but grew to 27% in 2023. Between 2020 and 2023, more than two-thirds of global added power capacity came from solar (55%) and wind (23%).

However, low-carbon electricity has not yet replaced electricity from non-renewable sources. Most recent power capacity additions from renewable sources have supplemented, rather than replaced, non-renewable-based generators, whose capacity continues to grow, though at a slower pace. With the ongoing expansion of low-carbon electricity supply, the share of electricity from fossil fuels is expected to fall below 60% by 2026.

Figure 4
Solar and wind power are growing, but not fast enough to replace non-renewable resources.
Power capacity in megawatts



Source: UN GCRG – technical team calculations, based on IRENA Renewable capacity statistics (2024).

Note: Renewable power capacity is the maximum net generating capacity of power plants and other installations that use renewable energy sources to produce electricity. Other renewables comprise mainly hydropower (excl. pumped storage), bioenergy, geothermal energy and marine energy.

Wind and solar energy are in a virtuous cycle of increasing deployment and falling costs, facilitated by trade. The global expansion of solar photovoltaic (PV) and wind energy plants has been accompanied by a significant cost reduction. Between 2010 and 2022, the total installation cost[3] fell by 83% for solar, 42% for onshore wind, and 34% for offshore wind. Consequently, electricity generation costs[4] decreased by 89% for solar PV, 69% for onshore wind, and 59% for offshore wind. These declining costs are spurring the rollout of solar and wind energy technologies while boosting the demand for complementary storage solutions – ranging from batteries to green hydrogen – to address the intermittency of power production.

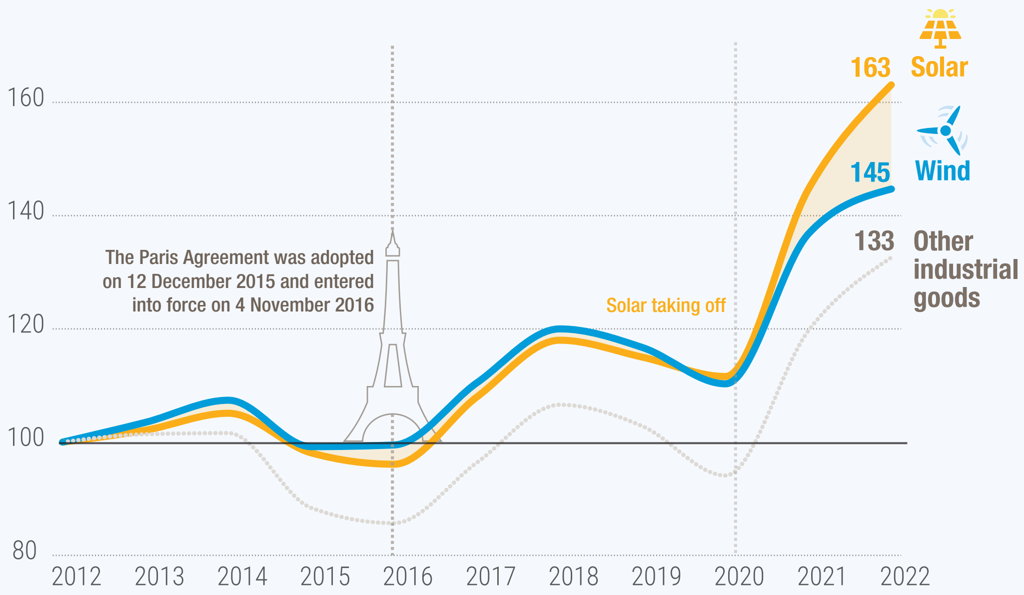
3 Total installed costs in 2022: solar US$ 876/kilowatt, onshore wind US$ 1,274/kilowatt, offshore wind US$ 3,461/kilowatt.

4 Levelized cost of electricity (i.e., the average cost of electricity generation for a generator over its lifetime) in 2022: solar US$ 0.049/kWh, onshore wind US$ 0.033/kWh, offshore wind US$ 0.081/kWh.

Despite the sharp decline in prices, the value of trade in solar and wind energy technologies and their components has outpaced trade in other industrial goods. Trade for these products was less susceptible to the trade slumps of 2015-16 and 2019-20. While both solar and wind have evolved dynamically in tandem since 2010, solar has gained more momentum since 2020.

Recent crises and volatility in energy markets have further increased the trade potential for renewable energy products. In addition to the urgency of tackling climate change and the dramatic cost declines of renewable energy technologies, recent shocks have also highlighted energy security risks. These risks include restricted access to fossil fuels, soaring energy prices, and the vulnerability of centralized electric systems amid geopolitical tensions, all of which have boosted the competitiveness of renewable power and elevated energy source diversification on the political and trade agenda.

Figure 5
Global trade in solar and wind energy goods has grown faster than in other industrial goods.
Index: year 2012 = 100



Source: UN GCRG – technical team calculations, based on UN Comtrade.

Notes: Many products used in renewable energy technologies can be used for several other purposes. Trade flows correspond to total global trade flows of these goods, as their final use cannot be tracked with bilateral trade data. Industrial goods refer to the WTO's Multilateral Trade Negotiations (MTN) category, covering among others, manufactured articles, minerals and metals, machinery, transport equipment, chemicals, products of wood or leather, textiles and clothing.

In focus

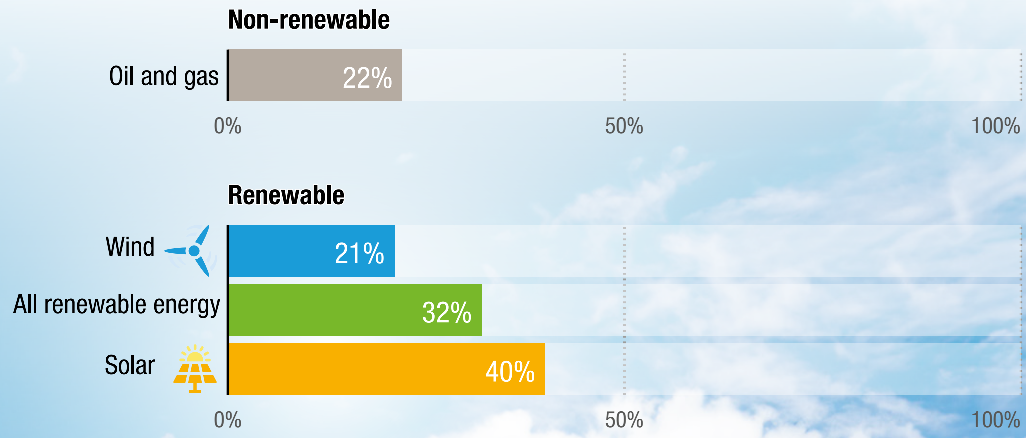
Increased and more inclusive employment in renewable energy

Globally, employment in renewable energy sectors has nearly doubled over the past decade, rising from 7.3 million jobs in 2012 to 13.7 million in 2022. Projections suggest that by 2050, employment in renewable energy could nearly double again from 2022 levels.

Solar and wind energy represent nearly half of all global renewable energy jobs. In 2022, solar PV represented about one-third of the total, employing 4.9 million people, while wind energy jobs totalled 1.4 million.

In addition, women's representation in the renewable energy workforce is higher than in non-renewable sectors. In 2021, the share of women employed in the renewable energy sector stood at 32%, compared to only 22% in the oil and gas industry.

Figure 6
Women's share in the solar energy workforce is twice as high as in the oil and gas industry.
Share (%) of women in the respective energy sector workforce in 2021



Source: UN GCRG – technical team, based on IRENA solar PV survey (2021).
Note: Renewable energy includes solar, wind, bioenergy, hydropower, geothermal, ocean, and others.

There are opportunities to increase the participation of women in technical roles. Employment of women in the renewable energy industry is higher compared to the oil and gas industry. However, women's participation in technical roles remains lower than men's, with women holding 28% of STEM[5] roles and 35% of non-STEM technical roles in the renewable energy industry.

5 STEM refers to science, technology, engineering, and mathematics. Non-STEM technical positions include lawyers, procurement officers, etc.

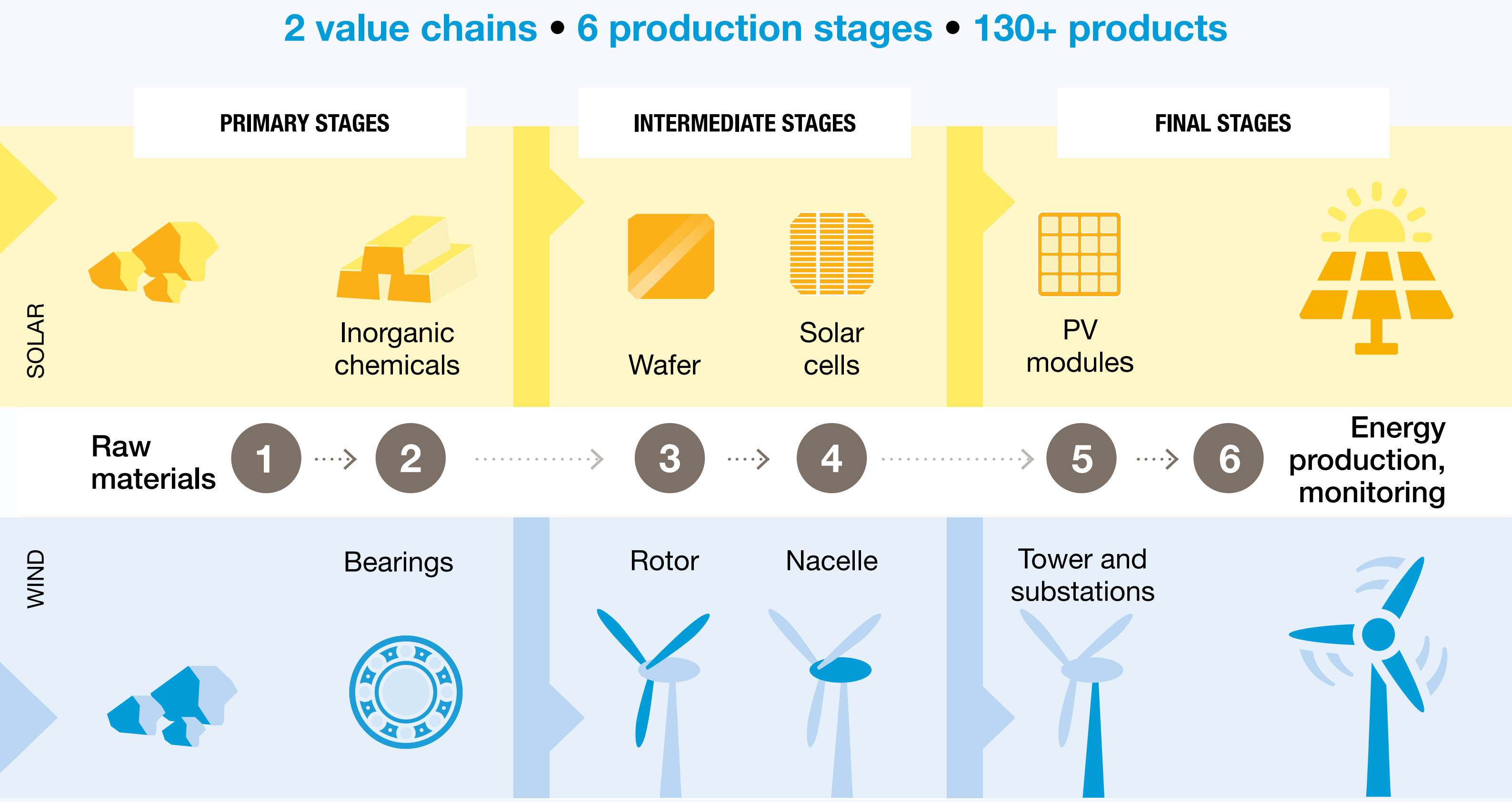
3.
The anatomy of green energy value chains

Dozens of inputs are needed to produce solar panels and wind turbines.[6] Some goods are used in both solar PV and wind energy technologies, particularly raw materials at the first stage of the value chain, such as aluminium or zinc, and components in the final stage of the value chain, like static converters (which convert direct current to alternating current) or electrical control and distribution boards.

Intermediate stages of solar and wind energy value chains feature distinct products. For solar panels, silicon is the primary input to produce silicon ingots, which are further sliced into thin wafers. These wafers are processed into solar cells and assembled with glass and plastic sheets to form photovoltaic modules (also called panels). For wind turbines, the primary components are the blades, which rotate when the wind blows, driving the rotor inside the nacelle. The nacelle, positioned atop the tower, contains the generator and a yaw mechanism that allows the turbine to face the wind.

6 Based on various sources, a list of more than 130 products at the HS 6-digit level has been compiled to analyse trade flows and trade policy along six stages of solar PV, onshore and offshore wind energy value chains (see annex).

Figure 7
Renewable energy technologies entail complex value chains with multiple opportunities to enter.
Products and stages of solar and wind energy technologies used for the analysis



Source: UN GCRG – technical team, based on Africa Centre for Energy Policy (ACEP) and Trade and Environment Sustainability Structured Discussions (TESSD) communication by the United Kingdom (INF/TE/SSD/W/26/Add.1)

Note: Many products used in renewable energy technologies can be used for several other purposes. Iron and steel materials in primary forms (ores, concentrates, ingots, etc.) were not considered.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4.

New technologies following historical trade patterns

Global trade in goods used for producing solar and wind energy technologies exceeded US$ 1.5 trillion annually between 2020 and 2022. Annual trade in goods within the value chains of solar panels and wind power plants amounted to US$ 790 billion and US$ 1.3 trillion, respectively, with goods used in both technologies totalling US$ 430 billion. As expected, the highest trade values are associated with the final stages of production, while the lower values are linked to primary commodities.

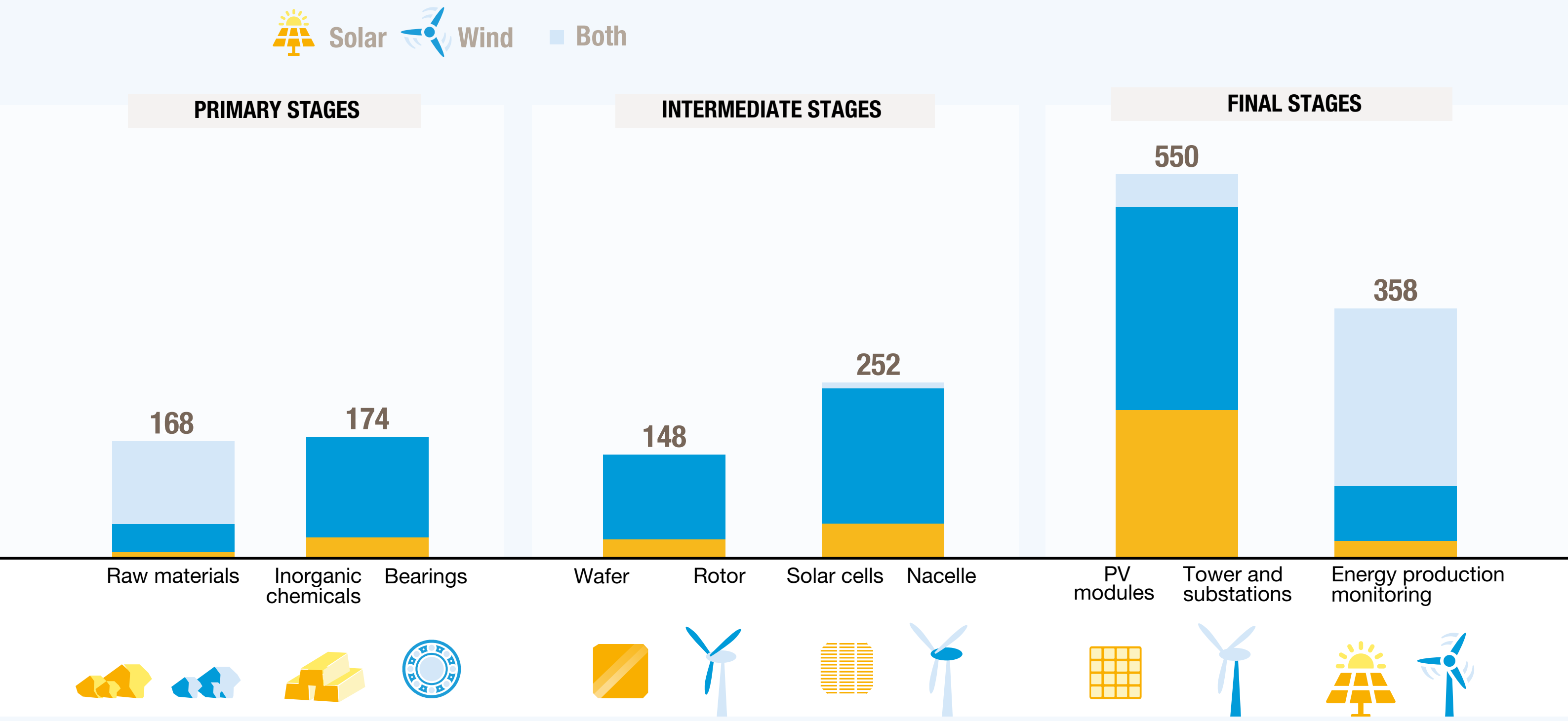
With the notable exception of China, exports of goods at intermediate stages are dominated by developed countries. While many developing countries rank among the top five exporters[7] at the primary stages, only a few developing countries – China, including Hong Kong SAR (China), and Mexico – are among the top five exporters of intermediate and final stage goods.

7 Such as Chile (CHL), Peru (PER), Brazil (BRA), Trinidad and Tobago (TTO) in Latin America and the Caribbean, and Indonesia (IDN) and China (CHN) in Asia.

Figure 8

Trade in solar and wind energy goods is highly concentrated in the final stages.

Average annual global imports in US$ billion for the period 2020-2022



Source: UN GCRG – technical team calculations, based on UN Comtrade.

Notes: Trade flows correspond to total global trade flows of these goods, as their final use cannot be tracked with bilateral trade data. Separate HS 6-digit product codes for solar cells and solar panels have existed only since 2022; cells are therefore partially captured in stage 5.

Export concentration is highest in the intermediate stages. For both solar and wind energy technologies, across all stages of the value chain, the top five economies account for at least 40% of exports. This concentration is particularly high for those intermediate-stage products for which global trade is lowest, e.g., goods needed to produce the polysilicon wafers of solar cells (69% of trade accounted for by top-5 exporters) and the rotors of wind turbines (59% of trade accounted for by top-5 exporters). For both solar and wind technologies, only eight economies feature among the top five exporters across the intermediate and final stages: China, Germany, the United States, Japan, Mexico, the Republic of Korea (for solar only), and Italy (for wind only). Such concentration might make it difficult for other countries to enter the intermediate stages of the value chains, and it may also exert downward pressure on raw material prices.

Figure 9

For solar and wind, top-5 exporters account for at least 40% of trade across value chain stages.

Export shares in per cent for top-5 exporters, 2020-2022

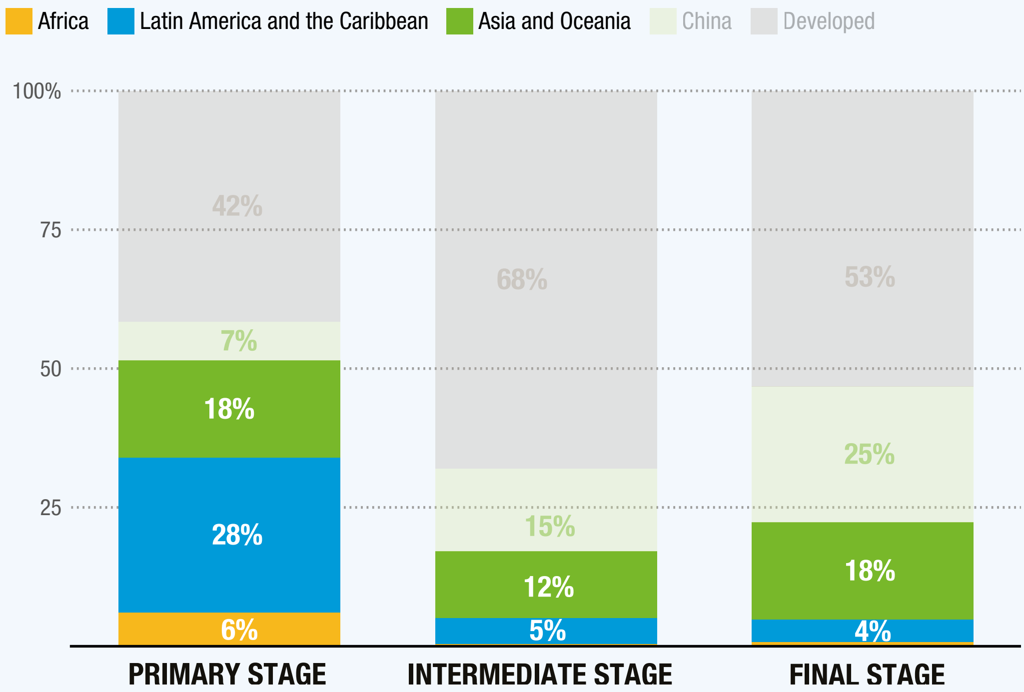
	Stage of the value chain	1st		2nd		3rd		4th		5th		Sum of top-5 exporters
SOLAR	Raw materials	CHL	21	PER	13	AUS	8	IDN	5	CAN	4	51
SOLAR	Inorganic chemicals	AUS	20	BRA	12	CHN	8	TTO	7	IDN	5	53
SOLAR	Wafer	JPN	21	CHN	20	DEU	11	USA	11	KOR	5	69
SOLAR	Solar cell	DEU	12	CHN	11	USA	8	KOR	6	JPN	5	42
SOLAR	Solar module	CHN	27	HKG	6	DEU	6	USA	6	JPN	6	51
SOLAR	Energy production	CHN	21	DEU	13	USA	8	JPN	5	MEX	5	52
WIND	Raw materials	CHL	17	PER	10	AUS	8	CAN	6	IDN	4	45
WIND	Bearings	CHN	19	DEU	14	USA	8	JPN	6	ITA	5	51
WIND	Rotor	DEU	20	JPN	16	USA	11	CHN	9	MEX	4	59
WIND	Nacelle	CHN	21	DEU	14	USA	8	JPN	6	ITA	5	54
WIND	Tower and substations	CHN	21	DEU	10	USA	8	JPN	4	ITA	4	47
WIND	Energy production	CHN	22	DEU	13	USA	8	MEX	5	JPN	5	52

Source: UN GCRG – technical team calculations, based on UN Comtrade.

Note: Trade flows correspond to total global trade flows of these goods, as their final use cannot be tracked with bilateral trade data. Separate HS 6-digit product codes for solar cells and solar panels have existed only since 2022; cells are therefore partially captured in stage 5. For readability, countries are indicated by their International Organization for Standardization (ISO) 3166-1 alpha-3 code.

Developing countries are slipping into historical trade patterns. They remain confined to supplying raw materials for energy transition, thus missing developmental opportunities. China, by leveraging its large domestic market, has become the leading producer and exporter of intermediate and final goods, driving global capacity expansion, price declines and international trade. However, when taking China out of the picture, a concerningly familiar pattern emerges – developing countries across all regions tend to be net exporters of raw materials and other goods at primary stages, but net importers of manufactured goods at intermediate and final stages. These countries could unlock further opportunities for sustainable industrialization and domestic value addition by focusing on the refining and processing of critical raw materials.

Figure 10
The role of developing countries is mostly confined to the supply of raw materials.
Shares of developing regions, developed countries, and China in world exports of goods in solar and wind energy technologies, 2020-2022



Source: UN GCRG – technical team calculations, based on UN Comtrade.

Note: Primary stages include raw materials, inorganic chemicals and bearings. Intermediate stages include goods entering the wafer, solar cell, rotor and nacelle. Final stages include goods entering the PV modules, tower and substations. The label "Asia and Oceania" excludes China.

The assembly stage can enhance the integration of developing countries into renewable energy value chains beyond raw material supply. In assembly, these countries could benefit from labour availability, lower technological complexity, and the ability to import inputs and export assembled goods. Southeast Asian economies such as Viet Nam, Malaysia and Thailand have developed significant assembly capacity, by leveraging their cost advantages, trade networks, and domestic policies (such as feed-in tariffs) to attract investors from big players, such as China. In the wind energy sector, opportunities for job creation are associated with nacelle assembly and its subcomponents, such as generators and gearboxes. Developing countries like India and Brazil have been establishing nacelle assembly facilities to tap into these opportunities.

5.

Trade barriers along green energy value chains

Setting the right trade policy for green energy value chains is a delicate balancing act. Lowering tariffs and non-tariff barriers to trade increases the affordability of imported goods, benefitting consumers and companies through lower prices. In particular, reducing trade costs on primary and intermediate goods can help integrate countries into global value chains. However, for many developing countries, tariffs are also an important source of revenue and serve as protection against foreign competition when building up an 'infant industry'.

Currently, developing countries' average tariffs on green energy goods range from 2.5% in Asia and Oceania to 7.1% in Africa. Non-tariff measures (NTMs) add additional costs of 0.4%-1%.[8] In Asia and Oceania, the inclusion of China skews the weight of the NTM component. Although trade-weighted tariffs on imports in China are lower than for the rest of developing Asia and Oceania, costs associated with NTMs are about twice as high, exceeding 1%.

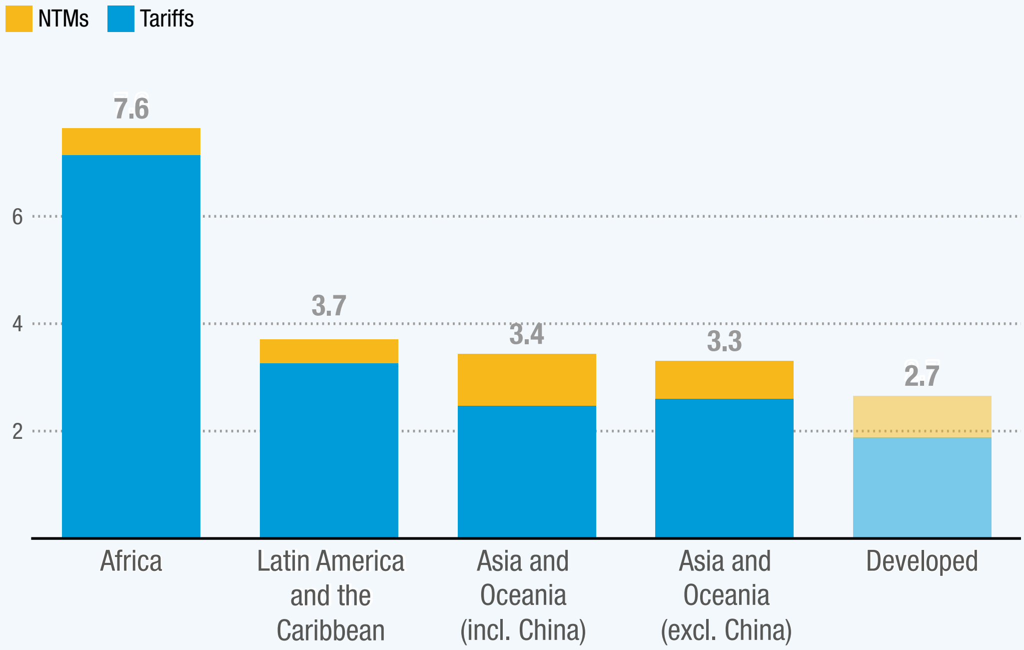
This pattern suggests that green energy goods face levels of protection comparable to other industrial products. For comparison, tariffs on all industrial goods range from 3.0% in Asia and Oceania to 7.0% in Africa, with NTMs ranging between 0.6% and 2.3%.

8 Simple average tariffs and ad-valorem equivalents of non-tariff border measures across traded goods are up to three times higher due to high trade costs on little traded products.

Figure 11

There is scope to reduce trade barriers for green energy goods in all regions.

Trade policy costs on the trade of goods in wind and solar energy technologies (%), 2020-2022



Source: UN GCRG – technical team calculations, based on UN Comtrade, UNCTAD and Kee and Nicita (2022).

Note: Trade costs as trade-weighted average of applied tariffs and ad-valorem equivalents of non-tariff border measures on goods entering solar and wind energy technology value chains by importing region.

High tariffs on intermediate-stage goods can be an obstacle for most developing countries seeking to enter green energy value chains at the assembly stage. Following the infant industry argument, one would expect higher tariffs on goods where countries aim to develop an industry and lower tariffs on inputs needed for their production. However, the current tariff structure in developing countries does not appear to be consistent with this argument: the highest tariffs are imposed on intermediate goods, which are challenging to produce domestically as they are more energy-intensive, capital-intensive, and technologically sophisticated. Lowering tariffs on intermediate goods could help particularly small economies and those with energy access deficiencies engage in the assembly of final green energy goods.

Intra-regional tariff liberalisation for green energy goods could be promoted in Africa and Asia to expand South-South trade. Regional integration is a strategy to achieve viable economies of scale by creating a larger market for local businesses and investors. It is particularly relevant for least-developed countries and many African economies, which often have small domestic markets. Latin America and the Caribbean is the only region where trade in solar and wind energy goods faces average tariffs below 1% within the region, significantly lower than average tariffs on trade with other regions. In contrast, tariffs applied to trade within Asia and Oceania average above 2%, and within Africa above 3%, even at primary and intermediate stages.

Figure 12

Lower tariffs on intermediates could help in developing green energy industries, notably in Africa.

Trade-weighted average applied tariffs (%) by stage, within and between regions, 2020-2022

		Africa		Latin America and the Caribbean		Asia and Oceania	
	Stage of the value chain	extra-regional	intra-regional	extra-regional	intra-regional	extra-regional	intra-regional
PRIMARY STAGE	Raw materials	0.7	4.6	2.1	0.2	0.9	0.7
	Chemicals Bearings	7.1	3.8	3.4	2.1	3.1	2.5
INTERMEDIATE	Wafer Rotor	6.8	3.3	4.3	0.4	3.7	2.0
	Solar cells Nacelle	8.1	4.4	3.8	0.9	4.1	3.4
FINAL STAGE	PV modules Tower, substations	7.3	3.5	3.0	0.9	2.6	2.3
	Energy production and monitoring	8.7	4.2	3.8	0.7	2.9	2.3

Source: UN GCRG – technical team calculations, based on UN Comtrade and UNCTAD.

Notes: Effectively applied tariffs are tariffs charged on imports, including preferential tariffs under free trade agreements. The label "Asia and Oceania" excludes China.

The benefits of lowering compliance costs associated with non-tariff measures are unambiguous. While setting tariffs involves a trade-off between revenue generation and trade facilitation, countries would benefit from reducing the cost burden of non-tariff measures on intra-regional trade, especially for smaller firms. Reducing these compliance costs while maintaining important functions, such as safety standards, can be achieved through increased transparency, ex-ante coordination, harmonisation of trade rules, and mutual recognition.

Reducing intra-regional border costs for green energy goods could be particularly beneficial for Africa and Latin America and the Caribbean. Several types of NTMs impact international trade. Among these are border measures, which are policy instruments such as customs controls, quota licensing, or pre-shipment inspections, that are applied at the border. As they affect the price difference between domestically and internationally sold products, their costs can be directly compared to tariffs. Trade policy instruments to lower these costs include regional trade agreements or the Trade Facilitation Agreement. In Latin America and the Caribbean, and partially in Africa, the costs associated with such border measures appear higher for intra-regional trade compared to trade with partners outside the region. For Asia and Oceania, the highest costs are associated with the final goods stages and with trade with external partners.

Figure 13

Reducing border costs for regional trade could foster supply chains, mainly in Africa and Latin America and the Caribbean.

Trade-weighted average ad-valorem equivalent (%) of border NTMs by stage, within and between regions, 2020-2022

	Stage of the value chain	Africa		Latin America and the Caribbean		Asia and Oceania	
		extra-regional	intra-regional	extra-regional	intra-regional	extra-regional	intra-regional
PRIMARY STAGE	1 Raw materials	0.1	0.3	0.2	1.1	0.0	0.0
PRIMARY STAGE	2 Chemicals / Bearings	0.4	0.8	0.3	1.3	0.5	0.5
INTERMEDIATE	3 Wafer / Rotor	0.5	2.1	0.7	1.8	0.8	0.7
INTERMEDIATE	4 Solar cells / Nacelle	0.7	0.6	0.6	0.9	0.5	0.4
FINAL STAGE	5 PV modules / Tower, substations	1.2	0.6	0.6	1.1	1.8	1.1
FINAL STAGE	6 Energy production and monitoring	0.6	1.7	0.2	0.4	1.3	1.1

Source: UN GCRG – technical team calculations, based on UN Comtrade and Kee and Nicita (2022).

Notes: Including products for which no NTMs were applied or AVEs were not significantly different from zero, but excluding products for which no information on NTMs was available. The label "Asia and Oceania" excludes China.

Developing countries across Asia are increasingly facing trade defence duties. Primarily imposed by other major producers, these duties aim to mitigate the negative effects of increased imports due to dumping (anti-dumping duties) or subsidies (countervailing duties). While China remains the most heavily targeted, from 2020 to 2022, more than twice as many measures were implemented against other Asian economies, led by Malaysia, India, and Viet Nam, followed by Indonesia, the United Arab Emirates and Saudi Arabia, Thailand, Türkiye, Oman and Kazakhstan. These actions reflect the growing competition among developing countries, with 16 trade defence measures imposed within Asia and Oceania (excluding China), raising costs by up to 55%.

More than 40 trade defence measures by developed countries targeted green energy goods from developing regions. Between 2020 and 2022, 59 new measures by developed countries entered into force, with 9 targeting China and 32 aimed at other Asian economies. Duties on goods entering solar and wind energy value chains can go as high as 300%. Notably, developed countries are targeted almost exclusively by other developed countries. With the European Union, the United States and other developed countries revitalizing industrial policy to scale up domestic manufacturing of clean technologies, trade defence measures and trade disputes are likely to increase.

Re-evaluating the use of trade defence measures could drive greater growth in renewable energy value chains. To better support green energy technologies, countries can enhance dialogues and effectively utilize trade remedy mechanisms to reach mutually agreeable solutions before resorting to anti-dumping or countervailing duties. In addition, countries could negotiate and include specific provisions in regional trade agreements (RTAs) to eliminate the application of trade remedies on green energy technologies. These agreements could promote a policy of non-use of trade remedies in certain situations and reclassify specific environmental subsidies as non-actionable. Incorporating the lesser duty rule, where duties are applied only to the extent necessary to counteract harm to domestic industries, would also be beneficial. Furthermore, enforcing shorter and fixed time limits on trade remedies for green technology goods can curtail the standard five-year duty period, further supporting the green energy transition.

Figure 14

Exporters in developing Asia are prime targets of trade defence duties on green energy goods.

Number of anti-dumping and anti-subsidy duties on goods in solar and wind energy technologies that entered into force, 2020-2022

Imposing region	Targeted exporting region: Developed	Asia and Oceania (excl. China)	China	Africa	Latin America and the Caribbean
Developed	18	32	9	0	0
Asia and Oceania (excl. China)	0	12	6	0	0
China	1	0	0	0	0
Africa	0	3	0	0	0
Latin America and the Caribbean	0	1	2	0	0

Source: UN GCRG – technical team calculations, based on WTO (2024), Trade Remedies Data Portal.

Notes: Anti-dumping and anti-subsidy (countervailing) duties are aimed at reducing negative effects from import surges resulting from price-dumping and subsidies, respectively.

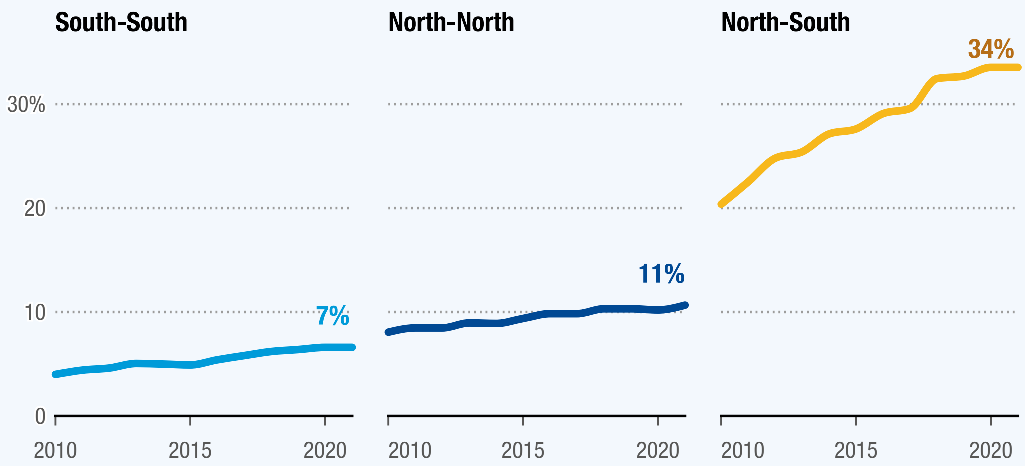
Developed countries could support developing countries and the global effort towards the green transition by reducing trade barriers for these countries. On average, developed countries impose lower tariffs on goods entering renewable energy value chains compared to developing countries. However, non-tariff measures (NTMs) play a relatively greater role. New requirements on greener value chains, many of which are private standards defined and enforced in 'green lead markets', could become entry barriers for developing countries. In addition to environment-friendly tariff setting, it is important to ensure that developing countries can fully participate in climate change-related standard setting and are not overly affected by regulations adopted in developed countries.

Provisions on renewable energy in trade agreements could support more effective integration of developing countries into the production of renewable energy technologies. A large majority of trade agreements signed since 2000 include provisions related to environmental concerns and renewable energy, aimed at reducing trade barriers.[9] The inclusion of provisions on renewable energy generation has increased strongly for trade agreements between developed and developing countries (North-South). However, for agreements between developing countries (South-South) and between developed countries (North-North) this trend is more muted, potentially because of the similarities in priorities and regulatory systems.

Figure 15

Provisions on renewable energy in trade agreements could support more effective integration of developing countries into the production of renewable energy technologies.

Share of trade agreements with provisions on renewable energy generation in per cent of all trade agreements and accessions



Source: UN GCRG – technical team calculations, based on the Trade and Environment Database.

Notes: Anti-dumping and anti-subsidy (countervailing) duties are aimed at reducing negative effects from import surges resulting from price-dumping and subsidies, respectively.

9 For example, the EU-Viet Nam Free Trade Agreement has a standalone chapter on "non-tariff barriers to trade and investment in renewable energy generation". The Environment Chapter of the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) includes provisions for cooperation on issues related to energy efficiency, and sustainable renewable energy. It also incorporates provisions to address barriers to trade in environmental goods and services, including non-tariff measures. The recent "Green Economy Agreement" between Singapore and Australia prioritises collaboration to reduce tariffs and eliminate non-tariff barriers on trade and investment in environmental goods and services, including renewable energy technologies.

In focus

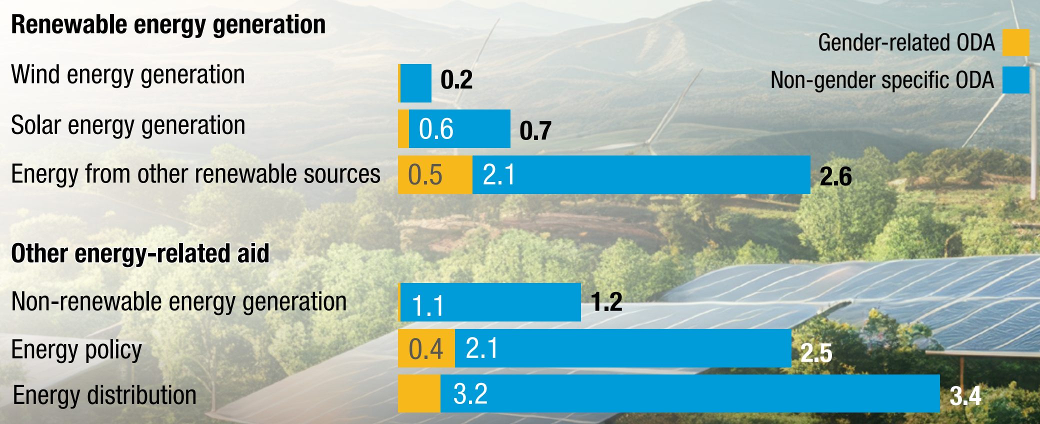
Rising aid for access to sustainable energy

Aid to the energy sector has been on the rise, with a focus on renewable energy. From 2012 to 2022, the annual Official Development Assistance (ODA) for renewable energy generation in developing countries more than doubled. Although aid to the energy sector had been gradually increasing before COVID, it saw a decline during the pandemic but rebounded significantly afterwards. Additionally, substantial funding has been directed towards energy distribution and energy policy initiatives, including regulation, research, and training.

Post-COVID, gender-related aid is most prominent in renewable energy generation. Over the period 2020-2022, more than US$ 900 million of ODA was disbursed for solar and wind energy generation projects in developing countries. Of that ODA, gender-related aid comprised 7% of the total for wind energy and 10% of the total for solar PV. For both technologies, the share of gender-related ODA increased by roughly one percentage point over the past decade. In contrast, ODA towards energy generation from other renewable resources increased to US$ 2.6 billion for the period 2020-2022 with the share of gender-related ODA more than doubling to 18%. Conversely, gender-related ODA towards non-renewable energy projects declined by 35%, and with a share of only 1.5%, gender is still hardly considered in non-renewable energy projects.

Energy distribution, the second biggest area of ODA for energy after renewable energy generation, is crucial for gender equality. Access to modern energy reduces women's unpaid care and domestic workloads and mitigates health impacts from cooking with dirty fuels. The share of gender-related ODA for energy distribution has increased from 3% a decade ago to 8% during the period 2020-2022.

Figure 16
Renewable energy received 3 times more ODA and 30 times more gender-related ODA than non-renewable energy.
Average annual ODA to developing countries by gender marker in US$ billion for the period 2020-2022



Source: UN GCRG – technical team calculations, based on OECD (Dec. 2023).

Notes: Other renewable energy sources include biofuel, geothermal, hydropower, marine energy, solar thermal, or multiple renewable technologies. Non-gender specific ODA also comprises ODA that has not been assessed for the gender marker.

6.

Fine-tuning trade policy to enhance renewable energy technologies

Setting the right trade policy for green energy value chains is a delicate balancing act between economic, social and environmental concerns. Tariffs, border measures, and trade defence instruments can either support or hinder developing countries' integration into green energy value chains, with ensuing consequences for energy poverty and low-carbon transition. Keeping in mind the trade-offs between trade integration and tariff revenue generation, as well as between lowering import costs and infant industry protection, reducing trade barriers at intermediate production stages can foster developing countries' integration into the assembly of renewable energy technologies. This is especially pertinent for South-South trade.

Intra-regional trade costs along green energy value chains vary by region. In Africa, tariffs are the predominant trade cost, averaging over 3% across all value chain stages, even for trade within the region. Latin America and the Caribbean has a higher level of regional trade integration (lower tariffs) for goods entering renewable energy value chains. In contrast, costs associated with non-tariff border measures tend to disadvantage intra-regional trade vis-à-vis trade with other regions. Asia and Oceania is currently the most advanced developing region in producing and assembling components of solar and wind energy technologies, even excluding China. However, increased use of trade barriers in the form of anti-dumping or countervailing duties reduces predictability and increases trade friction over the medium term.

There is an opportunity for developing countries to leverage critical raw materials to foster structural transformation and enhance sustainability. The demand for raw materials for renewable energy technologies is skyrocketing, with many developing countries being key suppliers. However, these materials are primarily exported in raw form and are often associated with environmental concerns and weak worker protection. With increasing international demand, there is an opportunity for developing countries to upgrade from extraction to processing and refining of minerals while simultaneously enhancing sustainability and generating greater employment. Processed and refined minerals are sold at a much higher value and can stimulate industrial development.

Integrating developing countries into renewable energy value chains should bring local benefits. To increase the economic and social impact of the green transition for these countries, they should include local content requirements, for instance in negotiations for licences with mining companies, trade-related infrastructure development (rail tracks, roads, storage, etc.), as well as tender procedures of development finance institutions for the financing of the installation of solar and wind energy power plants. Furthermore, the skills of local entrepreneurs who are aware of local needs, language, and culture, could be upgraded, so they can be more involved in advisory, installation, and repair services for such projects.

The export potential of renewable energy does not only exist for goods entering solar and wind energy technologies but extends to industries linked to renewable energy production. Energy storage solutions, such as batteries, are integral to solar and wind energy technologies to balance out the intermittency of power production. Also, demand for new products, such as green hydrogen, is emerging, with the potential to further expand trade and industrial development opportunities.

Developed countries should scrutinize whether their trade policies towards developing countries are consistent with the energy transition and achieving universal energy access. Targeting some developing countries with high tariffs on goods needed for the energy transition appears contradictory to both a sustainable development agenda as well as their interest in diversifying sources and suppliers. Rather, helping developing countries to enter renewable energy value chains through technology transfer, capacity building, climate funding and trade partnerships could address the double imperative on the energy sector as well as energy security concerns.

Reducing trade costs on green energy goods is just one part of the solution – addressing fossil fuel counterparts is another. To effectively encourage green energy technologies, trade policy must make renewable energy technologies more attractive compared to fossil fuels. Lowering trade costs related to tariffs and non-tariff barriers for renewable energy technologies should be paired with policy actions on fossil fuel substitutes, such as the phasing out of fossil fuel subsidies in line with the Addis Ababa Action Agenda.

A call for action – we must shift from the trade policy we have to the trade policy we need.

7. Annex

Analysed products in solar and wind energy value chains

The selection of products focused on photovoltaic systems for solar energy and covered both onshore and offshore wind power plants.

While some sources point to more aggregate 4-digit product groups, only goods at the 6-digit level were considered. For a product to be considered, a trade threshold was set at an average global trade flow of above US$ 1 billion over the period 2019-2022.

Iron and steel materials in primary forms (ores, concentrates, ingots, etc.) were not considered.

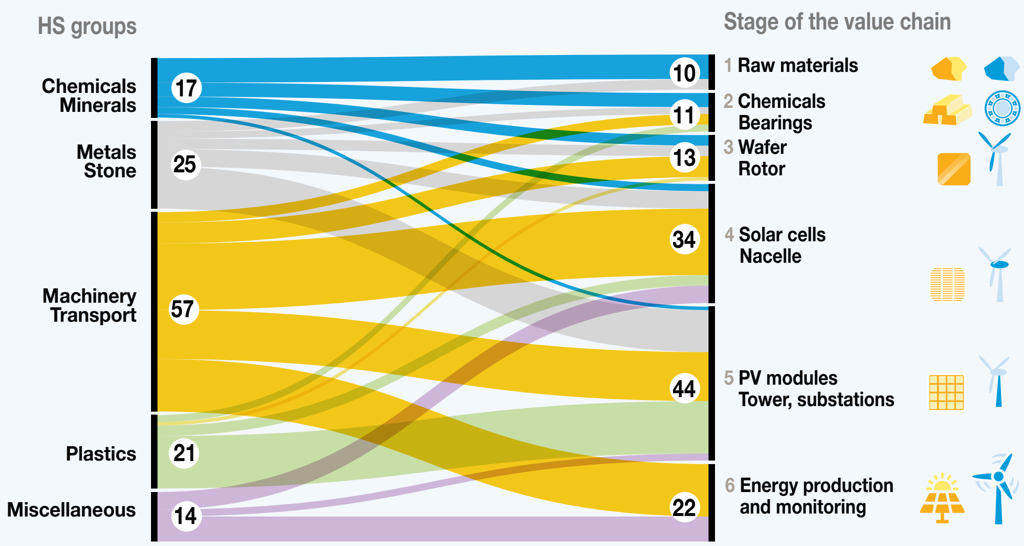
Almost all products used for solar and wind energy technologies can be used for several other purposes. Trade values cannot be disentangled according to their final use. Therefore, depicted trade flows correspond to total global trade flows irrespective of their use in renewable energy value chains or other industries.

Products considered include those that directly enter the final product, while products needed for planning of installations (for example, products needed for environmental survey, resource assessments etc.), or for the transport and installation of the plants (for example, cranes or vessels) were excluded.

Many analysed products entering solar and wind energy technologies fall under machinery and electrical equipment. This product group represents a quarter of the value chain for solar panels, and more than half of the value chain of wind power plants. Other important product categories include plastics and rubbers, metals, chemicals and allied industries.

Most products along the wind and solar energy value chains are machinery and electronic equipment.

Number of HS 6-digit products per section of the Harmonized System and stage of the value chains



Source: UN GCRG – technical team.

Notes: HS sections were summarized for illustration purposes: Machinery and electrical equipment (84-85) with transport (86-89), stone and glass (68-71) with metals (72-83), mineral products (25-27) with chemicals and allied industries (28-38).

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See the full list of HS 6-digit products.

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